Trinity River Restoration Program:

Integrated Assessment Plan

Version 1.0 – September 22, 2009

Prepared by staff, partners and interested parties of

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Table of Contents

List of Figures

List of Tables

Acknowledgements

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The authors look forward to your feedback, and continued improvement of this document in future years as we learn more about the Trinity River ecosystem. Happy reading!

Executive Summary

The IAP has been under preparation for the last two years and has undergone considerable revision in response to reviews of version 0.90 by the Science Advisory Board (SAB), TMC and TAMWG in 2006, extensive comments from Program partners in 2007, and a final SAB review (www.trrp.net/science/IAP.htm) of IAP version 0.98 in October 2008. Over this time period three workshops attended by SAB members and invited experts were held to refine various components of the IAP. As assessments are conducted and additional information is gained, the IAP must adapt to this improved understanding. Therefore the IAP is intended to be a "living document" that will evolve as we learn more about the Trinity River ecosystem, and determine which assessments are of the highest priority and greatest feasibility. The IAP authors believe that this current version of the IAP (1.0) has achieved most of the objectives that were set out for Part I of the IAP in August 2006 (Appendix O). Remaining work to do (over the next 1-2 years) includes refining assessment objectives to make them more specific, and further prioritization of assessments to a core set that can feasibly and cost-effectively achieve the purpose of the IAP. Section 2.4 of this document provides a decision tree which describes how we intend to undertake this prioritization

The Trinity River Flow Evaluation (TRFE, USFWS and HVT, 1999) recommended a restoration strategy for the Trinity River that integrates restoration of riverine processes with the instream flow-dependent needs of salmonids. This strategy is intended to rehabilitate the river ecosystem to improve and maintain the fish and wildlife resources of the Trinity River through managed flows combined with mechanical rehabilitation and coarse sediment augmentation projects. The subsequent EIS/EIR and Record of Decision (ROD, DOI 2000) selected the TRFE recommendations, plus a watershed restoration component, as the Preferred Alternative for restoring the mainstem fishery resources and native wildlife of the Trinity River. The TRFE and ROD provide a restoration strategy for the Trinity River Restoration Program (hereafter called the Program) but did not specify methods for assessing the effectiveness of the TRFE and ROD management actions in achieving Program goals or management targets.

To fill this need, the Integrated Assessment Plan (IAP) identifies key assessments that:

1. evaluate long-term progress toward achieving Program goals and objectives; and
2. provide short-term feedback to improve Program management actions by testing key hypotheses and reducing management uncertainties.

The ROD directed the Program to organize assessments around the principles of Adaptive Environmental Assessment and Management (AEAM) and to use AEAM to rigorously assess the river's response to management actions and ultimately the response of fish and wildlife populations that depend on the river. AEAM is a process that emphasizes iterative learning from carefully designed and monitored management actions. Analyses will be applied to quantitatively determine the overall status and trend of river system attributes and management targets relative to Program objectives. Appropriate empirical data to inform analyses will be collected based upon scientifically defensible monitoring designs. Conceptual and quantitative models will also be used to improve our current understanding of the Trinity River ecosystem and the underlying processes shaping the river. The causal relationship between rehabilitation of the fluvial nature of the river and increasing salmonid production will be a major focal point for monitoring and modeling.

In developing the IAP, the authors built on the goals and objectives listed in the TRFE to identify the primary objectives/sub-objectives of the Program to guide the development and prioritization of

assessments. Program assessments represent the combination of directed monitoring and subsequent associated analyses. The IAP identifies key assessments based on these objectives and sets the foundation for future Requests for Proposals (RFPs), but does not specify exactly how each assessment will be carried out, or who will undertake each assessment. In some cases monitoring designs and protocols are already well established, while in other cases RFP-responsive study designs need to be developed. The IAP does propose a general framework for integrating and linking assessments across monitoring domains, however, further refinement of the integration strategy is needed. Integration of assessments is essential for evaluating the Program's overall restoration strategy, involving coordinated actions to support multiple ecosystem processes and components. Integration will allow development of coordinated sampling designs and assessments that serve multiple or complementary objectives, and will improve our understanding of qualitative and quantitative functional relationships that link across subsystems in the Program area.

Six primary objectives for the Program area have been identified across monitoring domains and provide the foundation for the proposed IAP assessments:

Objective 1: Create and maintain spatially complex channel morphology

The TRFE recommended, and the ROD adopted, a restoration strategy where reshaping the channel at rehabilitation sites, combined with flow and sediment management to create and maintain a complex alluvial channel, will improve channel complexity in a way that will increase fry rearing habitat availability for anadromous salmonids, as well as aquatic and riparian habitat for other species and life stages. Promoting the physical processes that create and maintain geomorphic complexity in the mainstem Trinity River, while managing upslope fine sediment production and delivery are therefore the key physical sub-objectives of the Program. IAP assessments will encompass two components: 1) identifying the geomorphic conditions that create and maintain complex habitat that support the production of anadromous salmonids in the Trinity River, and 2) developing metrics and inventories that effectively quantify the abundance and quality of those geomorphic conditions.

Specific recommended assessments include:

- periodic mapping of channel complexity metrics;
- mainstem coarse sediment (bedload) transport and computations of mainstem coarse sediment budget;
- Rush Creek tributary sediment delivery;
- mainstem fine sediment (suspended and bedload) transport; and
- bed mobility and scour thresholds.

Objective 2: Increase/improve habitats for freshwater life stages of anadromous fish to the extent necessary to meet or exceed production goals

The current quantity and quality of available habitat within the Trinity River between Lewiston Dam and North Fork Trinity River is hypothesized to limit natural production of anadromous fish. The Program intends to increase habitat quantity and improve habitat quality by re-establishing fluvial processes and returning alluvial function to the river, scaled to the geomorphic potential of the mainstem within the existing infrastructure constraints and the five water-year type allocations. Fish habitat assessments in the IAP are intended to quantify changes over time in the amount, distribution and quality of habitat, and improve our understanding of the linkages between river channel complexity, quantity of fish habitat, fish use of habitat and fish production. Linking assessments of habitat availability, food availability, temperature, and habitat potential to carrying capacity and production will enable the Program to predict whether fish production goals can be achieved.

Specific recommended assessments include:

- available habitat for different salmonid lifestages based on a combination of (a) suitability based habitat mapping (SBHM) and (b) 2-Dimensional modeling of suitable habitat (to extend habitat estimates to other species, lifestages, flows and locations not captured by SBHM);
- water temperatures at specific times within specific reaches in regard to TRFE temperature objectives for salmonids and evaluating these in the context of the desired biological response; and
- food (macroinvertebrate) abundance and availability during key time periods for salmonids.

Objective 3: Restore and maintain natural production of anadromous fish populations

The cumulative effects of Program management actions are expected to increase natural production of anadromous fish populations in the Trinity River. Assessments of both the number of adults returning to spawn (escapement) and juvenile production of key species are therefore essential to provide feedback on annual management actions and allow evaluation of long-term Program goals for natural fish production. Supplemental assessments of reproductive success, growth and survival across life-stages will improve our understanding of the potential role of biological factors in limiting natural production. While the cumulative effects of Program management actions are expected to increase natural production of anadromous fish populations, assessments to identify other factors will also be required. Although the Program is not directly involved with Trinity River Hatchery management, assessments of the impacts of these programs on natural production may also be necessary to evaluate the potential for interference with the goals of the Program.

Specific recommended assessments include:

- distribution and abundance of spawning salmonids;
- fry abundance, density and growth rates;
- smolt abundance and survival;
- smolt outmigration timing and duration;
- incidence and severity of disease infection; and
- potential for interactions (i.e., predation, competition, adverse genetic effects) between natural and hatchery fish.

Objective 4: Restore and sustain natural production of anadromous fish populations downstream of Lewiston Dam to pre-dam levels, to facilitate dependent tribal, commercial, and sport fisheries' full participation in the benefits of restoration via enhanced harvest opportunities.

To track progress towards the Program goal of restored natural production and enhanced harvest opportunity, IAP assessments will provide annual quantitative population assessments for both natural and hatchery components of the total run, including the contribution of both natural and hatchery produced Trinity River anadromous salmonids to ocean and in-river fisheries. The harvest of Trinity River fall Chinook salmon is managed as part of the Klamath River basin stock, within an integrated harvest management process for ocean and in-river fisheries. Assessment of

Trinity River anadromous populations will, therefore, also need to account for current harvest management processes.

Specific recommended assessments include:

- escapement of naturally produced adult salmonids;
- production and productivity of key species; and
- contribution of Trinity River naturally produced salmonids to dependent Tribal, sport and commercial fisheries.

Objective 5: Establish and maintain riparian vegetation that supports fish and wildlife

The Program intends to promote patchy, diverse, heterogeneous (i.e., healthy) riparian vegetation throughout the Trinity River corridor through flow releases, sediment management, and rehabilitation activities. Healthy riparian vegetation is spatially variable (both in height and growing locations) and comprised of multiple age classes and cover types, which creates and maintains high quality habitat for aquatic and terrestrial animals. Although riparian vegetation is generally considered a natural and valuable component to high quality fish habitat, thirty years of near constant flows of 150 cfs in the Trinity River allowed development along mainstem edges of dense, continuous, and homogeneous berms of riparian vegetation that have caused channel simplification and are considered detrimental to aquatic habitat used by target fish species. Riparian assessments within the IAP therefore focus on three elements: 1) evaluating if management actions are promoting healthy riparian vegetation within the Trinity River corridor, 2) evaluating if management actions are successfully inhibiting detrimental riparian vegetation encroachment within the river's active channel, and 3) evaluating whether riparian vegetation that has been directly removed by bank rehabilitation efforts is recovering or being replaced (compliance monitoring).

Specific recommended assessments include:

- size and distribution of riparian vegetation patches along the mainstem;
- species and age class composition of riparian vegetation patches;
- distribution and abundance of colonizing and established riparian plants in the active channel; and
- extent and species composition of natural riparian and invasive exotic vegetation at bank rehabilitation sites.

Objective 6: Rehabilitate and protect wildlife habitats and maintain or enhance wildlife populations following implementation

Program activities that increase aquatic and riparian habitat complexity are expected to benefit target wildlife species (riparian and riverine birds, Foothill Yellow-legged Frogs, and Western Pond Turtles) in the Trinity River. IAP assessments will focus on evaluating short-term impacts to wildlife as a result of site rehabilitation implementation, as well as evaluating the long-term responses (e.g., survival, reproduction, productivity, abundance, species diversity, etc.) to the cumulative effects of managed flows, coarse sediment management, habitat rehabilitation, and other management actions. Assessments will also assist in evaluating success in establishing the amount and characteristics of riparian habitat that meet the needs of wildlife species. Supplemental assessments may also focus on whether particular wildlife components (e.g., abundance/distribution of piscivorous birds or invasive species) could have detrimental effects on Program fishery resource objectives.

Specific recommended assessments include:

- riparian and riverine bird species distribution, abundance, diversity and productivity;
- distribution of habitats for Foothill Yellow Legged Frogs and Western Pond Turtle; and
- abundance, survival and productivity of Foothill Yellow Frog and Western Pond Turtle.

The IAP proposes a sampling framework for conducting the major assessments across subsystems that are required at site, reach and system scales to fulfill the two purposes of the IAP (i.e., feedback to revise management actions; judging progress towards Program goals and subsystem objectives). The sampling framework proposed within the IAP should allow for comparable system-wide estimates generated using alternative approaches (e.g., census or sample). Ongoing assessments with scientifically established protocols will be maintained as long as they provide information at the appropriate scale and the sampling design is statistically sound. The proposed sampling framework allows assessments to fall into one of five different categories: 1) previously established valid protocols (census, sample, and model based); 2) census; 3) General Random Tessellation Stratified (GRTS) panel; 4) alternative sampling design (i.e., assessment requires a unique design); and 5) site-scale design (e.g., process-based study). The intent of this sampling framework is to provide an accepted base structure around which ongoing assessments and future RFPs can be developed and coordinated, and through which data can be combined across disciplines to elucidate cause-effect relations at a system scale.

Recommendations of the IAP steering committee concerning the next steps for the IAP

I. TMC approves Part I and IAP SC proceeds into a 1-2 year period of core program development period as outlined in the following steps.

II. Core Program Development
  - i. Assessment/Objective Prioritization
    1. Revise cross-domain prioritization utilizing previously developed and agreed upon prioritization criteria/process
    2. Lump/bundle/integrate assessments based on similar techniques/methods (efficiencies in sampling)
    3. Re-rank assessments based on both temporal sequence (use decision tree) and dependence on results of other studies (contingent assessments)
  - i. Refinement of performance measures – Interim targets – to be revised as information and adaptive management moves forward
    1. Identify which objectives may need TMC guidance prior to developing interim targets.
    2. Utilize the Program workgroups (TMC Subcommittee Report 2004) as the forum for developing interim targets with the IAP SC tracking/managing efforts.
  - iii. Tackle Priority Issues To Address (PITAs) outlined in the document
    1. Utilize the Program workgroups (TMC Subcommittee Report 2004) as the forum for addressing the PITAs.

III. Development of assessment/investigation plans to assess refined performance measures
  - i. Focused development of core assessments to ensure that they have the necessary attributes (see notes on boxes 1A, 2A and 3A of decision tree, in Table 2.3 of IAP)
  - ii. Compile investigation plans/proposals currently being conducted and refine if necessary.
  - iii. Issue RFPs as necessary (also see step V.iii.).

IV. Evaluations of proposals/methods in meeting prioritized Program information needs
  - i. Power analyses/update methods/external reviews
  - ii. Description of low, medium, and high reliability approaches to assessments.

V. Tasks for managing the implementation of the IAP.
  - i. Technical refinement – both specific assessments and overall IAP as new information is developed and insights obtained.
  - ii. Prioritization of assessments (annual or semi-annual)
  - iii. RFPs – needs to be coordinated with budget development process
    1. Responsive proposals (study plans)
    2. Review of proposals by Independent Review Panel (process for establishing ERPs need to be developed)
    3. Budget Development (based on responsive proposals)
    4. Re-rank priority assessments based on available $
    5. Define core assessments for a given year

VI. Under direction of the TMC, the IAP SC will continue to provide interdisciplinary synthesis and management of the IAP document, utilizing the TRRP workgroups as technical forums.

1. Overview

1.1 Purpose of the Integrated Assessment Plan (IAP)

The Trinity River Flow Evaluation (TRFE) (USFWS and HVT 1999) developed a mainstem fishery resource restoration strategy pursuant to the Trinity River Basin Fish and Wildlife Management Act of 1984. The restoration strategy proposed in the TRFE recommends management actions that integrate restoration of riverine processes with the instream flow-dependent needs of salmonids (Chapter 7, TRFE). The recommended management actions (annual and interannual flow management, mechanical channel rehabilitation, and coarse sediment augmentation) are expected to create a river system with enhanced channel morphology features and riverine processes. This functioning river, in turn, will provide and maintain the diversity and abundance of habitats necessary to restore the anadromous salmonid and other riverine dependent fish and wildlife populations of the Trinity River. Due to constraints on peak flow, coarse sediment, and infrastructure, the river is expected to be smaller in scale than what previously existed below Lewiston Dam. The Trinity River Mainstem Fishery Restoration EIS/EIR (USFWS *et al.* 2000) evaluated the TRFE strategy and other alternatives, along with a no-action alternative. On December 19, 2000, the Secretary of the Interior signed a Record of Decision (ROD) (USDOI 2000) selecting the TRFE recommendations, plus a watershed restoration component, as the Preferred Alternative for restoring the mainstem fishery resources of the Trinity River.

The primary hypothesis underlying the restoration strategy of the TRFE (Section 8.4.2, TRFE) is:

> *A combination of mechanical alterations and vegetation removal in addition to managed high-flow releases in the spring will promote geo-fluvial processes leading to a new channel form and temperature regime that is expected to provide significantly increased rearing and spawning habitat for anadromous salmonids.*

This primary hypothesis has three supporting sub-hypotheses:

- Salmonid habitat diversity below Lewiston Dam, both on the meso and micro scale, will increase following the implementation of the restoration strategy.
- Juvenile salmonid rearing habitat below Lewiston Dam, believed to be limiting smolt production in the Trinity River, will increase in both quantity and quality following the creation of a more complex and dynamic channel form.
- Salmonid smolt survival will improve as a result of better temperature conditions that increase growth and promote extended smoltification and reduced travel time associated with emigration.

The TRFE and ROD provide a restoration strategy, including management actions and associated targets for the Program. However, these documents do not provide detailed methods for assessing the effectiveness of the management actions in achieving Program goals or management targets. Ongoing monitoring continues without an integrated plan of monitoring tasks linked to assessing Program success.

For these reasons, the Program has undertaken the task of preparing this Integrated Assessment Plan (IAP). The purpose of the IAP is to identify key assessments that:

1. evaluate long-term progress toward achieving Program goals and objectives; and
2. provide short-term feedback to improve Program management actions by testing key hypotheses and reducing management uncertainties.

Achieving this purpose requires clearly linking each assessment to a hierarchy of Program goals and objectives, and integrating important components across different subsystems (e.g., Program actions, physical habitat, smolt production, fshing harvest, and spawner escapement).

The IAP is organized as follows:

- Chapter 1 provides an overview of: the goals of the Program, the strategy and actions by which these goals will be achieved, alternative hypotheses regarding the factors limiting fish production, how the Program proposes to apply Adaptive Environmental Assessment and Management (AEAM), the scope of the IAP, assessment tools we intend to use, and the process for proposal development and peer review.
- Chapter 2 outlines the hierarchy of objectives and sub-objectives required to achieve the Program goals, the criteria used for prioritization of assessments (both up until now and in the future), and the attributes of integration critical to success of the IAP.
- Chapter 3 describes the set of assessments proposed for each of seven major objectives, emphasizing what we propose to do and why.
- Chapter 4 provides a foundational and integrated sampling design for IAP assessments, and future RFPs.

1.1.1 IAP challenges

Writers of the IAP faced many challenges preparing this plan. Foremost of those challenges was achieving consensus amongst the Program partners. We developed and applied a process for identifying and resolving disagreements on technical issues, and for framing policy issues for resolution by the Trinity Management Council (TMC) or Government to Government (G2G) discussions. Beyond the continuing effort to find consensus among the writers and direct contributors, various challenges remain for the TMC, the Trinity Adaptive Management Working Group (TAMWG), the Science Advisory Board (SAB), the Technical Modeling and Analysis Group (TMAG), and Work Groups.

An important remaining challenge is the prioritization of assessments (discussed further in Section 2.4). Figure 1.1 portrays the key policy and prioritization questions. Consensus on IAP priorities will be assisted through clear definition of the roles of the Program in coordinating with the various entities responsible for harvest, hatchery and Klamath River basin management; these roles must be defined in the context of existing Federal, State, Local, and Tribal government responsibilities (upper left box in Figure 1.1).

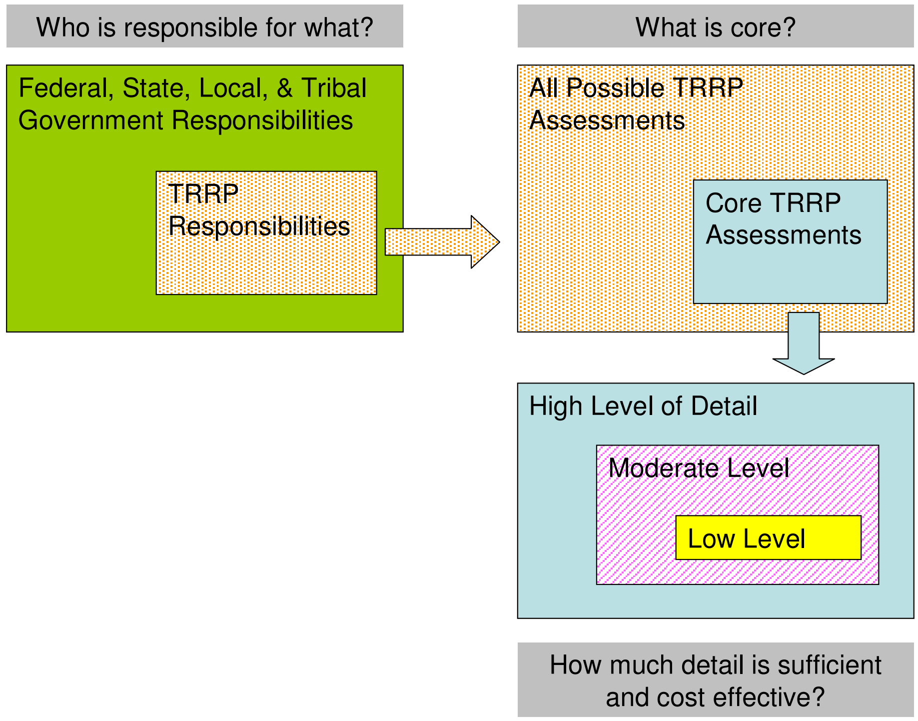

Figure 1.1. Key policy and prioritization questions.

Kin to these challenges is selecting, from a wide range of possible assessments, a set of prioritized **core** assessments that the Program will conduct to assess Program progress and to adaptively manage Program success (upper right box in Figure 1.1). The final challenge is determining what level of detail (and associated budget) is sufficient for each assessment, providing a prioritization scheme that serves the annual budget process reasonably and fairly. The IAP authors have made progress on all three challenges. Chapters 3 and 4 of this plan detail progress on the second challenge (i.e., developing a set of *potential* assessments and highlighting which ones are of highest priority). Section 2.4 provides a summary of our progress to date on prioritization of the potential assessments, and our intended continued work to converge on a set of feasible, cost-effective, **core** assessments over the next 1–2 years. Chapters 3 and 4 also begin to address the third challenge (How much detail is sufficient and cost-effective?), an issue to be further addressed through the development of RFPs, and detailed study plans for specific assessments.

1.2 Program goals and foundational documents

The purpose of the Trinity River Restoration Program is described in these foundational documents and statutes:

- the Trinity River Basin Fish and Wildlife Management Act (1984) and the 1996 amendment;
- Central Valley Project Improvement Act (1992);
- the Trinity River Flow Evaluation Final Report (USFWS and HVT 1999);
- the Trinity River Draft and Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR) (USFWS *et al.* 2000); and
- the Secretarial Record of Decision (ROD) (USDOI 2000).

Program goals derive from these documents as well as other legislative and administrative actions. The IAP Steering Committee, a subcommittee of the Trinity Management Council, drafted the following Program goal statement, which both the TMC and TAMWG considered to be acceptable for purposes of guiding IAP development (though still under review by the TMC as an official Program goal):

> *The goal of the Program is to restore and sustain natural production of anadromous fish populations downstream of Lewiston Dam to pre-dam levels, to facilitate dependent tribal, commercial, and sport fisheries' full participation in the benefits of restoration via enhanced harvest opportunities. The Program **strategy** for accomplishing this goal restores and perpetually maintains fish and wildlife resources (including threatened and endangered species) by restoring the processes that produce a healthy alluvial river ecosystem. The above restoration **strategy** will be achieved by implementing management actions in a science-based adaptive management program.*

The first sentence of the goal statement focuses on fish, and incorporates the language of fishery goals from such foundational documents as the Trinity River Basin Fish and Wildlife Management Act (1984) amended in 1996, Central Valley Project Improvement Act (1992), and the ROD.

The second sentence of the goal mentions both fish and wildlife, and very briefly describes the restoration strategy. Threatened and endangered species are mentioned to ensure compliance with the Endangered Species Act. The words on the restoration strategy (i.e., "restoring the processes that produce a healthy alluvial river ecosystem") are meant to concisely reflect the intent of the TRFE and ROD.

The third sentence of the goal statement reflects the commitment in the ROD, TRFE, and Implementation Plan to a science-based, adaptive environmental assessment and management program.

1.3 Program management actions

The strategy of Program actions for achieving Trinity River restoration is based on recommendations in the TRFE (USFWS and HVT 1999) (i.e., the Preferred Alternative) and on the best available scientific knowledge of alluvial river channels and riverine ecology. This strategy will restore the river ecosystem necessary for the recovery and maintenance of the fishery through managed flows combined with mechanical rehabilitation projects. Flow volumes and timing are designed to address both habitat and temperature needs for all riverine life stages of salmonids. Peak flows are designed to support the physical processes necessary to maintain habitat in an alluvial river. This strategy does not strive to recreate the pre-Trinity River Division (TRD) mainstem channel morphology, as several sediment and flow constraints imposed by the TRD cannot be overcome or completely mitigated. The new alluvial channel morphology will instead be smaller in scale, but it will exhibit almost all the dynamic characteristics of the 10 attributes of a healthy alluvial river presented in Chapter 4.8 of the TRFE (USFWS and HVT 1999), and considered necessary to restore and maintain fisheries resources. The Preferred Alternative also includes a watershed management plan, as well as measures to minimize and mitigate short term impacts.

The ROD (USDOI 2000) outlines the tasks and actions to be implemented to achieve the Program goals and objectives. The management actions specified in the ROD include:

1. flow management to drive fluvial processes that create and maintain suitable salmonid habitat (depth, velocity, cover, etc) and provide suitable thermal regimes;
2. mechanical rehabilitation of the channel;

3. watershed rehabilitation (road maintenance, rehabilitation, closure; Hamilton Ponds operation and maintenance) to control tributary fine sediment delivery;
4. coarse sediment augmentation; and
5. floodplain infrastructure improvements (including bridges) to allow for increased flow releases. A detailed understanding of Program actions is essential for developing the most reasonable and cost-effective assessments.

1.3.1 Summary of actions

There are three broad categories of management actions: 1) increased annual flow regimes and variable reservoir releases; 2) fine and coarse sediment management; and 3) mainstem channel reconstruction (channel rehabilitation sites). Each has unique objectives within the overall restoration strategy. All actions will be evaluated within an Adaptive Environmental Assessment and Management (AEAM) program, described in Section 1.4. The IAP describes what assessments are required to evaluate the response of key ecosystem components to Program actions, using contrasts over time (e.g., before/after comparisons) as well as contrasts over space (e.g., above, at and below rehabilitation sites) to assess the effects of management actions.

1.3.2 Flow management actions

Release patterns for each Trinity River water-year class were developed to address the needs of each of the life stages of the anadromous fish present in the Trinity River and reestablish the river's ability to move sediment and reshape itself (i.e., fluvial geomorphic processes). Annual flow releases vary for each water-year class (see Table 1.1) because different geomorphic processes and thermal regimes are addressed in different water-years, as was the case prior to dam construction. Under the terms of the ROD, flow releases depend entirely on the current water year. Multi-year water management and carryover storage (e.g., to mitigate the effects of a string of dry years) is not currently permitted.

Table 1.1. Annual volumes and peak releases – flow evaluation alternative.

Water-year class	Acre-feet	Peak flow (cfs)
Critically dry	369,000	1,500
Dry	453,000	4,500
Normal	636,000	6,000
Wet	701,000	8,500
Extremely wet	815,000	11,000

Four primary components were identified and are addressed by the release patterns:

1. **Summer/fall temperature control flows (July 1 through mid-October).** These were developed in response to summer and early fall conditions when warm water temperatures are a concern for holding and spawning spring Chinook salmon. Achieving mandated temperature criteria (Table 1.2) generally requires flows of 450 cfs for all water years. Dam releases are actively managed to meet adult temperature criteria at compliance points. This strategy would result in minimal variability in summer/fall thermal regimes for a given water year, but the actual thermal regime varies due to annual hydro-meteorological variability.
2. **Salmonid spawning/rearing flows (mid-October through late April/mid-May depending on water-year class).** These were developed to provide suitable spawning and rearing habitat for

Chinook salmon, coho salmon and steelhead in the pre-ROD channel condition. Flows of 300 cfs would be released during this period, since effective spawning has been observed at this flow level. Additionally, such flows would provide habitat, minimize the potential for dewatering of redds, and protect early life stages of salmonids.

3. **Fluvial geomorphic/salmonid smolt temperature control flows (late April/mid-May through June 30).** These were developed to provide fluvial geomorphic processes and suitable temperature and flow conditions for outmigrating salmonid smolts. Peak flows of 11,000 cfs would be released for 5 days beginning May 24 during extremely wet water years to assist in geomorphic processes such as mobilizing sediment, scouring the riverbed, reshaping the channel, and removing encroaching vegetation. The peak levels would vary for each water-year class, down to a minimum of 1,500 cfs in critically dry years. During such years, these flows would not be sufficient to recontour the channel, but would help prevent the germination of unwanted vegetation along the low flow channel. During Normal or wetter water years, released flows are intended to provide optimal temperatures for outmigrating salmonids, while during Dry and Critically Dry water years, released flows would provide marginal temperatures. Flow schedules that are expected to meet the objectives are set in April.
4. **Ramping rates (all times of year).** This is the rate at which flow releases are either increased (ramped up) or decreased (ramped down). The ramping rates were developed to mimic natural ramping rates for the Trinity River.

Table 1.2. North Coast Water Quality Control Board (NCRWQCB) temperature criteria.

Time period	Location	Criteria
July 1-Sept 14	Douglas City	< 60º F
Sept. 15 - 30	Douglas City	< 56º F
Oct. 1 – Dec. 31	N. Fork confluence	< 56º F

The timing of diversions through the Clear Creek Tunnel would be shifted from spring/summer to the summer and early fall periods to maintain suitable release temperatures for the in-river fishery resources. Summer/fall is a critical period for holding/spawning spring Chinook salmon, migrating/spawning fall Chinook salmon, and holding summer steelhead. Shifting exports to the summer/early fall maintains coldwater reserves in Trinity Reservoir for use in the Trinity River, versus exporting this water earlier to assist coldwater releases to the Sacramento River. Additionally, exporting water through the Clear Creek Tunnel during summer/early fall results in water moving quickly through Lewiston Reservoir, thereby not allowing the water (which is eventually released from Lewiston Dam) to warm. The Preferred Alternative assumes that Trinity Reservoir would be operated to maintain a minimum carryover storage of 600,000 af between water years. The increased carryover provides cooler water for dam releases for the benefit of the in-river fishery resources.

No single baseflow can provide all habitat for all salmonid life stages, and no single high flow can create and maintain a dynamic alluvial channel morphology. Therefore, annual reservoir releases are varied (magnitude, duration, frequency and timing) and scheduled by water supply conditions and Trinity River basin runoff projections. High runoff years serve geomorphic and ecological functions differently than do low runoff years. This flow variation is intended to reestablish river system integrity by: 1) mimicking the natural snowmelt hydrograph (including both the snowmelt peak and recession components); 2) rejuvenating and maintaining alluvial processes; 3) increasing the availability of suitable microhabitats (depth and velocities) required by salmonid life stages for holding, spawning and rearing in the mainstem channel; and 4) providing suitable seasonal water temperatures (in the mainstem below Lewiston Dam for holding and spawning anadromous salmonids down to the North Fork Trinity River confluence, for smolt outmigrants of all three salmonid species to Weitchpec, and for year-round rearing of juvenile steelhead and coho salmon).

1.3.3 Sediment management actions

It may require a long time for the watershed to recover from over 150 years of disturbances, which includes logging, agriculture, land and road development, and construction and operation of the Trinity River Division (TRD) of the Central Valley Project. Preventing excess fine sediment from entering the mainstem remains a priority. The Secretary of the Interior[1] assumed that the following programs and ordinances, relating to overall watershed protection in the Trinity River basin, would continue:

- Watershed protection under the jurisdiction of U.S. Forest Service (USFS) and Bureau of Land Management (BLM) would continue, including implementation of existing land management plans and the ROD on the President's Northwest Forest Plan (USDA and USDOI 1994).
- Trinity County's Decomposed Granite Grading Ordinance (No. 379) would be enforced for lands and projects under its jurisdiction.
- California Forest Practice Rules that regulate activities on private lands within the Trinity River basin, which require erosion control measures that in turn minimize sediment inputs into the river, would be enforced by California Department of Forestry and Fire Protection.
- Implementation of the South Fork Trinity River Action Plan would continue. The Plan includes: watershed rehabilitation to reduce sediment sources, upgrading inefficient irrigation systems and dedicating the saved water to instream fishery flows, cattle exclusion fencing to decrease sediment inputs and improve water quality, and riparian plantings to help decrease water temperatures and conserve streambanks.
- BLM would continue to acquire sensitive lands in the Grass Valley Creek watershed and along the Trinity River mainstem corridor.

Specific Program management actions include measures to limit fine sediment inputs into the mainstem Trinity River, including accelerated road decommissioning, road maintenance, and road rehabilitation on public and private lands. These additional measures would essentially represent a modification of part of a 1993 proposal by the Committee for Healthy Communities in Healthy Forests, as endorsed by the Trinity BioRegional Group and Trinity County for implementation of the President's Forest Plan. Full-scale implementation of the watershed protection Program would result in a reduction of 240,000–480,000 yd^3/yr of sediment, which is approximately 9–17% of the average annual sediment produced in the Trinity River basin.

Coarse bed material supplementation upstream from Rush Creek is required to rehabilitate a dynamic alluvial channel morphology. The annual volume of supplementation will be a function of peak releases, with wetter water years requiring greater supplementation. To rehabilitate mainstem channel morphology above Rush Creek, coarse bed material supplementation must exceed mainstem transport capacity. Long term gravel augmentation to balance sediment transport from ROD releases will be required near Lewiston Dam in perpetuity.

[1] Draft EIS, pg. 2-7 (USFWS *et al.* 2000)

1.3.4 Channel rehabilitation actions

Mainstem channel rehabilitation will be required in selected reaches to encourage alluvial processes, such as frequent channel bed mobilization and alternate bar formation. The degree of morphological adjustment will depend on channel location. The mainstem from Lewiston Dam to the North Fork Trinity River confluence was divided into four reaches based on present-day alluvial characteristics and future alluvial potential. The two mainstem reaches downstream from the Indian Creek confluence will have greater opportunities for alluvial recovery, as tributaries contribute more flow and coarse sediment. All reaches will require selective removal of the riparian berm down to the original pre-TRD channel bed surface. Closer to Lewiston Dam, channel modification will require selective riparian berm removal and construction of skeletal alternate bars, the latter to encourage rapid deposition and channel readjustment given the limited coarse sediment supply and constraints on maximum peak flows. These projects will include construction of functional floodplain surfaces to encourage natural riparian regeneration. Once mechanical changes are completed, high flows and gravel transport would naturally create and maintain dynamic alluvial features and floodplain riparian communities. Consequently, no mechanical maintenance would be planned for the proposed or existing channel rehabilitation projects.

Channel rehabilitation projects include a combination of selected vegetation removal and earthworks (e.g., floodplain lowering, side channel construction, berm removal, point bar creation). Following these actions, the Program will plant riparian vegetation to meet environmental permitting requirements, enhance wildlife habitat, and provide a future supply of large woody debris for potential fish habitat. Gravel augmentation will be conducted above Indian Creek, both as part of channel rehabilitation projects and as stand alone implementations.

Channel rehabilitation projects are designed to maximize geomorphic response to ROD high flow releases which allow the river to develop the desired channel complexity and associated habitat features over time. Channel complexity is expected to increase system wide (between Lewiston Dam and the North Fork Trinity River), both at project sites and on the river reaches between them. Rehabilitation project designs are tailored to the geomorphology specific to each site. Designs seek to avoid impacts to areas with existing high habitat value and, whenever possible, include features that benefit short term habitat development (e.g., leaving selected vegetation patches, utilizing large trees to be removed by placing them on-site as large woody debris).

A standard approach for project monitoring uses an implementation, effectiveness, and validation scheme, and has been well documented in the literature (Beamer *et al.* 1998; Reeves *et al.* 2002; Collins 2003; Derr *et al.* 2005; Roni *et al.* 2005). Site, reach, and system wide assessments will follow this approach to both document baseline conditions and test channel rehabilitation project design hypotheses:

- Pre-construction geomorphic and habitat conditions will be documented as part of system-wide *baseline* monitoring efforts currently underway. Some additional site specific documentation may also be required.
- Channel rehabilitation design documents will explain the *design hypothesis* (i.e., the geomorphic, habitat, and if possible, the biological response expected for each major design feature).
- *Implementation* monitoring will be conducted to document the as-built site conditions and verify that projects are constructed as planned (site scale).
- *Effectiveness* monitoring will periodically assess whether actions have the predicted effects on physical processes; i.e., whether the anticipated channel complexity and habitat are developing as predicted in the design hypothesis (site, reach, and system scale).
- *Validation* monitoring will assess the biological response as site conditions evolve (system, reach, and site scale).

The baseline, implementation, effectiveness, and validation monitoring scheme does not include a formal, controlled experimental study design for all rehabilitation sites in the Program area. Rather, process based assessments will be conducted as needed to understand specific fluvial and/or riparian interactions, and to guide management actions.

Channel rehabilitation projects are generally located within the boundaries described by the EIS (USFWS *et al.* 2000) for the proposed 47 channel rehabilitation sites. Channel rehabilitation construction sites will generally be sequenced following a top down approach starting from Lewiston Dam. A top down approach targets the areas near Lewiston Dam first to provide needed rearing habitat in the area with the highest spawning density. The top down approach then tries to spread out fish production by expanding suitable spawning and rearing habitat areas downstream. There are two exceptions to the top down approach: 1) projects that benefit infrastructure protection as required by the ROD for flow releases above 6,000 cfs; and 2) projects located between Canyon Creek and the North Fork Trinity River. The decision to construct the first rehabilitation projects (2005–2006) downstream of Canyon Creek was driven by pending litigation (settled in 2004) over implementation of the ROD flow releases. The rationale was that sites constructed downstream of Canyon Creek would have the highest probability of success if full ROD flow releases were postponed by the litigation.

Channel rehabilitation projects are being constructed as quickly as Program funding levels allow. Channel rehabilitation project construction started in 2005. Under current funding levels, the full 47 sites are expected to be completed as early as 2013. The large map in Appendix N at the back of this document shows the spatial distribution and timing of channel rehabilitation projects. The timing of construction implementation places a high priority on gaining design insights from existing rehabilitation projects in the near term, so as to improve the design of the rehabilitation projects which remain to be constructed. Learning may result (for example) in changes in near-term earthworks construction, periodic tweaking of side channel entrances, and other adjustments. While the Rehabilitation Implementation Group (RIG) is focused on compliance issues at these projects (e.g. documenting assumptions, confirming that the projects were built as designed), the IAP assessments are concerned about performance and effectiveness of these projects for fish and wildlife populations. Changes to existing projects are most easily made if they are completed within the 5-year permitting window.

Impact assessment of management actions

The National Environmental Protection Act (NEPA) and the California Environmental Quality Act (CEQA) both require that projects analyze their potential impacts on the environment. Mitigation measures have been outlined which seek to eliminate direct and indirect impacts (short-term) from project implementation. These measures are then included via construction contract specifications, Program staff, or via a sub-contractor or cooperator that carries out and reports on the mitigation measures. NEPA/CEQA mitigation measures are generally required by permitting agencies before they will issue project permits. Required permits and approvals are listed in Appendix A.

1.3.5 Annual decisions on management actions

Writers of the IAP believe that all of the Program management actions are important in combination, and that it is undesirable to prioritize actions relative to each other. While it might appear easy to prioritize water temperature over increasing habitat for example, our current strategy dictates that both are necessary for long term sustainability of the fish population in the Trinity River. However, priorities could change from year to year (e.g., geomorphic processes are more feasibly stimulated in wetter years). When considering modifications to annual management actions, the general principle to be followed is that it’s appropriate to alter the flow schedule to test action effectiveness hypotheses as long these changes: 1) don't disrupt another high priority single-year or multi-year hypothesis test, or 2) cause an unacceptable level of risk to Valued Ecosystem Components. Within any given year, the relative importance of different Program actions should be determined by:

1. what is required to meet overall Program goals; or
2. what is required to assess the effectiveness of, or fine tune, specific Program actions.

Examples of annual management actions include:

1. flow/temperature management (create optimal temperature conditions);
2. channel rehabilitation (induce fluvial processes);
3. gravel augmentation (induce fluvial processes);
4. sediment/watershed management (limit fine sediment production processes, transport tributary sediments, increase bed mobility); and
5. management of vegetation encroachment and establishment (allow vegetation that does not simplify channel).

Annual AEAM decisions are discussed in more detail in Section 1.4.2.

1.3.6 Other management actions

Harvest

Fishing[2] would continue under current harvest plans. At this time, only fall Chinook salmon have an integrated harvest management plan, with the Trinity River stock as part of the Klamath River basin management unit. The harvest of other Trinity River anadromous fishes is managed by several entities including tribal, state and federal authorities.

Hatchery

The Trinity River Hatchery (TRH) would continue to produce fish at current levels (Table 1.3). The Program manages neither the TRH nor the fisheries which depend on their output. However, the Program *will* assess the impacts of hatchery fish on natural production, and if required provide management recommendations to the appropriate management agencies.

Table 1.3. Trinity River salmon and steelhead hatchery production.

Species	Egg take	Smolt release	Yearling releases
Spring Chinook salmon	3,000,000	1,000,000	400,000
Fall Chinook salmon	6,000,000	2,000,000	900,000
Coho salmon	1,200,000	n/a	500,000
Steelhead	2,000,000	n/a	800,000

[2] Draft EIS, pg. 2-8 (USFWS and HVT 2000)

1.4 Adaptive Environmental Assessment and Management (AEAM)

The ROD (USDOI 2000) directed the Program to organize around the principles of Adaptive Environmental Assessment and Management (AEAM), and to use such an organization to rigorously assess the river's response to management actions, reduce critical uncertainties, and improve resource management. AEAM is a process that emphasizes iterative learning from carefully designed and monitored management actions. Figure 1.2 represents AEAM as a 6-step feedback loop. There are at least three significantly different time scales and functions of AEAM in the Program:

1. feedback to affect the design and implementation of annual flow scheduling and sediment management actions (e.g., changing the duration of peak flows during a given water year to improve bed mobility and the scour of riparian vegetation on newly formed gravel bars);
2. feedback during the 2009-2013 period to improve the design of the final phase of channel rehabilitation projects (based on evaluations of previously constructed channel rehab projects); and
3. longer term feedback, on the scale of decades, regarding the overall effectiveness of the Program in meeting its overall goals and hierarchy of objectives (overall test of the restoration strategy).

There is more work required over the next 1-2 years to determine which assessments truly have the attributes required to generate reliable feedback to adjust management actions, and become core AEAM assessments.[3] Feedback on annual flow / sediment management decisions and channel rehab site designs (#1 and 2 above) will be *primarily* based on selected feasible assessments of physical, riparian and habitat conditions (i.e., insights on what affects the rate of creation of suitable habitat, indices of the amount of suitable habitat at different places or times). It is possible that some fish and wildlife population assessments could provide useful feedback on some attributes of annual management decisions, if there is sufficiently strong evidence (e.g., if frog eggs are being scoured away by peak flows, and/or juvenile salmonids are emigrating prematurely at small sizes from these flows, it might make sense to re-examine peak flow timing). However, given the uncertainty in estimating fish and wildlife production and abundance, and the multiple factors influencing populations, it will be very difficult (if not impossible) to use fish and wildlife *population* assessments to fine tune annual management actions. Rather, assessments of fish and wildlife populations will primarily serve to provide reliable longer term trend data as feedback on the overall effectiveness of the Program over the next two decades (#3 above). Fish habitat assessments will also assist with function #3, and hence contribute to all three time scales.

As implied by the conceptual model (Figure 1.3) and discussed further in Chapter 3 subsections on "expected response", the response times to management actions vary across different system components, which in turn affects what rates of AEAM feedback are possible. It is very difficult to predict how quickly different ecosystem components might respond. In general, we expect flow and sediment augmentation actions to initiate changes in physical processes almost immediately (e.g., sediment transport, temperature, coarse sediment storage), which over a decade or so of implementation should gradually increase the area of suitable habitat for fish and wildlife. However, rates of change in the area of suitable habitat will greatly depend on the proportion of wetter water years in future years (faster rates of increase with more wet water years). Mechanical work at channel rehab sites immediately creates appropriate depths and velocities for juvenile fish at the channel rehabilitation sites, but could require another decade after construction for various geomorphic and vegetation processes to fulfill the site's habitat potential

3 These required attributes are described in detail in Section 2.4.2 (see notes on Box 2A of the decision tree in Table 2.3). Briefly, the attributes are: specific objectives and performance measures, a reliable model linking management actions to outcomes, an if-then decision rule that can be reliably evaluated, the ability to aggregate observations to reach or system-wide scales, and a substantial risk to the Program Goal if actions are not revised when the objectives are not achieved.

(e.g., bank erosion, coarse sediment transport into the site from upstream, establishment of vegetative cover in upper floodplain zones).

Given these time lags in the creation of juvenile fish habitat, juvenile fish production responses to the *area* of suitable habitat might only be expected to occur after 10–15 years of Program actions. Juvenile fish production responses to improved temperatures (e.g., improved growth and survival rates) could however occur much more quickly (i.e., within a few years), since temperature regimes respond immediately to changes in flow. Because of both these time lags and year to year variability, it might therefore require two decades of monitoring to convincingly demonstrate the magnitude of the change in juvenile production.

It is very difficult to predict how long it will take before we will observe changes in spawning escapements. Logically, spawning escapements would be expected to increase only after there are significant increases in juvenile fish production which, based on the lags in habitat creation, may take at least one to two decades. However, increases in the size of emigrating pre-smolts could cause improved smolt to adult survival and increased escapements even prior to numerical increases in juvenile production, and some restoration programs have shown rapid increases in fall Chinook salmon escapements[4]. The ability to detect significant changes in escapement is driven by both natural variation (process error) and the precision of monitoring methods (measurement error). Measurement error in estimating escapement is less than the measurement error in estimating juvenile fish production. However, natural variation in escapement is usually much greater than natural variation in juvenile production (Bradford *et al.* 2005). For example, changes in ocean conditions can cause a 10-20 fold change in smolt to adult survival rates. To understand what is driving changes in escapement, various factors need to be documented, including changes in habitat, hatchery operations, Klamath estuary conditions, ocean conditions, harvest rates, and straying from other stocks in the region. The rates of response of wildlife populations will vary across different species depending on their life history characteristics, and the rate of change in the most critical habitat features affecting their growth and survival (see "Expected Response" parts of Section 3.6).

Hypothesize and predict

The TRFE (USFWS and HVT 1999) and Conceptual Model document (TRRP 2005) described the overall hypotheses of the Program. The IAP consolidates these overall hypotheses as a hierarchy of connected objectives (Figure 2.1), sub-objectives (Table 2.1), and general hypotheses for each subsystem (Chapter 3). Detailed study plans for specific assessments (in response to RFPs) will present more specific testable hypotheses and associated analytical methods.

Design

The design step of Figure 1.2 was first conceptualized at a strategic level in the TRFE, and then expanded in more detailed management plans (e.g., rehabilitation project designs, flow schedules, coarse sediment management plan). The IAP represents a foundation for the design of assessments (Chapter 3) as well as an integrated sampling design (Chapter 4).

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[4] In the Clear Creek restoration program, the escapement of fall chinook increased quickly after the initiation of new flows, and was five times higher in the post restoration period (1995-2004), as compared to the period before restoration began (1967-1991) (Brown and DeStaso 2005).

Implement

The Program consists of two components—implementation and assessment—both directed under authority of the TMC. The Rehabilitation and Implementation Group (RIG) implements the prescribed management actions. The Technical Modeling and Analysis Group (TMAG), in cooperation with Program partners, executes the science and assessment portions of the Program, which provides insights for iterative revision of management actions (see top of Figure 1.5).

Monitor

Assessments should include *implementation monitoring* to confirm what actions were done when and where, and *effectiveness monitoring* to check whether the expected physical and biological responses occurred. In some (but not all) assessments, *validation monitoring* is required to determine cause-effect relationships in more detail, so as to iteratively improve management actions (Beamer *et al.* 1998). The spatial / temporal scale and form of monitoring is determined by the data requirements of particular assessments, which vary widely (e.g., assessing the effectiveness of a channel rehabilitation site vs. assessing system-wide changes in habitat and fish production). The potential types of assessments and the monitoring they require to provide needed data are described in Chapter 3.

All Program monitoring data will be stored in an Integrated Information Management System (IIMS). The IIMS is structured in a manner that supports both local control and interagency collaboration. Entities which collect and store particular data continue to maintain their local databases (e.g., USGS maintains flow databases; USFWS maintains databases of emigrant trapping data). The Trinity IIMS then periodically extracts key performance measures and metadata from these local databases and stores this information in a central database (the IIMS) with internally consistent descriptors of the locations and times at which data were collected, as well as required metadata so that efforts to combine data for analysis, modeling and assessments are legitimate. This structure facilitates inter-disciplinary analysis and synthesis (e.g., can quickly generate reports on sediment transport vs. flow, or fry and presmolt emigration vs. flow), while ensuring local control over data collection, storage and revision.

Assess

Chapters 3 and 4 of the IAP describe the Assessment step in Figure 1.2. These assessments include establishing targets and baselines, predicting the outcome of proposed management actions, and measuring changes in performance measures over time. Chapter 3 describes the proposed assessment strategy and its rationale (i.e., *what* will be assessed and *why*). Sub-sections of Chapter 3 also describe proposed performance measures, the integration of these performance measures with those from other disciplines, the expected response, analytical approach, and proposed space and time frames. Chapter 4 presents the Program's integrated sampling design strategy (i.e., *where* and *when* sampling should occur to support interdisciplinary assessments at multiple scales). The intended monitoring protocols (i.e., *how* data will be collected at specified places and times) will be described in detailed study plans that respond to developed RFPs.

The SAB has emphasized the importance of prompt data analysis and reporting. Annual reports (some much more detailed than others) will be provided on all assessments. Particularly important are reports on selected physical, riparian and habitat responses to the previous year's management actions (for core AEAM assessments that feed back to annual flow and sediment management actions). As data accumulate over several years, detailed reports will describe the status and trend of valued ecosystem components relative to Program goals and objectives. The latter would include a thorough description of the objectives of the previous year's flows and sediment actions, and an evaluation of whether or not those objectives were achieved. These annual reports will be presented at biannual Trinity River Science Symposia, as well as at smaller meetings held in the non-Symposia years, and focused on communicating what we have learned about key hypotheses and questions. This is important both for AEAM at various time scales, as well as simply to monitor what resulted from Program investments of resources in science. Involving outside scientists at these meetings can help to challenge conclusions, suggest novel analyses and field work to resolve critical uncertainties, and invigorate the science program with fresh ideas. Involvement of outside scientists could extend beyond these meetings.[5]

Adapt

Although not yet complete, all assessments will ultimately need to jointly specify the triggers for changing management actions (i.e., if-then rules). What actions can be adapted under each of the three time scales described at the start of this section? At the first time scale (annual management decisions), there is some flexibility in flow and sediment actions (e.g., how the overall volume of flow is distributed over the year, what peak flows and durations are applied, how much and where coarse sediment is added, the grain size distribution of the added sediment). As described in Section 1.4.2, revision of annual management actions requires an analysis of tradeoffs across multiple objectives. Program scientists will continue to make the sub-objectives for each component more specific (e.g., specifying an expected magnitude of quantitative change in key performance measures, and the time expected for the change to occur). Specifying sub-objectives in greater detail will make it easier to determine the degree to which they have been achieved, and therefore how much adaptation is (or isn't) required.

At the second time scale (2009–2013), there is some flexibility to change the designs of channel rehab sites, and further adjustments can be made to these sites during the five year construction permit period. Even beyond the 5-year construction period, it is possible to do further mechanical work at the channel rehab sites if evidence shows that this is necessary.

At the third time scale (testing the effectiveness of the overall restoration strategy), we need to wait at least two decades to see how things turn out, notwithstanding that there may be some fine tuning of actions along the way. After two decades, if there is evidence that improved habitat has not resulted in improved fish production, and evidence that other factors are preventing recovery of fish populations, it will be necessary to explore how to adapt the factors that are preventing recovery (e.g., changing hatchery operations to reduce effects on natural spawners, reducing watershed generation of fine sediment, improving Klamath estuary conditions, changing harvest rates). The testing of the overall restoration program hypothesis (and alternative hypotheses) is described in more detail below in Section 1.4.1.

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[5] The SAB has recommended using IPAs (Intergovernmental Personnel Actions) as an inexpensive way to enrich the set of skills and experience engaged in the Program.

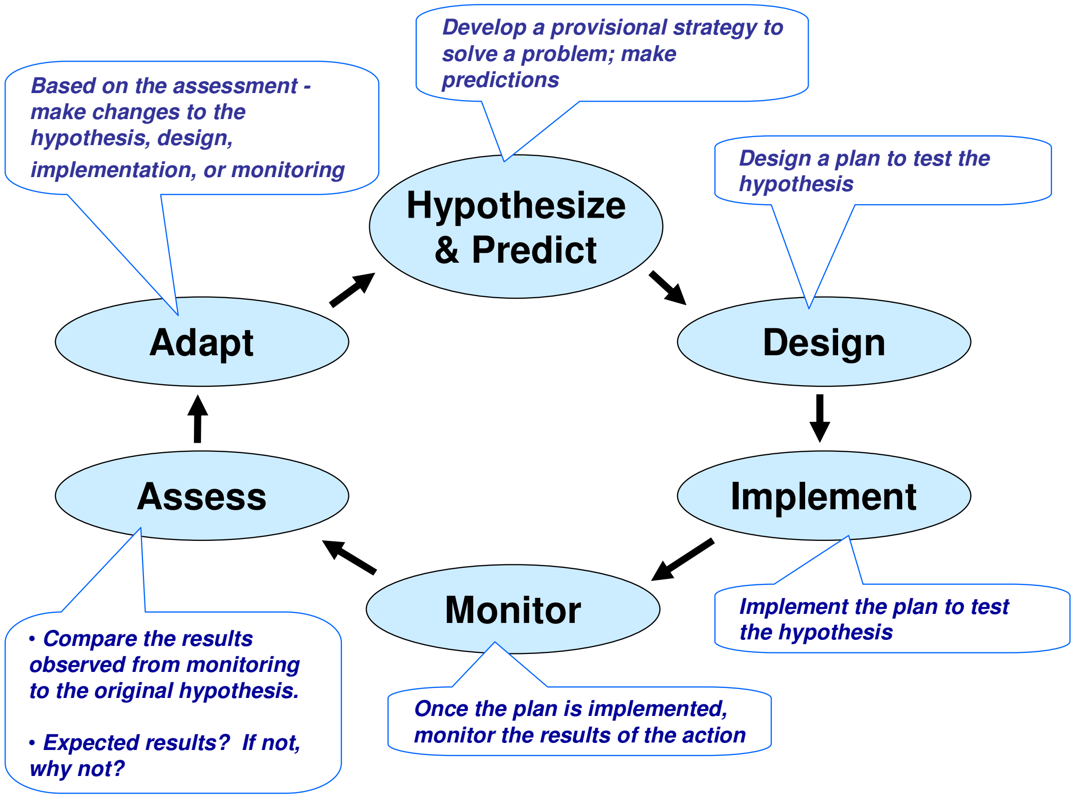


Figure 1.2. The process of Adaptive Environmental Assessment and Management (AEAM). Adapted from the TRFE (USFWS and HVT 1999) and Murray and Marmorek (2003).

1.4.1 Reporting on progress towards program goals and testing program hypotheses

Progress toward habitat and fish production objectives can be quantitatively assessed and reported annually to stakeholders. Example questions of interest to stakeholders might include:

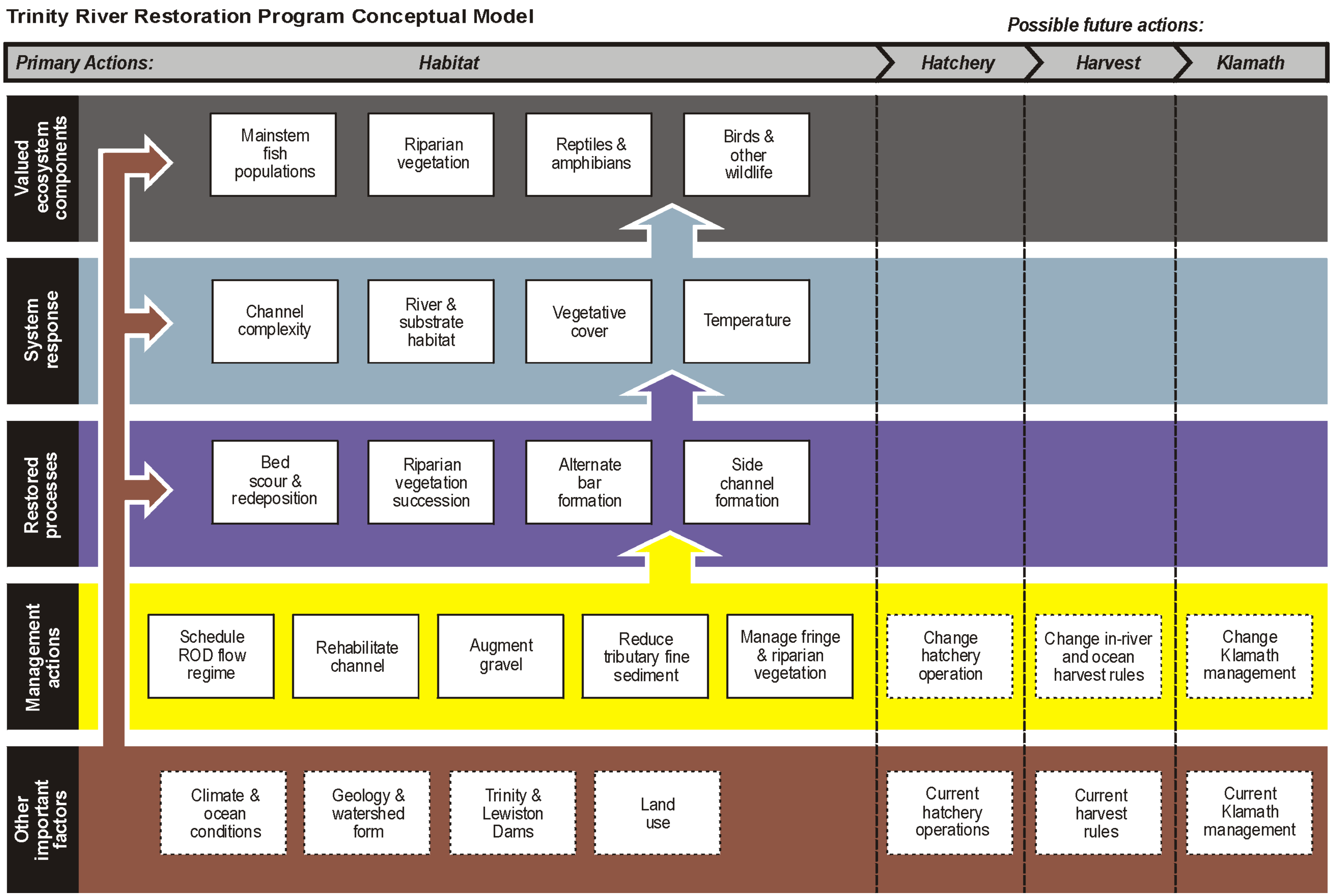
1. Are salmonid population numbers (quantify as population estimates not just abundance indices) improving?
2. Is anadromous salmonid habitat improving?
3. Are dependent tribal, sport and commercial fisheries fully participating in the benefits of restored Trinity River fisheries?
4. Are native riparian communities establishing on different geomorphic surfaces? Are reservoir releases removing germinated vegetation?
5. Are the riparian berms continuing to build, are they remaining stable, or are they beginning to break down from Lewiston Dam to the North Fork Trinity River confluence?
6. Are channel reaches migrating laterally and becoming more dynamic?
7. Are floodplains forming?

8. Are alternate bars forming?
9. How does Trinity River water affect water quality of the Klamath River? There is evidence that water quality conditions in the Klamath River may be, at times, substantially worse than those in the Trinity River. Will Klamath River water quality during spring outmigration affect smolt survival, especially in dry years? What about other life stages?

Answers to these questions will provide a sense for the status and trend of valued components of the Trinity River ecosystem. More formally though, the Program is testing specific hypotheses related to the ability of the Program to create habitat, and the benefits of that habitat for fish populations. As scientists, we need to formally articulate those hypotheses that we are testing now, and those that we may choose to test later if necessary.

The overall conceptual model for the Trinity River system is shown in Figure 1.3. This conceptual model indicates that if the Program management actions shown (row 4 of the figure) are implemented, then various fluvial geomorphological processes will occur in addition to providing habitat (including suitable thermal regimes). These processes will in turn stimulate system responses that create certain types of habitats. If these habitats are created, then various valued ecosystem components will benefit. Valued fish, wildlife and vegetation (top row of Figure 1.3) relate most clearly to the Program Goal described in Section 1.2. Therefore, assessments to track progress towards Program objectives will need to monitor valued ecosystem components. To determine if the implemented management actions are working as intended requires monitoring the processes that are directly affected by actions (row 3 of Figure 1.3) and the system responses that support valued ecosystem components (row 2 of Figure 1.3).

The bottom row (row 5) of Figure 1.3 shows factors currently outside Program control, but with potentially significant effects on the rate of recovery of fish populations and other ecosystem components: climate and ocean conditions, the geology and watershed form, existing dams, land use changes, hatchery operations, harvest rules and Klamath River conditions. In Table 1.4, the first column describes hypothetical mechanisms by which some of these factors could limit recovery of Trinity River fish populations. These mechanisms could all be operating concurrently to have a cumulative effect, making it difficult to tease apart their relative importance. For example, hatchery releases (H1), current harvest rates (H4), and poor ocean survival (H5) could be exacerbating the effects of insufficient rearing habitat (H0) for juvenile salmonids.



5 **Figure 1.3.** Conceptual model of overall system, showing the cause-effect chain from TRRP management actions to Valued Ecosystem Components. Management actions in the row second from the bottom (to the left of the dashed line) are within the mandate of the Program; actions to the right of the dashed line may be implemented in the future (see Table 1.4). Factors in the bottom row affect various processes and system responses, but are not within the control of the Program, and may confound some of the assessments of TRRP management action effectiveness.

Table 1.4. Primary (H0) and alternative hypotheses (H1-H5) describing how different factors could be affecting Trinity River fish populations. These mechanisms may operate cumulatively.

Hypothesis	*Possible* AEAM approach to test hypothesis	Proposed IAP approach to testing hypothesis
H0. The quantity and quality of freshwater habitat for fry rearing as well as juvenile or adult life stages limits the recovery of salmon and steelhead populations.	Implement Program actions (TRFE & ROD) to reestablish the fluvial processes that create and maintain habitat (flow, mechanical channel rehabilitation, gravel addition, fine sediment reduction, flows to provide suitable habitat and thermal regimes, reduction of watershed fine sediment production).	Implement Program actions (Section 1.3). Conduct IAP assessments to assess action effectiveness, revise actions if necessary, and evaluate progress toward Program goals (described throughout Chapter 3).
H1. Current levels of hatchery releases of Chinook salmon, steelhead and coho salmon smolts reduce natural production through competition, and reduction of genetic diversity.	Implement a deliberate change in annual hatchery releases (in a time pattern different from H4 manipulations), and assess the response in natural production (e.g., natural smolts/spawner and genetic diversity).	Do not recommend active AEAM approach until H0 test is convincingly completed, or substantial evidence suggests a change in operations may be required. Use various performance measures to indirectly assess the effects of hatcheries on natural production. If problems are detected, recommend changes to hatchery operations. See Section 3.3.3.
H2. Current land use patterns in the Trinity River watershed are contributing sufficient fine sediments to significantly reduce egg to fry survival and overwinter survival of coho salmon salmon and steelhead.	Implement a deliberate increase in watershed rehabilitation actions (with both spatial and temporal contrasts), and assess changes in fine sediment contributions from tributaries, and fine sediment concentrations within spawning area gravels.	Implement watershed protection actions described in EIS (Section 1.3.6). Periodically monitor fine sediment contributions from tributaries, and concentrations within spawning area gravels. If problems are detected, recommend further watershed rehabilitation actions. See Section 3.1.4.
H3. Current conditions in the lower Klamath River below Weitchpec (high temperature, disease rates) have a negative effect on both emigrating smolt and returning spawner survival rates.	Implement a deliberate change in Klamath River management to reduce temperature and disease problems, and assess changes in smolt and adult survival through the estuary.	Monitor smolt and adult survival through the lower Klamath River and disease assessments. If problems are detected, recommend management changes to Klamath River management agencies. See Section 3.3.2.
H4. Current harvest rates on Trinity River naturally produced salmonids are limiting the rate of recovery of natural spawning populations.	Implement a deliberate change in annual harvest rates (in a time pattern different from H1 manipulations), and assess various responses in naturally spawning fish populations (e.g., is recovery limited by spawning escapement?).	Do not recommend active AEAM approach until H0 test is convincingly completed. Estimate harvest and escapement to assess progress towards goals of harvest and increasing proportion of natural spawners See Section 3.4.
H5. Ocean conditions and climate fluctuations are limiting the rate of recovery of natural spawning populations.	No AEAM approach is possible.	Use various indices or covariates to account for these factors in analyses of year to year fluctuations in natural production, including trends in other nearby stocks. See Section 3.4.

How can we understand the relative magnitude and importance of each factor's effects on fish survival rates, both over the entire life cycle, and at various life history stages? Direct manipulation of management actions to create contrasts in both time and space (i.e., an AEAM approach) is the best way to evaluate the effects of management actions (Walters 1986; Hilborn and Walters 1992, 2001). While ocean conditions and climate are not under human control (other than the very long term effects of humanity on global climate), the other factors *could*, at least in theory, be manipulated deliberately in an AEAM approach with short-term responses to actions.

The second column of Table 1.4 outlines, in a very general manner, the kind of AEAM approaches which *could* (at least in theory) be performed to elucidate the importance of each factor. Implementation of the ROD, as described in Section 1.3, and the assessments described in Chapter 3 of this document, will provide a direct test of the habitat hypothesis (H0), believed to be the most significant factor preventing recovery of fish populations. If Program actions and assessments provide compelling evidence against H0 (i.e., increasing habitat does not improve juvenile fish production), then we will need to consider AEAM approaches to hypotheses H1, H2, H3 and/or H4 (second column of Table 1.4). The sequence of testing hypotheses H1 to H4 will depend on evidence acquired in assessments, while recognizing the desire to maintain and increase fish harvest (i.e., avoid the changes implied under H4 as long as possible). While we are testing the primary hypothesis H0, we can however still use indirect approaches (i.e., without manipulation of actions) to examine the other hypotheses (third column of Table 1.4). While such indirect approaches are a less powerful way of getting evidence than are deliberate AEAM experiments, they are the only practical approach at this time. Should this indirect evidence suggest that mechanisms other than habitat limitation (H0) are very important, then the Program will recommend to other management entities a re-examination of current management and possible AEAM approaches to evaluate alternative management (e.g., different hatchery practices, watershed rehabilitation actions or harvest rates in the Trinity and/or Klamath River basins). These alternative AEAM experiments are illustrated on the right side of Figure 1.3.

As described above at the start of Section 1.4, it will likely take two decades to adequately test H0, given the lags in habitat creation, responses in juvenile fish production, and responses in adult fish populations. H0 is the primary hypothesis the Program must test, and consequently the intention is to keep other factors (harvest and hatcheries) within their historical range of variation. Variation in other factors (e.g., Klamath estuary, ocean conditions) are outside the control of the Program but could significantly affect the rate of recovery of fish populations.

1.4.2 Annual AEAM decisions

Annual AEAM decisions have already been discussed in the introduction to Section 1.4, in terms of what forms of feedback are likely to be most relevant, and what decisions might change. This section discusses the process of making annual decisions.

Once the water year has been decided, there is a need to decide whether to simply implement the actions specified in the TRFE, or to modify them, either for the purpose of testing certain hypotheses, or because evidence suggests that revisions to the TRFE actions are required to meet Program objectives. These decisions involve two scales. First, specific **core** assessments will be performed to determine the status and trend of *individual components* (e.g., geomorphic, riparian, fish habitat), or *groups of components* that are closely intertwined (e.g., geomorphic and riparian; riparian and fish habitat). Second, inter-disciplinary evaluations must be made ***across*** *these components*, considering tradeoffs across multiple objectives and between short-term and long-term hypothesis tests. Figures 1.4a and 1.4b suggest a possible protocol for performing this synthesis. As described in Section 2.4, more work is required over the next one to two years to refine the set of necessary and feasible core AEAM assessments which fulfill various attributes.

Figure 1.4a begins with an evidence-based evaluation of whether the previously established management objectives and targets for each component (e.g. those in the TRFE and IAP) are still appropriate. As described at the start of Section 1.4, annual evaluations will rely *primarily* on physical, riparian and habitat assessments, though fish and wildlife assessments might provide some guidance (e.g., on the timing of flows). If the evidence clearly indicates that previously established objectives for physical, riparian or habitat components need to be revised, they are adjusted accordingly. Then assessments are used to evaluate whether each component is moving satisfactorily towards the defined (and possibly revised) objectives, and if not, whether existing evidence is strong enough to suggest that changes in actions are warranted for this component (lower left box of Figure 1.4a). Uncertain answers to these questions require either more time to assess responses, small scale management experiments (or spatial / temporal contrasts), or improvements to the assessments used to address these questions.

Figure 1.4b deals with the many cross-component issues that need to be considered prior to making changes to management actions. For example, reshaping the hydrograph to benefit one component could have negative consequences for one or more other components in a particular water year, or possibly undermine some longer term hypothesis test. In performing their inter-disciplinary analysis of tradeoffs, the scientists and managers involved in annual decisions need to consider at least five different questions, as illustrated in Figure 1.4b. This includes a consideration of whether the proposed actions are consistent with the overall Program strategy and the overall experimental test of that strategy, if they are supportive of other components' objectives, and if they address factors most limiting fish production in the short and long term. Ultimately, the selected actions should be those which have the strongest possible effect on achieving the Program Goal.

As mentioned above in Section 1.3.2, flow releases depend entirely on the current water year. Multi-year water management and carryover storage (e.g. to mitigate the effects of a string of dry years) is not currently permitted.

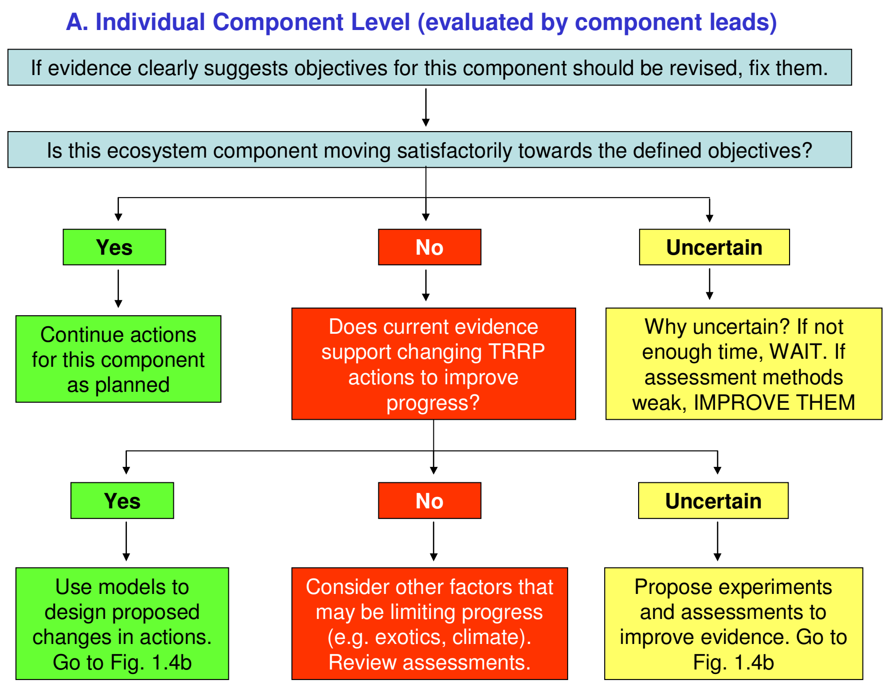


Figure 1.4a. Annual AEAM decisions: assessments for individual components.

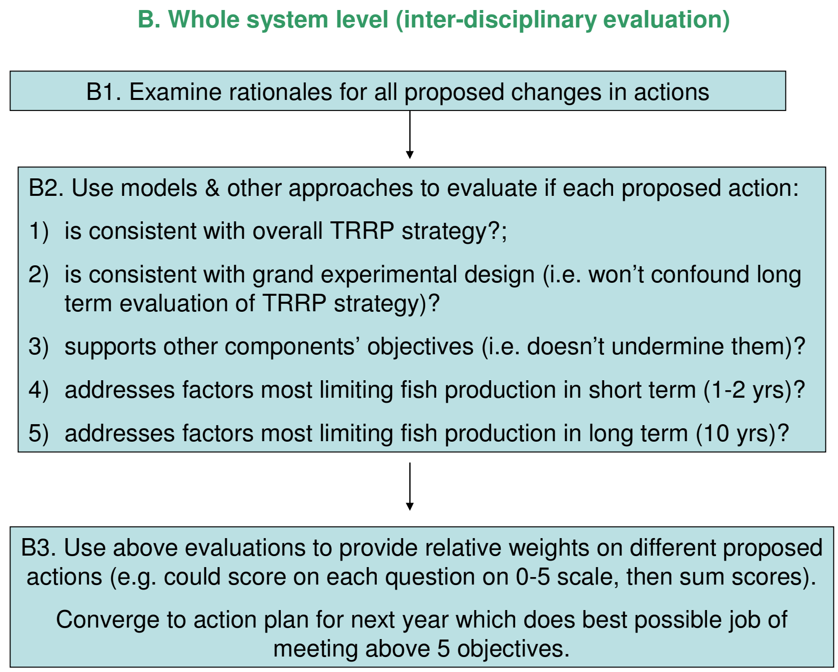


Figure 1.4b. Annual AEAM decisions: whole system assessments *across* all components, considering tradeoffs.

1.5 Structure of the IAP

Figure 1.5 is a graphical representation of the structure of the IAP that depicts how the various parts fit together. At the top of the diagram are the Program goals, sub-goals, and major objectives, described in Chapter 2. Achieving these goals requires both the implementation of actions (right side of diagram) and scientific assessments (left side of diagram, and the focus of the IAP).

Chapters 2 and 3 of the IAP describe the composition of each assessment, why the assessment is important to the overall AEAM process, and the proposed performance measures and analytical approach (unshaded portion of Figure 1.5). Chapter 4 covers the top two rows of the shaded portion of Figure 1.5 (i.e., an integrated sampling design specifying where and when assessments will occur). Detailed study plans, to be developed through the Acquisition plan and RFP process, will outline the specific monitoring protocols and data to be collected at each location and time (bottom two rows of the shaded portion).

We developed various criteria to determine if each assessment deserves to be part of the core monitoring for the Program (see Appendix B). To date, we have only formally applied these criteria to some of the assessments, but have attempted throughout Chapters 3 and 4 to specify the logical sequence, frequency, duration, spatial focus and species priority of assessments. Additionally, Appendix H outlines the relative priority of assessments within each domain. Continued application of these criteria is required over the next two years to converge on a core set of assessments (Figure 1.1). Core assessments are those which will be repeated (at various frequencies) over several decades to determine progress towards Program objectives. Other assessments to develop / compare / refine methods, test specific hypotheses or understand key processes will be of shorter duration.

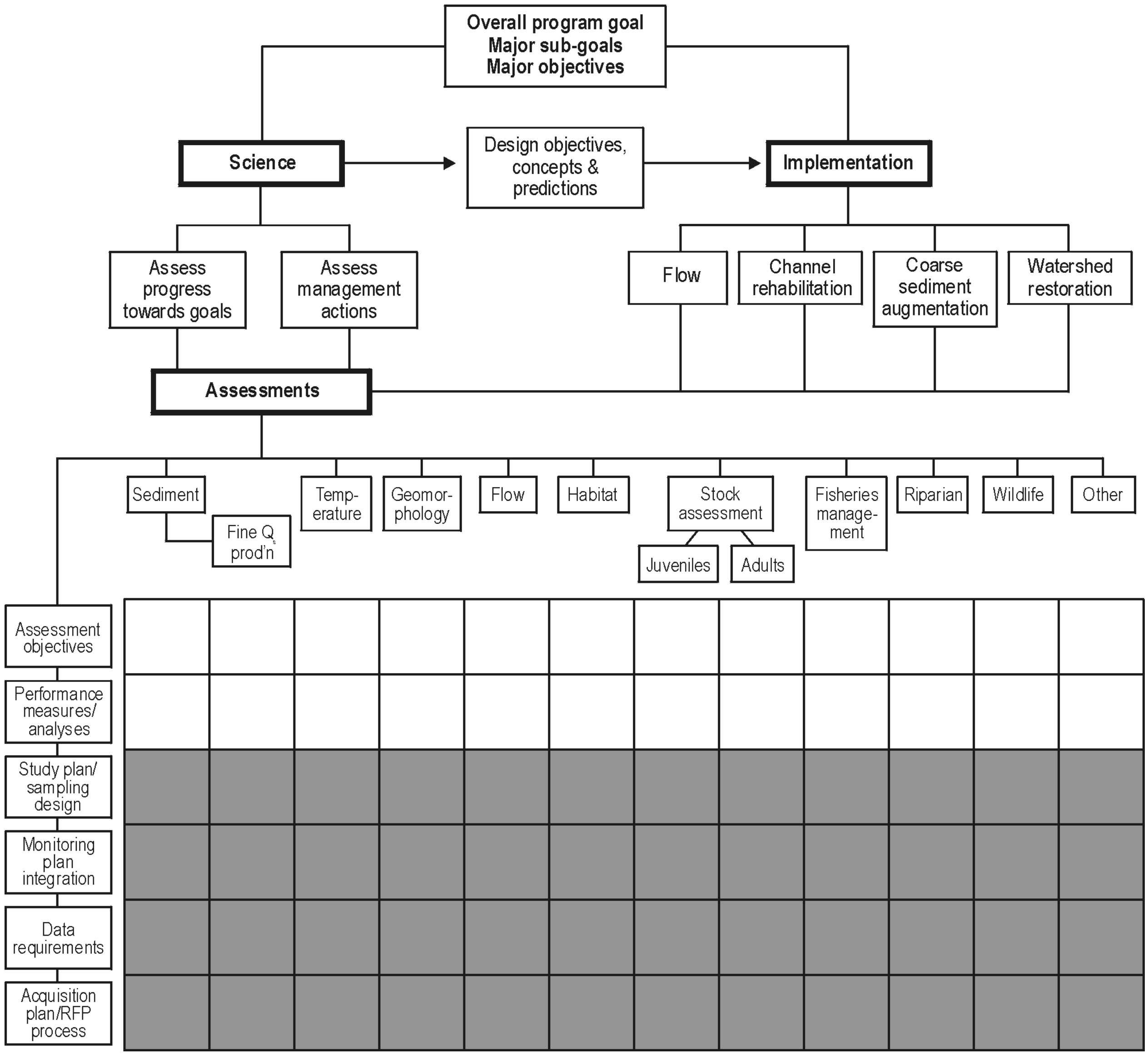


Figure 1.5. IAP structure. Chapters 1–3 cover the unshaded portion. Chapter 4 covers the top two rows of the shaded portion (i.e., an integrated sampling design specifying where and when assessments will occur). Detailed study plans, to be developed through the Acquisition plan and RFP process, will outline the specific monitoring protocols and data to be collected at each location and time (bottom two rows of the shaded portion).

1.6 Assessment tools

In April 2004, the Program began implementation of formal AEAM by providing four critical elements:

- a detailed description of the conceptual models, subsystem linkages, critical hypotheses and key performance measures driving the Program (TRRP 2005), available from the Trinity River Restoration Program website www.trrp.net/science/IAP.htm;
- an **Integrated Assessment Plan (IAP)** that builds on TRRP 2005, outlining the assessments required to: 1) evaluate progress towards Program goals; and 2) guide annual flow, channel modification, and sediment management decisions (this report);
- an **Integrated Information Management System** (**IIMS**) to centralize storage of the monitoring data, and facilitate rapid feedback from monitored outcomes through databases, data analyses, and modeling to revise annual management decisions and periodic assessment reports (see www.trrp.net/science/IIMS.htm); and
- **peer review** of designs and assessments (see Section 1.7 below).

Chapters 7 and 8 of the TRFE (USFWS and HVT 1999) include specific objectives for many system attributes. These attributes include flow, fluvial processes, temperature, sediment mobility, riparian vegetation, physical habitat for fish and wildlife populations, juvenile fish production, and protection of threatened and endangered species. Statistical analyses need to be applied to quantitatively determine the overall status and trend of these system attributes relative to Program objectives, using appropriate data to describe each attribute, with data collected based upon scientifically defensible monitoring designs. Status and trend monitoring is particularly important for key 'system-wide' performance measures such as the area of fry rearing habitat, or salmonid juvenile production. Early detection of potential problems in key performance measures (e.g., poor smolt quality) is critical to initiate research into possible causes and consider changes in management.

Other analytical methods will be applied, particularly simulation models, to evaluate alternative management actions that the Program is considering (e.g., different flow schedules to achieve annual objectives). Conceptual and quantitative models improve our current understanding of the Trinity River ecosystem, the underlying assumptions driving the Program, and key uncertainties within the system. Predictive capabilities for fish populations, fish habitat availability, temperature conditions, hydraulics, sediment balance, and riparian encroachment will be gradually improved by testing model predictions through field verifications. The relationship between rehabilitation of the fluvial nature of the river, increased area of suitable habitat and increased salmonid production is a major focal point for monitoring and modeling.

Functional relationships within conceptual or simulation models may be purely empirical (shaped by observed data only) or they may be shaped by theoretical principles and parameterized using observed data. Testing the cause-effect hypotheses in these models can help determine whether or not the foundation of the restoration strategy is correct. Examples include assessing whether channel rehabilitation sites create habitat attractive to salmon fry, whether increases in fry habitat lead to more and healthier smolts, and whether implemented flow releases prevent establishment of vegetation at low margins. Data to apply and test models can help to fine tune such management actions as coarse sediment additions and flow releases.

In addition to numeric simulation models, empirical models and analyses will be extensively applied to assess cause-effect relationships, test hypotheses, and detect trends. The IAP recognizes the independent and mutually reinforcing roles of models and empirical data collection (Figure 1.6). Both are critical for answering specific questions. Empirical observations are necessary to: 1) demonstrate in real-world terms the status and trends of important performance measures; 2) calibrate, refine and test simulation models; and 3) validate/verify model outputs. Simulation models predict rehabilitation performance, help design robust management experiments, and identify new management strategies. To improve reliability, models must continuously undergo verification and refinement as new empirical data are collected.

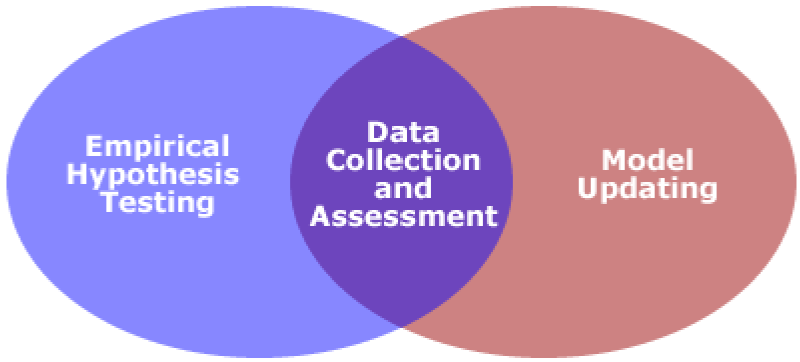


Figure 1.6. Assessments aimed at evaluating management actions and reducing critical uncertainties require a combination of empirical hypothesis testing and model updating.

Both simulation models and empirical models / analyses will be used to clarify the cause-effect chains by which management actions affect fluvial processes, habitat quantity and diversity, and population responses.

1.7 Proposal development and peer review process

The hallmarks of a sound AEAM science program are peer review, publication, and a funding process based on the scientific merit of ideas in relation to stated strategy, objectives, and priorities. This section proposes a proposal development and peer review process that accomplishes the specific requirements of the Implementation Plan directed by the Secretary of the Interior (Trinity River Mainstem Fishery Restoration EIS/EIR, USFWS *et al.* 2000: Appendix C, Chapter 7).

In a science based program organized around the principles of AEAM, the peer review process transcends the organization and permeates every aspect of the decision making process. Integral to the peer review process is the Integrated Assessment Plan (IAP). The IAP structure (Figure 1.5) begins with the Overall Program Goal (Chapter 2). Major sub-goals and objectives follow from the Overall Program Goal.

Recent comments from the Scientific Advisory Board (SAB 2006a) suggest that not all scopes of work need to be submitted for competitive bids from outside entities. Regardless, all proposals should respond to statements of work in RFP form with subsequent peer review. The TMC has expressed support for implementing an RFP process but the details of this have yet to be developed. The TMC established a subcommittee to address the budget development process, which should include identification of what projects will be subjected to the RFP process as well as incorporating the development and issuance of RFPs into the TRRP budget process.

Figure 1.7 lays out a proposed proposal development and peer review process. The process begins with the IAP and the assessments planned therein. The IAP describes the relationships between the Program goals, objectives, assessments, and data acquisition. Figure 1.7 ties these elements together in an open and fair structure that emphasizes peer review and an objective-based, proposal driven funding process. The following paragraphs describe the elements of Figure 1.7.

In response to overall experimental design, TMC priorities, and drawing upon the assessments defined in the IAP, the TMAG and Work Groups refine the assessment objectives and draft a statement of work (requirements) for each individual assessment/study/design/project. An assessment may include multiple tasks.

Once drafted, the TMAG submits the statement of work to an Expert Review Panel (ERP) made up of qualified experts in the subject area. Their purpose is to review the statement of work for soundness and fidelity to overall strategy of the Program and the IAP, including the sampling design strategy described in Chapter 4. The TMAG and Work Groups finalize the statement of work and assessment objectives in response to the ERP review comments, as well as the factors to be used for evaluating proposals.

Pursuant to the Implementation Plan, following review and approval by the TMC, an RFP (Request for Proposal) is issued by the Program. (As indicated above, details of the RFP process are still to be worked out by the TMC and the Interior funding agencies.) Proposals received in response to the RFP are forwarded to an anonymous Independent Review Panel (IRP). An IRP is a temporary, anonymous panel of experts convened to evaluate proposals using the assessment objectives and evaluation factors produced by the TMAG and Work Groups. The IRP rank all received proposals based on the assessment objectives and evaluation factors. The IRP product may also provide technical feedback and recommendations for modification and resubmission of the proposal if it does not initially meet the requirements of the RFP.

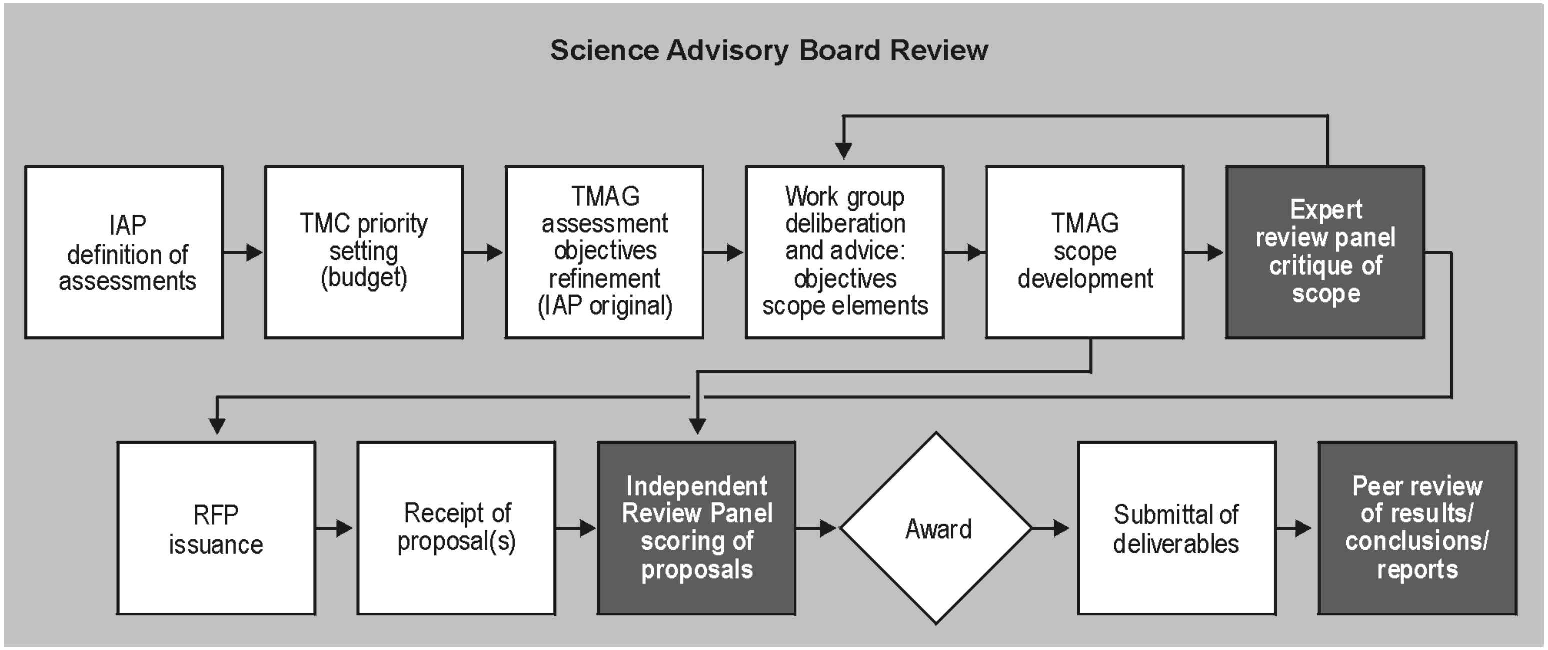
Upon receipt of proposal ranking and award recommendation, the agency that will fund the proposal will submit the Statement of Work through its internal funding process. Concerning multiple-year awards, the federal acquisitions process requires annual review, and out-year funding is contingent upon Congressional appropriation. In other words, there are multi-year agreements, but with the exception of interim reports, annual reports, or other interim deliverables, they would not go through this initial portion of Figure 1.7 on an annual basis. One exception is Annual Funding Agreements (AFAs) with tribes. Title IV activities under Tribal AFAs are negotiated annually.

Upon completion of the work and submission of the deliverable(s), the draft deliverable(s) will undergo a peer review. Upon completion of the peer review and appropriate revisions, the Awardee finalizes the deliverable(s), and the products will be distributed to the Program.

The Science Advisory Board has the role of reviewing and making recommendations relative to how science has been implemented in the Program, including the IAP, the entire process described in Figure 1.7, and Program outputs and outcomes.

In summary, there are four levels of peer review: 1) ERP review of the statement of work including assessment objectives and evaluation factors; 2) IRP review of proposals; 3) peer review of draft deliverables; and 4) Science Advisory Board review of the entire process ensuring scientific fidelity.

1



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3 **Figure 1.7.** The proposal development and peer review process, in accordance with the EIS/EIR Implementation Plan. Shaded parts of this
4 figure represent the four components of peer review, including overall review by the Science Advisory Board.

5

2. Overview of assessment needs

This chapter contains three elements which serve as preparation for the more detailed descriptions of assessments in Chapter 3; they are:

1. an illustration of the hierarchy of objectives and sub-objectives required to achieve Program goals;
2. a tabular description of the sub-objectives associated with each major objective; and
3. a discussion of the different forms of integration which need to be woven through the IAP.

2.1 Hierarchy of objectives and sub-objectives

Figure 2.1 depicts the organization of the tiered objectives from the Program goals. Figure 2.1 has a structure that is generally similar to that of Figure 1.3 (the conceptual model), except that Figure 2.1 shows the hierarchy of the major Program objectives required to support the overall Program goal.

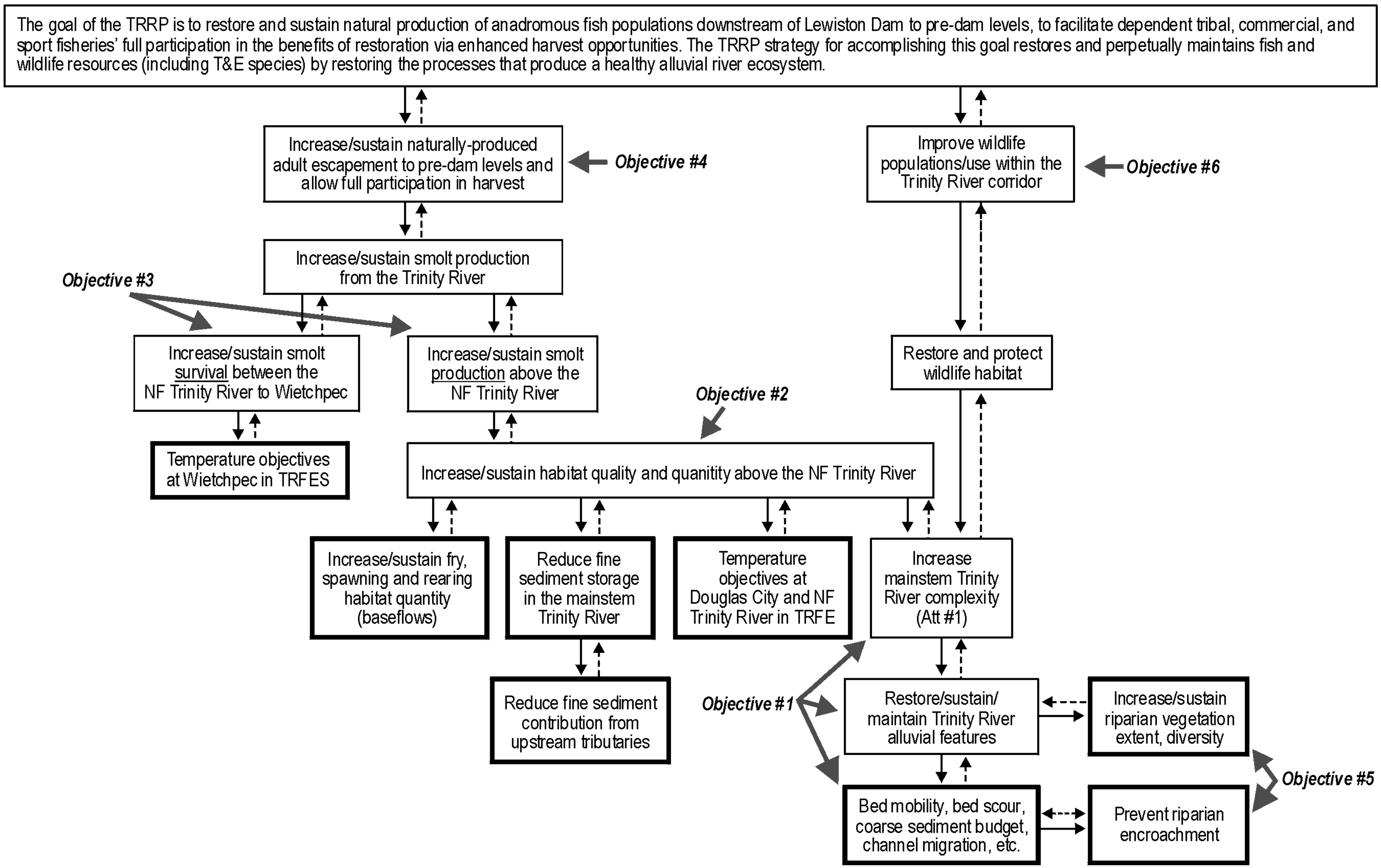

Figure 2.1. Linkages between draft Program Goal and core management actions and objectives contained in the TRFE. Outlined boxes depict specific objectives from the TRFE. Labeled "Objectives" indicate how the IAP objectives relate to these core TRFE management actions and objectives. Solid black lines show actions or ecosystem attributes *required* to support higher level objectives and goals. Dashed lines show chain of causality (e.g., meeting temperature objectives increases survival which in turn increases smolt production).

2.2 Major program objectives

Building on the Program Goal and foundational documents, the authors of this IAP have developed the following broad objectives to guide assessments:

1. create and maintain spatially complex channel morphology;
2. increase/improve habitats for freshwater life stages of anadromous fish;
3. restore and maintain natural production of anadromous fish populations;
4. restore adult anadromous fish numbers to pre-TRD levels in order to facilitate dependent tribal, commercial, and sport fisheries full participation in the benefits of restoration via enhanced harvest opportunities;
5. establish and maintain riparian plant communities that support fish and wildlife; and
6. rehabilitate and protect wildlife habitats and maintain or enhance wildlife populations following implementation.

Each of these objectives is discussed in sub-sections of Chapter 3.

2.3 Objectives hierarchy

Table 2.1 provides three levels of objectives in a hierarchical form, with an indication of their relative priority. Some of the interdependencies of these objectives are explicitly shown in Table 2.1 (e.g., achieving physical habitat diversity and availability (Objective 1.1) supports various fish habitat, riparian and wildlife objectives (2.1, 5.1, 5.2, 6.4.1, 6.5.1)).

Further delineation of some objectives to greater levels of specificity is contained in an expanded version of this table in Appendix E. Lower level sub-objectives become more specific, eventually yielding performance measures and standards or thresholds that can be quantitatively assessed through specific assessments. The SAB was concerned that many of the objectives in version 0.98 of the IAP were too simple and vague. In IAP version 1.0 we have attempted to make some of the objectives in Table 2.1 more specific, to the degree permitted by our current state of knowledge, and have incorporated into Chapter 3 further details on the “Expected Response” of each system component. We will continue to work towards more specific objectives (e.g. specifying an expected magnitude of quantitative change in key performance measures, and the time expected for the change to occur).

Table 2.1. Three levels of IAP objectives. Level 1 and 2 objectives form the sub-sections of Chapter 3 (e.g., Level 1 Objective 1 is described in Section 3.1, Level 2 Objective 1.1 is described in Section 3.1.1). More specific objectives are outlined in Chapter 3, though further refinement of objectives is still required. The priorities shown in the rightmost column are relative priorities **within** each Level 1 Objective, not across all Level 1 Objectives. Cross-domain prioritization is described in Section 2.4 and Appendix H.

Level 1 Objectives	Level 2 Objectives	Level 3 Objectives	Priority of Objectives (L,M,H)
1. Create and maintain spatially complex channel morphology	1.1. Increase physical habitat diversity and availability *(to achieve Fish Habitat objective 2.1, Riparian objectives 5.1 & 5.2, and Wildlife objectives 6.4.1 & 6.5.1)*	1.1.1.Increase the size, frequency and topographic relief of bar/pool sequences	**M**
		1.1.2 Increase channel/thalweg sinuosity	**H**
		1.1.3 Increase geomorphic unit and substrate patch diversity	**L**
	1.2 Increase coarse sediment transport and channel dynamics	1.2.1 Increase and maintain target coarse sediment transport rates	**H**
		1.2.2 Frequently exceed channel migration, bed mobilization, and bed scour thresholds	**H**
		1.2.3. Encourage bed-level fluctuations on annual to multi-year time scales	**L**
		1.2.4 Route coarse sediment through all reaches	**L**
	1.3 Increase and maintain coarse sediment storage	1.3.1 Increase bars, side-channels, alcoves, and other complex alluvial features	**H**
	1.4 Reduce fine sediment storage in the mainstem Trinity River	1.4.1 Transport fine sediment through mainstem at a rate greater than tributary input	**H**
		1.4.2 Reduce fine sediment supply from tributary watersheds	**M**
		1.4.3 Encourage fine sediment deposition on floodplains	**L**
2. Increase/improve habitats for freshwater life stages of anadromous fish to the extent necessary to meet or exceed production goals	2.1 Increase and maintain salmonid habitat availability for all freshwater (in-river and tributary) life stages *(linkage to Riparian Objectives 5.1.2 & 5.2)*	2.1.1 Increase/maintain salmonid fry and juvenile rearing habitat in the upper 40 miles of the mainstem Trinity River by a minimum of 400 % following rehabilitation of fluvial attributes	**H(1)**
		2.1.2 Increase/maintain spawning habitat quantity and quality to 2,550,000 square feet in the upper 40 miles of the mainstem Trinity River	**H(2)**
		2.1.3 Create channel form that reduces loss of fry to stranding in the upper 40 miles of the mainstem Trinity River following rehabilitation during high flows	**M**
		2.1.4 Maintain or increase adult holding habitat from baseline conditions in the mainstem Trinity River	**M**
		2.1.5 Minimize physical impacts to lamprey habitat	**M**
		2.1.6 Minimize physical impacts to other native fish habitats	**L**
		2.1.7 Maintain or increase tributary habitat	**M**
	2.2 Improve riverine thermal conditions for growth and survival of natural anadromous salmonids	2.2.1 Provide optimal temperatures to improve spawning success of spring and fall-run Chinook salmon	**H**
		2.2.2 Improve thermal regimes for rearing growth and survival of juvenile steelhead, coho salmon and Chinook salmon	**H**
		2.2.3 Improve thermal regimes for outmigrant salmonid growth and survival (dependent on water year)	**H**
		2.2.4 Minimize temperature impacts to other native fish habitats	**L**

Level 1 Objectives	Level 2 Objectives	Level 3 Objectives	Priority of Objectives (L,M,H)
	2.3 Enhance or maintain food availability for fry and juvenile salmonids	2.3.1 Increase and maintain macroinvertebrate populations *(achieve Fish Production objective 3.1.1)*	**M**
3. Restore and maintain natural production of anadromous fish populations	3.1 Increase spawning, incubation and emergence success of anadromous spawners	3.1.1 Optimize adult utilization of suitable spawning habitat areas in the mainstem within 3-4 brood cycles following rehabilitation of fluvial river processes	**M**
		3.1.2 Optimize adult utilization of suitable spawning habitat areas in tributaries within 3-4 brood cycles following rehabilitation of fluvial river processes	**M**
		3.1.3 Reduce temperature related pre-spawning mortality and protect in-vivo egg viability of anadromous spawners in the mainstem Trinity River	**L (dependent on importance of fine sediments)**
	3.2 Increase freshwater production of anadromous fish	3.2.1 Increase fry abundance, growth, physical condition, and health from baseline conditions in the mainstem Trinity River within 3-4 brood cycles following rehabilitation of fluvial river processes	**H**
		3.2.2 Increase outmigrant juvenile life stage abundance, growth, physical condition and health from baseline conditions in the mainstem Trinity River within 3-4 brood cycles following rehabilitation of fluvial river processes	**H**
		3.2.3 Improve juvenile fish production as a function of water temperature and habitat flow relationships from baseline conditions in the mainstem Trinity River within 3-4 brood cycles following rehabilitation of fluvial river processes	**H**
		3.2.4 Reduce clinical disease incidence in Trinity River origin outmigrants in the Klamath River to less than 20% within 5 years	**M / H**
		3.2.5. Reduce fry stranding in the upper 40 miles of the mainstem Trinity River by 50% following rehabilitation of fluvial river processes	**L**
		3.2.6 Reduce non-native fish predation on naturally produced fish by 50% in the mainstem Trinity River within 3-4 brood cycles following rehabilitation of fluvial river processes *(linkage to Wildlife objective 6.3)*	**L**
	3.3 Minimize impacts of predation, competition, and genetic interactions between and among hatchery and natural anadromous fish	3.3.1 Limit impacts of hatchery fish predation on naturally produced juvenile salmonids to less than 20% over the 40 miles	**M**
		3.3.2 Increase proportion of Natural Influence (pNI) to 0.7 or greater	**H**
4. Restore and sustain natural production of anadromous fish populations downstream of Lewiston Dam to pre-dam levels, to facilitate dependent tribal, commercial, and sport	4.1 Increase naturally produced fall-run Chinook salmon adult production to the extent necessary to meet or exceed escapement objectives and facilitate expanded harvest opportunity	4.1.1 Increase escapement of naturally produced fall-run Chinook salmon to 62,000 adults	**H**
		4.1.2 Increase harvest of naturally produced fall-run Chinook salmon adults	**H**
	4.2 Increase naturally produced spring-run Chinook salmon adult production to the extent necessary to meet or exceed escapement objectives and facilitate expanded harvest opportunity	4.2.1 Increase escapement of naturally produced spring-run Chinook salmon to 6,000 adults	**H**
		4.2.2 Increase harvest of naturally produced spring-run Chinook salmon adults	**M / H**
	4.3 Increase naturally produced coho salmon adult	4.3.1 Increase escapement of naturally produced coho salmon to 1,400 adults	**H**

Level 1 Objectives	Level 2 Objectives	Level 3 Objectives	Priority of Objectives (L,M,H)
fisheries' full participation in the benefits of restoration via enhanced harvest opportunities	production to the extent necessary to meet or exceed escapement objectives and facilitate expanded harvest opportunity	4.3.2 Increase harvest of naturally produced coho adult salmon adults	**L**
	4.4 Increase naturally produced steelhead adult production to the extent necessary to meet or exceed escapement objectives and facilitate expanded harvest opportunity	4.4.1 Increase escapement of naturally produced steelhead to 40,000 adults	**H**
		4.4.2 Increase harvest of naturally produced steelhead adults	**H**
	4.5 Increase naturally produced Pacific lamprey adult production to the extent necessary to meet or exceed escapement objectives and facilitate expanded harvest opportunity	4.5.1 Increase escapement of Pacific lamprey adults	**L**
		4.5.2 Increase harvest of Pacific lamprey adults	**L**
	4.6 Increase naturally produced green sturgeon adult production to the extent necessary to meet or exceed escapement objectives and facilitate expanded harvest opportunity	4.6.1 Increase escapement of green sturgeon adults	**L**
		4.6.2 Increase harvest of green sturgeon adults	**L**
5. Establish and maintain riparian vegetation that supports fish and wildlife	5.1 Promote diverse native riparian vegetation on different geomorphic surfaces that contribute to complex channel morphology and high quality aquatic and terrestrial habitat *(achieve Fish Habitat objective 2, Fish Production objective. 3.1, and Wildlife objective 6.1)*	5.1.1 Increase species, structural, and age diversity of riparian vegetation to improve and maintain wildlife habitat	**M / H**
		5.1.2 Encourage establishment of riparian species on surfaces within the future channel migration corridor that will recruit LWD	**M**
		5.1.3 Encourage establishment of vegetation that provides habitat for anadromous fish, aquatic organisms and aquatic / riparian wildlife	**H**
	5.2 Prevent riparian vegetation from exceeding thresholds leading to encroachment that simplifies channel morphology and degrades aquatic habitat quality *(achieve Fish Habitat objective 2.1, Wildlife Objectives 6.2 & 6.4)*	5.2.1 Manage flows, coarse sediment augmentation, and channel rehabilitation that cause sufficient riparian plant mortality along low water margins to prevent channel simplification leading to degraded fish habitat	**H**
	5.3 Recover riparian vegetation area equal or greater than disturbed by physical rehabilitation (achieve Wildlife Objective 6.1)	*- no level 3 objective required, as level 2 objective is sufficiently specific*	**H**
6. Rehabilitate and protect wildlife habitats and maintain or enhance wildlife populations following implementation	6.1 Maintain Trinity populations and species diversity of birds using the riparian zone in the Program area	6.1.1 Enhance quality and maintain quantity of riparian bird nesting and foraging habitats *(linkage to Riparian objective. 5.1)*	**H**
	6.2 Maintain Trinity River riverine bird populations and species diversity in the Program area *(linkage to Riparian Objectives 5.1.2 & 5.2)*	6.2.1 Enhance quality and maintain quantity of riverine bird nesting and foraging habitats *(linkage to Physical objective 1.1, Fish Habitat objective 2.3.1, Fish Production objectives 3.2.1 & 3.2.2 and Riparian objectives 5.1 & 5.2)*	**H**
	6.3 Minimize impacts of riverine bird predation on fry and smolts	6.3.1 Adapt timing of hatchery release to alter distribution of avian predators and minimize predation on natural fry and smolts *(achieve Fish Production objective 3.3.3)*	**M**

Level 1 Objectives	Level 2 Objectives	Level 3 Objectives	Priority of Objectives (L,M,H)
	6.4 Increase population size, survival, distribution, and recruitment success of Foothill Yellow-legged Frogs (FYLF)	6.4.1 Increase population size, survival, distribution, and recruitment success of Foothill Yellow-legged Frogs	**H**
		6.4.2 Increase quality and quantity of breeding and rearing habitat for Foothill Yellow-legged Frogs *(linkage to Riparian objectives 5.1 & 5.2)*	**H**
	6.5 Increase population size, survival, distribution, and recruitment success of Western Pond Turtle (WPT)	6.5.1 Increase population size, survival, distribution, and recruitment success of Western Pond Turtles	**H**
		6.5.2 Increase structural and thermal diversity of aquatic habitats used by various age classes of Western Pond Turtles	**H**
		6.5.3 Increase recruitment of younger age classes of Western Pond Turtles	**M**
	6.6 Minimize adverse impacts to additional native riparian or aquatic associated wildlife from Program activities. Focus on wildlife species associated with a healthy river ecosystem, not necessarily all species	6.6.1 Discourage invasive species	**M**

2.4 Prioritization of sub-objectives and assessments

The authors of the IAP agree with the SAB that the Program needs to converge to a manageable set of core assessments which are done well. The IAP authors have made considerable progress in prioritizing objectives and assessments within each major IAP component, as well as across components. We also recognize that more work remains. This section describes both the prioritization work done to date, and how we propose to continue this work over the next 1-2 years. We recognize that changing conditions in the river, and changing management priorities can alter the relative priority of sub-objectives and assessments.

Prioritization of sub-objectives within IAP Components

In developing the IAP, the authors prioritized Level 3 objectives *within* each of the six Level 1 objectives or IAP components (i.e., Physical, Fish Habitat, Juvenile Fish Production, Adult Fish Production, Riparian, and Wildlife). The results of this effort are shown by the **L**ow, **M**edium, and **H**igh ratings in the last column of Table 2.1. These ratings are intended to help with the prioritization of associated assessments, though there is not a 1:1 mapping between sub-objectives and assessments. Some assessments might serve multiple sub-objectives (e.g., riparian vegetation assessments are important to riparian, geomorphic, fish habitat and wildlife habitat sub-objectives). Four sets of questions (a simplification of the criteria listed in Appendix B) were used to help scientists rate the relative priorities of each sub-objective *within* each objective:

1. Will assessing this sub-objective result in revised management actions via AEAM? Which actions? How important is this sub-objective to revising management actions?
2. Will assessing this sub-objective be critical for tracking progress towards the TRRP goal? Which components of the goal?
3. What are the consequences of not assessing this sub-objective? Why and how would these consequences occur?
4. Given the overall restoration strategy, what sub-objective assessments are needed first, as opposed to later (i.e., things that need to be done first are a higher priority)?

Questions 1 and 2 are based on the two driving functions of the IAP (see the top half of Figure 2.2, below). The criteria used for determining core assessments are listed in Appendix B, and summarized in Figure 2.3. Some assessments included in this IAP are shorter term investigations of specific hypotheses or processes (e.g. insights on the design of channel rehabilitation projects are most important during the period of construction, intended to be completed by 2013). Other assessments (e.g. spawner and smolt estimates) are long term, continuing assessments of progress towards habitat and fish production objectives. Some assessments are only required periodically (e.g., after significant geomorphic change), as described in Appendix H. It is expected that the Program will converge on the core program over the next two years.

The IAP sets the foundation for future RFPs, but does not specify exactly how each assessment will be carried out, or who will do it. Chapter 4 describes an inclusive, integrated *sampling design* (when and where sampling will occur), based on our best current understanding of the *evaluation design* (what will be done with the data to address one or both of the two primary assessment functions), and current *response designs* or *monitoring protocols* (how data are acquired at each time and location). In some cases monitoring protocols are already well established, while in other cases RFP-responsive study designs will need to consider the cost, feasibility and sufficiency of different monitoring protocols and either recommend a proposed approach, or (if specified in the RFP) compare alternative approaches.

Prioritization of assessments within IAP components

In developing the inclusive, integrated sampling design for Chapter 4, we catalogued all proposed assessments (Appendix H), and reviewed all existing sampling designs and monitoring protocols with Program scientists (Appendix L). Appendix H also includes prioritization efforts by IAP authors *within each component* (i.e., physical, fish habitat, juvenile fish production, adult fish production, riparian, wildlife), based on the consensus judgment of the authors working within that component. The authors considered the relative importance of each assessment in meeting the two IAP objectives, the appropriate sequence of assessments, and packages of assessments that should logically go together. There are several different dimensions to the prioritization completed within each component in the sub-sections of Chapter 3:

a) key performance measures (PMs) and candidate PMs;
b) key locations for assessments (prioritization in space);
c) expected response time, sampling interval (prioritization in time);
d) priority issues to address (PITAs) (Appendix P); and
e) priority sampling design issues (Appendix L).

If assessment methods have not been finalized for a high priority sub-objective, then resolving this uncertainty (e.g., through protocol comparisons) itself becomes a high priority.

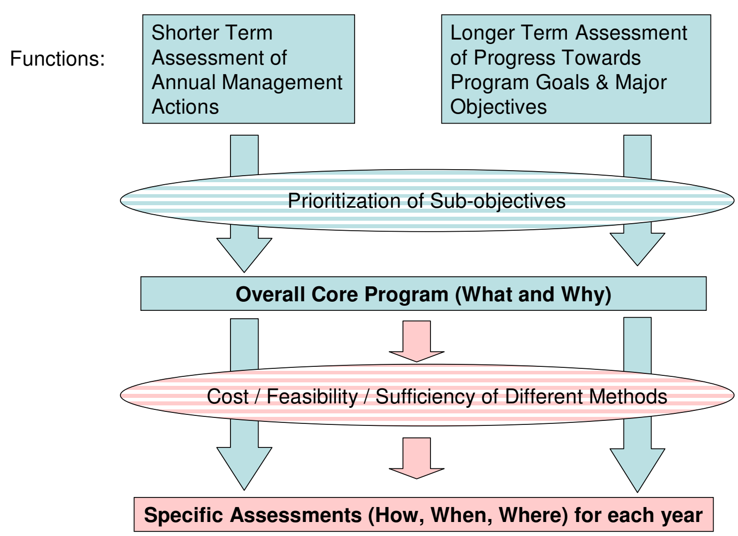

Figure 2.2. Filtering process to prioritize assessments. The top two blue boxes represent the two key functions of assessments, as described in Figure 1.5. Chapters 2 and 3 of this document (and Appendix H) present an initial prioritization to develop the Core Program, focusing on what needs to be done and why (top / blue part of figure). Chapter 4 of the IAP describes when and where specific assessments will be performed, through an integrated sampling design. Further work on the cost/feasibility/sufficiency of different methods will be developed via RFPs and responses to them.

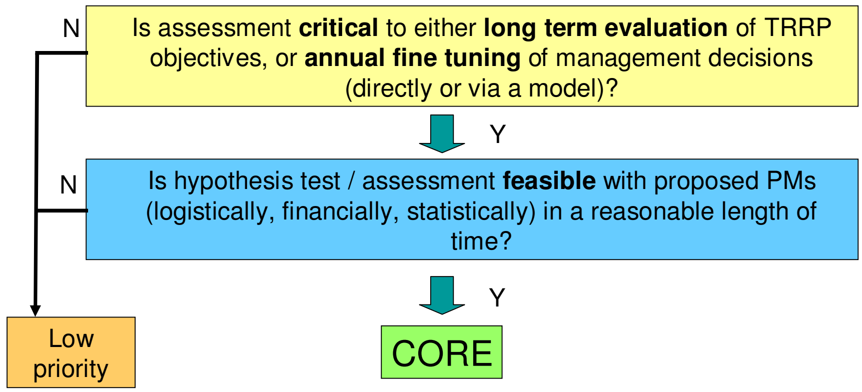

Figure 2.3. Summary of the justification criteria listed in Appendix B.

2.4.1 Prioritization Across Components

Building on the within-component prioritization, the IAP Steering Committee went through several iterations of prioritization *across* components. This cross-component prioritization was based on the following eight criteria and principles:

1. Build on within-component prioritization: ensure that all assessments of all six Level 1 objectives (i.e., the six components) are represented in the top half of ranked assessments. The following procedures were used to get an initial grouping and ranking:

    a. All assessments ranked *first* within each component (see Appendix H) were grouped together in the following order of priority: fish > physical and riparian > wildlife. The three fish components (habitat, juvenile fish, adult fish) each ranked their assessments in order.

    b. All assessments ranked *second* within each component (see Appendix H) were grouped together in the following order of priority: fish > wildlife > physical and riparian. This procedure was followed because none of the physical and riparian assessments were given a "third" priority ranking.

    c. All assessments ranked *third* within each component (see Appendix H) were grouped together in the following order of priority: fish > wildlife.

2. Recognize that in the long term, system-wide assessments are of the highest priority (e.g., adult and juvenile fish, habitat, birds), but these assessments must also be implemented in the short term (2009-13) to maintain the time series of data.

3. In the short term (2009-13), we need AEAM evaluation of rehab sites, flow, and sediment actions, but within the system-wide sampling frame established in Chapter 4 (when appropriate for the specific assessment), involving rigorous selection of sampling sites.

4. When conducting pair-wise comparisons of possible assessments, consider which would be worse to lose (in terms of their effects on the two fundamental purposes of the IAP).

5. Apply the species priority described in Section 3.3 of the IAP: fall Chinook salmon > spring Chinook salmon > coho salmon > steelhead > lamprey and sturgeon.

6. If an assessment is not required immediately, classify it as a *contingent assessment*. IF a primary assessment raises a concern, THEN do secondary (contingent) assessment.

7. Consider the sphere of influence of the Program. If an assessment is likely to be confounded by other influences (e.g., fish survival in the Klamath estuary is affected by conditions in both the Trinity and Klamath), then rank this assessment at a lower priority.
8. To ensure neutrality, a straw prioritization was first completed by a neutral, non-TRRP scientist, who clearly stated his rationale. The rationales and rankings were then reviewed and revised by the IAP Steering Committee. Further revisions were made based on the SAB review of IAP version 0.98. Further input is still required from other Program participants.

The assessments which were ranked in the upper half are listed in Table 2.2. There are several caveats around these rankings:

1. Priorities will evolve as we learn—these rankings are not locked in stone. Assessments that are lower ranked could rise in priority, and vice versa.
2. This is a strategic guide to program planning, NOT a budget table.
3. Many *data analyses* are not listed, but funds will need to be allocated for analyses, by both agency staff and subcontractors.
4. The level of detail of each assessment isn't specified. More work is required to determine the required precision, given the intended decisions to be made with the information (as outlined in the decision tree in Section 2.4.2). This will have a large effect on which assessments can be conducted within the available budget.

Table 2.2. Assessments in the upper half of ranked assessments for the 2009-2013 period (rank in second last column). Further details on each assessment are contained in Appendix H. Explanations of contingent assessments are in Section 2.4.

IAP Component	Objective(s)	Assess-ment	Assessment type (primary benefit)	Description	General ranking guideline	Contingent Assessment? (Y/N)
Habitat	2.1.1, 2.1.7	2H	Both	Map and quantify the extent (area) of available fry/juvenile rearing habitat throughout the mainstem	1	N
Habitat	2.1.1	1H	Both	Map and quantify the extent (area) of available fry/juvenile rearing habitat at rehab sites	2	N
Fish (adult)	4.2.1, 4.2.2, 4.2.3, 4.2.4	13A	Progress towards goals	Monitor adult escapement of hatchery and naturally produced spring and fall Chinook, coho and fall steelhead	3	N
Fish (juvenile)	3.2.2, 3.2.3, 3.2.4	4J-FC and SC	Progress towards goals	Monitor smolt outmigrant numbers,Monitor smolt timing	4	N
Fish (juvenile)	3.2.2, 3.2.3, 3.2.4	4J-FC and SC	Progress towards goals	Monitor smolt timing, as well as pre-smolt/smolt size, condition and disease incidence at outmigration (fish in hand)	5	N
Habitat	2.2.1. 2.2.2, 2.2.3	7H	Needed to revise specific actions	Monitor water temperatures at existing Trinity River temperature stations (supplemented where necessary) to model achievement of species-specific Water Year and seasonal temperature targets for rearing juveniles, outmigrating smolts and spawning adults	6	N
Fish (adult)	3.1.1, 3.1.2	1A	Progress towards goals	Monitor redd distribution, abundance, and densities (includes carcass surveys)	7	N
Fish (adult)	4.2.2	17A	Progress towards goals	Monitor harvest (tribal, sport and commercial) of naturally produced fall Chinook	8	N
Physical	1.1.1	1P	Both	Quantify changes in channel width/geometry and geomorphic features within the wetted channel (including sinuosity, radius of curvature, thalweg crossings, controls, length of edge (banklength), etc.)	9	N
Riparian	5.1.1, 5.1.2, 5.1.3, 1.1.1	1R	Needed to revise specific actions	Map and quantify changes in riparian floodplain vegetation (e.g., species, age-class, initiation success, structural attributes) at GRTS sites, including near-channel vegetation	10	N
Wildlife	6.1.1	4W	Progress towards goals	Monitor abundance and composition (richness/diversity) of riparian bird species during breeding, post-breeding and migration periods	11	N
Fish (juvenile)	3.2.2, 3.2.3, 3.2.4	4J- SHD and COH	Progress towards goals	Pre-smolt/smolt size, condition and disease incidence at outmigration (fish in hand)	12	N
Fish (juvenile)	3.2.1, 3.2.3	2J	Progress towards goals	Monitor fry density and abundance at GRTS sites across upper 40 miles (standing stock assessment)	13	N
Physical	1.1.1	12P	Needed to revise rehab proj	Assess design performance of specific design features (alcoves, side channels, lowered floodplains, etc)	14	N

IAP Component	Objective(s)	Assess-ment	Assessment type (primary benefit)	Description	General ranking guideline	Contingent Assessment? (Y/N)
Physical	1.2.1, 1.2.4, 1.3.1	14P	Needed to revise flow	Predict sediment transport and use predictions to help guide annual flow scheduling process.	15	Y
Riparian	5.2.1	3R	Needed to revise specific actions	Map and quantify the state of near-channel riparian vegetation at GRTS sites	16	N
Physical	1.2.1	5P	Needed to revise specific actions	Monitor bedload transport rates, compute coarse sediment loads, and evaluate coarse sediment rating curves that are expected to change over time in response to management actions.	17	N
Habitat	3.2.1	3H and 4H	Progress towards goals	Map and quantify the extent (area) of available adult spawning habitat at rehab sites and throughout the mainstem	18	N
Physical	1.2.2	6P	Needed to revise specific actions	Monitor bed mobility and scour thresholds	19	N
Fish (adult)	4.1.1, 4.2.1, 4.3.1	22A	Progress towards goals	Develop cohort reconstructions for Chinook and coho and evaluate cohort performance or year class strength, and population growth rate	20	N
Fish (juvenile)	3.2.1, 3.2.3	1J	Progress towards goals	Monitor fry density and abundance at rehab sites	21	N
Wildlife	6.4.1	11W	Progress towards goals	Monitor the abundance and distribution of FYLF egg masses throughout the forty mile system	22	N
Fish (juvenile)	3.2.2, 3.2.3, 3.2.4	4J-SHD and COH	Progress towards goals	Monitor smolt outmigrant numbers	23	N
Fish (juvenile)	3.2.1	3J	Progress towards goals	Monitor size (length/wt and condition of fry)(fish in hand)	24	N
Fish (adult)	4.1.2	16A	Progress towards goals	Monitor harvest (tribal, sport and commercial) of naturally produced spring Chinook	25	N
Riparian	5.2.1	5R	Needed to revise specific actions	Model how streamflow actions will affect the bank location of initiating seedlings	26	Y
Wildlife	6.5.1	13W	Progress towards goals	Monitor the distribution and abundance of WPT	27	N
Wildlife	6.4.1	10W	Needed to revise specific actions	Monitor the abundance/density of multiple FYLF lifestages, and reproductive output and/or reproductive success (recruitment) at rehab sites	28	N
Physical	1.4.1, 3.1.1	16P	Progress towards goals	Evaluate spawning gravel quality in upper reach(es)	29	Y

IAP Component	Objective(s)	Assess-ment	Assessment type (primary benefit)	Description	General ranking guideline	Contingent Assessment? (Y/N)
Physical	1.4.1	9P	Needed to revise specific actions	Map and quantify fine sediment storage on the bed surface of the mainstem	30	Y
Fish (adult)	3.1.1, 3.1.2, 3.1.3	3A	Progress towards goals	Monitor pre-spawning mortality to assess the number and proportion of un-spawned or partially spawned female Chinook and coho salmon	31	N
Wildlife	3.3.1	9J	Progress towards goals	Monitor the proportion of hatchery reared to natural smolt outmigrants (best undertaken in conjunction with assessment 4J)	32	N
Wildlife	6.1.1	1W	Needed to revise specific actions	Monitor abundance/density and composition (richness/diversity) of riparian bird species during breeding, post-breeding and migration periods at rehab sites	33	N
Wildlife	5.1.1, 5.1.2, 5.1.3, 1.1.1	2R	Progress towards goals	Map and quantify the distribution of vegetation types in the river's floodplain riparian zone and across the valley bottom	34	N
Wildlife	2.2.2	8H	Both	Monitor the degree of thermal heterogeneity for the program area	35	Y
Wildlife	2.2.1. 2.2.2, 2.2.3	12H	Needed to revise specific actions	Re-evaluate appropriateness of the species-specific Water Year and seasonal temperature targets for rearing juveniles, outmigrating smolts and spawning adults being used in the Trinity River	36	Y
Wildlife	6.1.1	2W	Needed to revise specific actions	Monitor age ratios, health, breeding condition, and reproductive success (productivity) of riparian bird species over the 40 mile reach	37	N
Riparian	1.2.1, 1.2.2, 1.2.3, 1.2.4	7P	Needed to revise specific actions	Predict changes in gravel storage as determined from coarse sediment budget calculations	38	Y
Physical	2.1.1, 2.1.7	8P	Needed to revise specific actions	Monitor coarse sediment inputs from tributaries	39	Y
Habitat	2.1.1	13H	Progress towards goals	Determine potential habitat carrying capacity for anadromous fish species	40	N
Fish (adult)	4.2.1, 4.2.2, 4.2.3, 4.2.4	18A	Progress towards goals	Monitor harvest (tribal, sport and commercial) of naturally produced coho	41	N
Physical	3.2.2, 3.2.3, 3.2.4	19A	Progress towards goals	Monitor harvest (tribal, sport and commercial) of naturally produced steelhead	42	N
Physical	3.2.2, 3.2.3, 3.2.4	6W	Progress towards goals	Monitor abundance and productivity (as measured by the ratio of juveniles to adults observed) of riverine bird species	43	N

2.4.2 Decision tree for converging to core assessments

In full recognition that the process of prioritizing assessments is not complete, and in response to SAB requests at the October 2008 review of IAP 0.98, the IAP Steering Committee developed the decision tree shown in Figure 2.4. Each of the boxes in this figure are further described in Table 2.3.

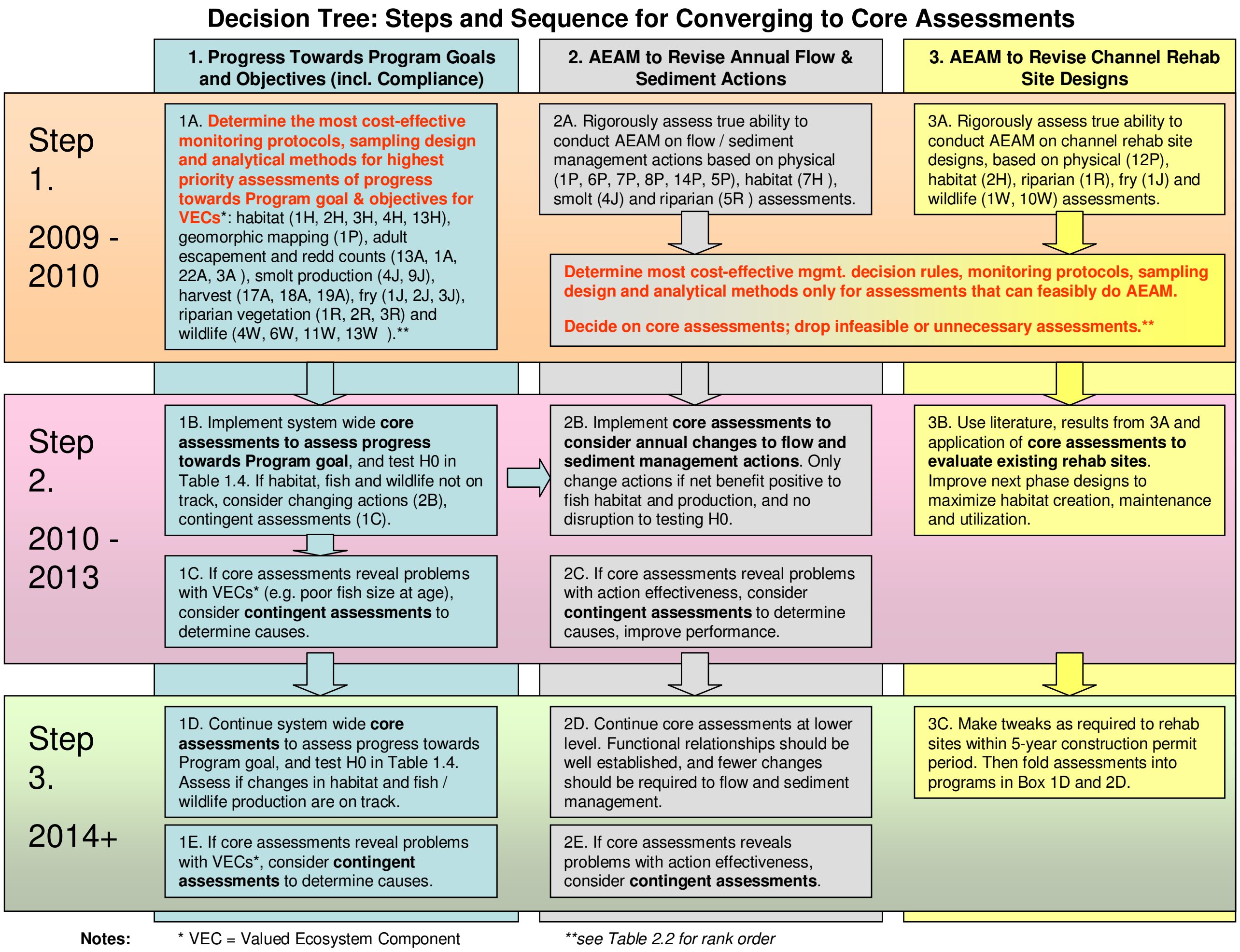

Figure 2.4. Decision tree for continuing the prioritization of assessments in future years of the Program. Each of the boxes shown in this figure is described in more detail in Table 2.3. Columns 1, 2 and 3 are assumed to be of equal importance in the short term (next 5 years). In the longer term however, column 1 will become more important, since: a) it contains the fundamental metrics of Program performance; b) rehab sites will be completed (column 3); and c) appropriate flow and sediment actions and functional relationships for different water years should be well established (column 2). Most assessments tend to fall into either columns 1, 2 or 3, but there are a few (e.g., habitat assessments, smolt outmigration) which serve more than one function. There are significant budget tradeoffs which need to be resolved (e.g., doing only a few core assessments very reliably vs. doing many assessments with less certain results; maintaining consistent management actions from year to year and focusing on column 1 assessments (progress towards Program Goals) vs. more year to year adjustment in management actions based on column 2 adaptive management assessments).

Table 2.3. Elaboration of the decision tree contained in Figure 2.4, with a complete list of all contingent assessments, and the conditions / primary assessments which might trigger them.

<table>
<tr><th>Box in Fig. 2.4</th><th colspan="2">Notes</th></tr>
<tr><td></td><td colspan="2">Column 1: Progress towards Program Goals and Objectives (including compliance)</td></tr>
<tr><td>1A</td><td colspan="2">This involves the following steps:
a. sharpening the Chapter 3 sub-objectives for each component (and their associated performance measures), using simple approaches (e.g., 10-fold increase in fry rearing habitat and fry abundance; 5-fold increase in smolt production per spawner; 5-fold increase in adult escapement; target composition of riparian vegetation), including compliance-related assessments;
b. clarifying assumptions supporting these sharpened sub-objectives (e.g., juvenile and adult fish production sub-objectives assume that habitat increases, and that there's no change in harvest rates or hatchery practices during this period; time to reach fish sub-objectives depends on rate of habitat creation, sequence of water years, ocean conditions, etc.);
c. building on recommended assessment strategies in Chapter 3 of IAP, evaluate a range of approaches to each assessment to determine the most cost-effective approach given the precision required to judge whether sub-objectives have been achieved (this may include field work and simulation / analysis to determine the relationship between effort and precision, and the needed precision given the size of changes expected under point a above);
d. finalizing the sampling design and monitoring protocol, consistent with Chapter 4 of the IAP, and addressing the high priority issues outlined in Appendix L.</td></tr>
<tr><td>1B</td><td colspan="2">Primarily expect to see significant changes in fish habitat and riparian vegetation during this 5-year period. There will be a lag in smolt numerical response due to salmon life cycle, though there may be an improvement in smolt size and condition. Significant adult salmon numerical response not expected in this period, and very dependent on ocean conditions and spawning escapements. There may be some response in riparian and aquatic bird communities, though more likely in 1D.</td></tr>
<tr><td rowspan="4">1C & 1E</td><td colspan="2">Contingent assessments: Various assessments currently labeled contingent could become high priority if certain conditions occur, as identified from other primary assessments.</td></tr>
<tr><td>IF primary assessments and management priorities indicate …</td><td>THEN consider doing these contingent assessments (listed in order of priority and sequence)…</td></tr>
<tr><td>A potential shortage of holding habitat based on geomorphic mapping (1P) and/or delays in redd establishment (1A) relative to adult return timing (13A)</td><td>3H/4H: Map and quantify the extent (area) of available adult holding habitat at rehab sites and throughout the mainstem</td></tr>
<tr><td>Low smolt to adult return rates observed relative to other well-monitored stocks (4J, 13A)</td><td>12J: Monitor smolt survival in lower Klamath River and estuary</td></tr>
</table>

Box in Fig. 2.4	Notes	
	Pilot evaluations of spawning gravel quality (16P) show % fines are a problem	*Progressive sequence of more detailed assessments. Only do next assessment in sequence if previous assessment suggests it's required (order based on Steering Committee's Oct 20th ranking of assessments):* 16P: Do a more thorough evaluation of spawning gravel quality in upper reach(es) 9P: Map / quantify fine sediment storage on the bed surface of the mainstem 17P: Compute fine sediment budget (input, output, change in storage) 10P: Monitor fine sediment removal/migration from mainstem berms and river banks 11P: Monitor fine sediment delivery from tributary streams upstream from gravel areas with fine sediment problems 4A: Monitor in-vivo egg viability
	Increased priority for understanding effects of watershed rehabilitation actions on tributary spawning and rearing habitat (relative to other assessments)	6H: Map and quantify the available spawning and rearing habitat in tributaries
	Assessments 3J and 4J show that fry, parr and smolts have poorer growth than expected	9H: Monitor abundance of macroinvertebrate prey available as drift 10H: Monitor standing crop and production rates of macroinvertebrate populations 11H: Monitor extent (area) of available macroinvertebrate habitat and the duration of inundation of specific macroinvertebrate habitats under a range of flows
	Primary assessments of FYLF (11W, 10W) and management concerns indicate that further understanding of flow-habitat relationships are warranted	9W: Map and quantify the extent (area) of available Foothill Yellow-legged frog (FYLF) breeding habitat at a range of flows
	Primary fish habitat, fry, smolt and adult assessments (1H, 2H; 1-4J; 1A, 13A) show lack of increase in freshwater production despite increase in habitat (i.e., negation of H0), carcass surveys show high proportion of hatchery fish (1A); assessment 9A (monitor pNI) suggests serious concerns; and managers are willing to consider changes in hatchery operations (H1)	*Progressive sequence of more detailed assessments. Only do next assessment in sequence if previous assessment suggests it's required (order based on fish group's ranking from Sept 10-11/08 workshop):* 8J: Monitor predation rates by hatchery reared fish (primarily steelhead) on natural fry 8W: Monitor distribution, abundance and behavior of piscivorous riverine bird species in areas of hatchery releases (build off evidence from 6W)
	Primary habitat assessments (1H, 2H, 3H, 4H) are considered insufficient to assess habitat response under H0	5H: Map the full suite of microhabitats (depths and velocities) available for different life stages within selected mainstem reaches of species not covered by 2H
	Ramping rates at dam appear insufficient to prevent fry stranding (from anecdotal field observations during fry sampling (1J, 2J, 3J))	5J: Monitor fry strandings numbers and evaluate as proportion of annual production

Box in Fig. 2.4	Notes	
	Observations of low egg to fry or egg to smolt survival indices from assessments 13A, 1A, 4J, 2J	7J, 6J: Monitor abundance of non-native predatory fish species and their predation rates on fry and smolts, system wide (including rehab sites)
	If clear inferences obtained on what forms of physical attribute variability are correlated with fish habitat suitability and/or fry presence (analyses linking 1P and 2H, or 1P and 2J, 3J, 1J)	3P: Assess hydraulic parameter variability in 2-D model
	Geomorphic mapping (1P) indicates more investigation is required to document changing conditions	13P: Map coarse bed-surface grain sizes 15P: Quantify historic and future topographic change to document lateral scour, deposition, and riparian berm evolution
	Problems observed from assessments 1W and 4W	5W: Monitor age ratios, health and breeding condition (productivity) of riparian bird species
	There are: a) large returns of spawners (13A); b) evidence from redd mapping that superimposition may be occurring (1A); and c) demonstrated feasibility of assessment (difficult to do)	2A: Monitor redd superimposition metrics
	Indicated species increase in relative importance for regulatory and/or ecological reasons	14A: Monitor adult escapement of Pacific lamprey 20A: Monitor harvest (tribal) of naturally produced Pacific lamprey 15A: Monitor adult escapement of green sturgeon 21A: Monitor harvest (tribal) of naturally produced green sturgeon 14W: Monitor the demographic structure (proportion of different age classes) and survivorship of WPT populations
	Anecdotal evidence accumulates that invasive species are a serious problem for ecosystem and VECs	15W: Monitor abundance of invasives (e.g., bull frogs, New Zealand Mud snails)
1D	Core program must be maintained for 2-3 decades. Most require annual monitoring, though some assessments (e.g., geomorphic maps – 1P, valley vegetation maps – 2R), are required less frequently, as summarized in Appendix H.	

<table>
<tr><th>Box in Fig. 2.4</th><th colspan="2">Notes</th></tr>
<tr><td></td><td colspan="2">Column 2: AEAM to revise annual flow and sediment actions</td></tr>
<tr><td>2A</td><td colspan="2">To be both a feasible and necessary AEAM feedback to management actions, AEAM assessments must complete the four steps described for Box 1A (above), and also demonstrate the following attributes:
a. management targets (similar to the sharpened objectives described under Box 1A);
b. reliable, cost-effective[6] model linking action to outcome (i.e., if we increase or decrease flow / sediment, we know how outcomes will change);
c. if…then decision rule regarding unacceptable outcomes that require change in management action (e.g., management objective not achieved in > x% of system after y years[7]), and ability to evaluate this decision rule with an acceptable level of certainty;
d. ability to aggregate site-specific observations of outcomes to reach or system scale, so that decision rules are based on large scale patterns; and
e. substantial risk to ecosystem or Program Goal if flow / sediment management actions are not revised when objectives are not achieved (e.g., significant risk of vegetation encroachment, significant risk of thermal impacts on fish growth or survival).
For example, assessment 7H (temperature) has all of these attributes. Assessment 6P (assessing bed mobility) fulfills only some of these attributes (i.e., the TRFE has targets (a) and the IAP/TRFE describes encroachment risks if bar surfaces aren't scoured in wet years / lack of bed mobility (e), but it isn't clear that there's a model (b), a decision rule (c), or a system-scale aggregation approach (d)).</td></tr>
<tr><td>2B</td><td colspan="2">Core program includes only those AEAM assessments which have fulfilled the five conditions in Box 2A. These are implemented on an annual basis to assess need for changes in flow and sediment management actions, following procedure in Section 1.4.2 of IAP.</td></tr>
<tr><td rowspan="5">2C & 2E</td><td colspan="2">Contingent assessments: Various assessments currently labeled contingent could become high priority if certain conditions occur, as identified from other primary assessments and pilot studies.</td></tr>
<tr><td>IF primary assessments, pilot studies and management priorities indicate …</td><td>THEN consider doing these contingent assessments (listed in order of priority)…</td></tr>
<tr><td>Fulfillment of five conditions in Box 2A for a feasible and necessary AEAM assessment (demonstration in 2009-10)</td><td>7P: Predict changes in gravel storage as determined from coarse sediment budget calculations
8P: Monitor coarse sediment inputs from tributaries
14P: Predict sediment transport and use predictions to help guide annual flow scheduling process
5R: Model how streamflow actions will affect the bank location of initiating seedlings</td></tr>
<tr><td>Temperature monitoring and modeling under 7H suggests potential problems for target species</td><td>8H: Monitor the degree of thermal heterogeneity for the program area
12W: Monitor the structural and thermal complexity of habitats available for Western Pond turtles (WPT) at rehab sites (could be linked with assessment 8H)</td></tr>
<tr><td>Clear demonstration of need for this information to make management decisions</td><td>8A: Monitor maturation timing of adult fall and spring Chinook salmon
10A: Monitor the extent of hybridization between fall and spring Chinook salmon</td></tr>
</table>

6 SAB recommends evaluating the cost effectiveness of modeling by: 1) estimating true costs of modeling (funding to modelers, data collection, meetings, training); 2) projecting level of certainty in model predictions over next 2, 5 and 10 years; and 3) if necessary, getting an independent panel to comment on 1 and 2.

7 The duration of the decision rule is important (e.g., coarse sediment balance maintained annually or over 5 years).

Box in Fig. 2.4	Notes	
	Temperature data, fish health, weights (4J, 7H) suggests there is a problem with existing targets	12H: Re-evaluate appropriateness of the species-specific Water Year and seasonal temperature targets for rearing juveniles, outmigrating smolts and spawning adults being used in the Trinity River
	Riparian mapping (Assessment 1R and 3R) suggests more detailed investigation is warranted	4R: Monitor plant induced berm-growth
	Abundance of target riparian birds declines >30% across Program area	5W: Monitor health and productivity of target riparian birds at rehabilitation and control demographic sites
	Column 3: AEAM to revise channel rehab site designs.	
3A	Complete the four steps described under Box 1A. Apply the five criteria listed for Box 2A to determine which rehab site evaluation assessments are both feasible and necessary, but as applied to revision of rehab site designs rather than flow and sediment management actions. What do we mean when we say a particular rehab site design feature is "working" or not?	
3B	Implement those rehab site assessments which have fulfilled the requirements in Box 3A, and revise rehab site designs as required. These rehab site assessments should as much as possible work within the system-wide GRTS sampling design.	
3C	If assessments demonstrate need, continue to make further tweaks to rehab site designs within duration of construction permit period.	

2.5 Integration

What do we mean by the term *integrated* when we refer to an Integrated Assessment Plan? The term is used frequently by TRRP scientists, both verbally and in writing (version 0.9 of the IAP used various conjugations of *integrate* over 70 times). Version 0.90 was criticized as not being "sufficiently integrated." Attempting to deal with this criticism has been made more difficult by the ambiguity of the term. Discussions at IAP workshops among scientists and managers have revealed that there are multiple interpretations of what constitutes *well-integrated* assessments, and that individuals have strongly-held, differing views on both which attributes of integration are most important, and the degree of integration required. Dictionary definitions of the verb "integrate" are very general and not particularly helpful (e.g., "to form, coordinate, or blend into a functioning or unified whole; to make whole or complete by bringing together separate parts"[8]).

Without greater clarity of meaning, there is a risk that the term *integrated* will become a "plastic word" (Poerksen 1995). While once being a scientific word with a specialized meaning, a plastic word has now been stripped of that meaning, has become malleable to fit multiple circumstances, displaces more precise words, and actually blurs meaning (Poerksen 1995).

This section of the IAP attempts to restore some clarity and functional use to the term *integrated*, with the objectives of both improving communication and guiding further IAP improvement. At an IAP Workshop held November 6–8, 2007, the group jointly developed Table 2.4, which defines eight different attributes of integration considered essential to the success of the IAP. To avoid confusion, none of these definitions use the word *integrate*. A similar, independent effort to define *ecosystem management* converged on many of the same attributes (Grumbine 1994). While healthy differences of opinion persist on which of these attributes are most critical to the success of the IAP, this table of definitions was accepted by all IAP authors.

[8] Merriam-Webster; Webster's New World Dictionary of the American Language

Table 2.4. Attributes of integration essential to the success of the IAP, as defined and accepted by IAP authors at a workshop held November 6-8, 2007.

Attribute of Integration	Purpose
1. Linkage Among objectives and sub-objectives to Achieve Program Goal	Clarify how each of the subsystem's major objectives and sub-objectives jointly combine to achieve the Program goal.
2. Qualitative and quantitative functional relationships that link across subsystems (e.g., actions ⇒ fluvial processes ⇒ habitat ⇒ juvenile fish ⇒ smolts ⇒ adult fish)	Illustrations of hypothesized cause-effect relationships clarifies how component analyses can by synthesized to explore of the consequences of alternative management actions. The shapes of curves illustrate alternative hypotheses. The strategy for developing these relationships is to break the system down into component parts, understand those components, and then re-synthesize that understanding into tools (e.g., models, statistical analyses) connected to actions.
3. Development of performance measures, field measurements and assessments that serve multiple or complementary objectives.	Maximize the ability to develop cause-effect relationships and test hypotheses. Improve cost-effectiveness, so that certain types of data are only gathered once, but have multiple applications.
4. Coordinated sampling design to address multiple assessments, test critical hypotheses, and aggregate field measurements to the required scale.	Common locations and times for sampling performance measures that are used in multiple assessments, to improve cost-effectiveness. Well planned contrasts over space and time to test hypotheses and provide inputs to #2. Rigorous methods of site selection to ensure that, if required, site-scale measurements can be scaled up to reach and system wide scales (, habitat area, habitat vs. flow).
5. Synthesis of assessments across disciplines for annual AEAM decisions	Explore the consequences of alternative management actions for multiple objectives, facilitating robust decisions that make the best use of each water year given the current state of the system. Synthesize data for complimentary assessments.
6. Programmatic commitment to AEAM	Ensure commitment to the complete 6-step AEAM process (hypothesize/predict ⇒ design ⇒ implement ⇒ monitor ⇒ assess ⇒ revise) in the implementation (RIG), science (TMAG and partners) and policy (TMC) structure of the TRRP.
7. Compilation of key performance measures from multiple subsystems into a relational database	Ensure that TMAG acquires data from partners and contractors. Promote the development of cause-effect analyses and application of models across subsystems, using common data structure.
8. Coordinate management of issues not directly under TRRP control but affecting Trinity R ecosystem (e.g., hatchery operations, Klamath, harvest)	Ensure the overall goal of TRRP is achieved, and not undermined by other management actions

2.5.1 Linkage among objectives and sub-objectives to achieve Program goal

The restoration strategy involves multiple, coordinated actions to support multiple ecosystem processes and components. High level linkages among objectives are illustrated in Figure 2.1 and Table 2.1. For example, Objective 1.1 ("Increase physical habitat diversity and availability") supports the achievement of riparian, wildlife and fish habitat objectives. More detailed versions of Table 2.1 (see Appendix E) reveal other linkages among sub-objectives.

2.5.2 Qualitative and quantitative functional relationships that link across subsystems

Independent assessments of each of the rows in the Figure 1.3 (the system conceptual model) provide information on the *status and trend* of each system component. While this is absolutely necessary, it does not provide insights on *interdisciplinary* cause-effect relationships, that is, on the arrows which lie *between* the rows of Figure 1.3. Reducing critical interdisciplinary uncertainties is necessary to evaluate the overall effectiveness of the TRRP restoration strategy, to diagnose any 'weak links' in the strategy, and to determine how management actions should be modified to improve outcomes. Appendix D summarizes various cross-system interdisciplinary linkages identified by TRRP scientists as being important to improving management actions over the long term.

Wilson (1998) promoted the idea of *consilience*, which he describes as "a deliberate systematic linkage of cause and effect relationships across disciplines" (Wilson 1998:29). For the TRRP, critical cause-effect, interdisciplinary relationships are those for which increased knowledge would significantly change management decisions (middle part of Figure 2.5).

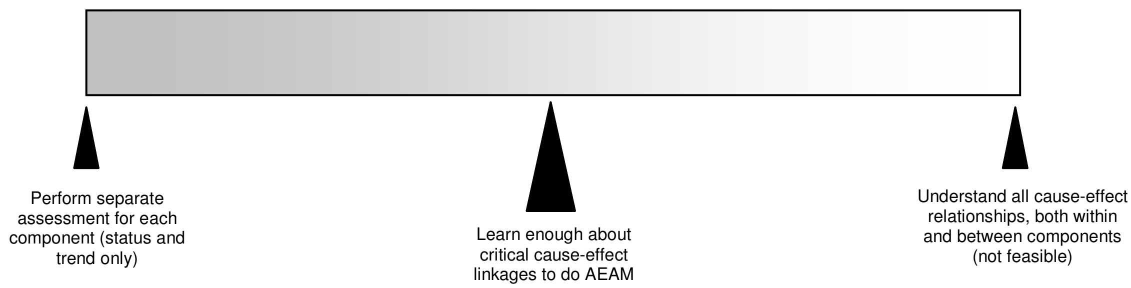

Figure 2.5. Interdisciplinary cause-effect linkages in the TRRP. Separate assessments of each subsystem's key performance measures provide an indication of the status and trend of each monitored component (left side of figure). A complete understanding of cause-effect relationships (right side of figure), is not feasible, either scientifically or financially. An intermediate position, not necessarily half way between these two extremes, is to provide enough insights about *critical linkages* between and within subsystem/disciplines to be able to effectively implement AEAM (middle of figure).

Figure 2.6 illustrates some of the important cross-system, interdisciplinary linkages described in the Conceptual Model Document (TRRP 2005). The arrows on the left side represent the change of *causation* that occurs in nature. The arrows on the right side reflect efforts to break down the system into a few components that can be studied separately to improve *understanding* of those pieces of the puzzle. Examples include understanding the functional relationships between:

- [the type of channel rehab action (simple/cheap vs. complex/expensive)], [the frequency of channel-forming flows] and [the rate of formation of alternate bars in different types of reaches];
- [the amount of alternate bars in a reach] and [the area of preferred fry rearing habitat with suitable temperatures and flows during the fry rearing period];
- [the area of different types of preferred fry rearing habitat] and [the level of fish utilization of these habitats];
- [the fish habitats that are utilized], [food available in these habitats] and [juvenile fish growth];
- [juvenile fish growth] and [smolt production]; and
- [smolt size, health and production] and [adult fish production].

Figure 2.6 expands upon Figure 2.5, and shows examples of some functional relationships which could be used to link flow actions to juvenile fish growth and production. The intent is to build a complete cause-effect chain from management actions to adult salmon returns. The Y-axis of one relationship becomes the X-axis in the subsequent relationship. The rationale for these functional relationships (and other related factors) is described in much more detail in Appendix C. Beginning at the bottom of Figure 2.6, functional relationships are developed to link flow and temperature to an estimate of fry rearing habitat capacity. Fry rearing capacity can be translated into the potential number of fry based on the habitat requirements of each fry. The potential number of juveniles is shown in the middle of Figure 2.6 as a function of both the potential number of fry and the amount of juvenile rearing habitat. The next step considers juvenile growth as a function of temperature and food (right side of figure). The combined set of functional relationships can then generate numbers and growth rates of both fry and juveniles (top of Figure 2.6). The size of outmigrants in turn has a significant effect on smolt to adult survival rates (Figure 2.8), which is critical to estimating the ultimate effect of management actions on adult returns. In summary, this suite of relationships hypothesizes that adult returns will increase as improvements are made in both habitat capacity and ecosystem productivity.

Challenges and strategies for dealing with them

Incomplete understanding of cause-effect chains

Some of the biggest scientific challenges are at the bottom and top of the cause-effect chain shown in Figure 2.6. At the bottom of Figure 2.6 (boxes 1–3), there are models of system components like sediment transport, but insufficient understanding to reliably predict how the overall distribution, size and character of the river's physical features from Lewiston Dam to the North Fork will evolve as a function of management actions. Mapping is essential to provide a picture of how these physical features are changing over time, but complementary work is required to develop a functional understanding of how physical features change in response to flow manipulation, coarse sediment augmentation, channel rehab projects and watershed rehabilitation actions. In the middle of Figure 2.6, relationships like those in Figure 2.7, or simulation models such as SALMOD, can be used to link box 3 (physical form) to box 6 (smolt production). At the top of Figure 2.6 (i.e., from box 6 (smolt production) to box 7 (adult production), further work is needed to complete the cause-effect chain, including functional relationships to predict smolt to adult survival rates, as a function of smolt size, health, harvest and other factors like estuarine and ocean conditions.

Some functional relationships can be established empirically whereas others must be modeled. In some cases best guesses from experts (e.g., a scientific panel) may be required to complete the cause-effect chain until adequate data are collected. Sensitivity analyses of a complete model are important (i.e., with all major links, even if some are guesses), so as to identify those links where improved understanding would have the strongest benefits for both revising management actions and improving Program outcomes (e.g., Alexander *et al.* 2006). These *critical* links should receive priority attention. Each pathway should be written down, with the units of measurement labeled (i.e., no 'conceptual' axes). Each integrative pathway should mature (refining the X-Y's, oftentimes selecting different units of measurement) and be expected to morph through time (replacing X-Y's). Some pathways might be eliminated and/or new ones created.

Creating contrast

Developing reliable X-Y (or multivariate $Y= F(X_1, X_2, X_3)$) functional relationships requires contrasts in the X variables. The TRRP is an imperfect experiment. It is a large scale rehabilitation experiment on one river (i.e., no spatial replication), with actions implemented over several years, and habitat/biota responses over several decades, and many potentially confounding factors (bottom row of Figure 1.3). However, there *are* possibilities for using smaller scale contrasts within the overall experiment, with a greater level of control, to yield insights on the above described functional relationships.

Top-down vs. bottom-up

Wilson (1998:73–75) makes the critical point that it is far easier to gain understanding in a top-down fashion than bottom-up, since the higher levels of a system (e.g., habitat selection by juvenile fish) have emergent properties that can only be understood at that level, and are not predictable from lower levels (e.g., the physics of bank erosion and alternate bar formation). He notes that progress in the natural sciences has been made by working top down across two or three levels of organization at a time by reductionist analysis, and then bottom up across the same levels by synthesis.

Ecosystem emergent properties were defined by George Salt (1979) as a property "which is wholly unpredictable from observations of the components of that unit". Examples include population regulation (Berryman *et al.* 2002), landscape diversity in river corridors (Ward *et al.* 2002), movement of migratory fish among habitats (Fausch *et al.* 2002). These complex properties are scale dependent, non linear, and not always quantifiable (Fausch *et al.* 2002; Wiens 2002; Rai and Anand 2004). It therefore makes the most sense to work through the causal chains in Figures 2.6 and 2.7 first in a top-down manner, i.e., from the observed responses and distribution of fish and other valued ecosystem components, down to the actions and physical processes which created their preferred habitats. Then, one can use various quantitative tools and qualitative descriptions to re-connect the pieces together in a bottom-up effort of synthesis, so as to fine tune management actions.

Clarity about linkages

The IAP needs to specify the spatial and temporal scales at which data will be gathered and analyzed to elucidate cause-effect relationships, the specific performance measures to be assessed, the performance standards that are sought to fulfill TRRP objectives (where known), the triggers for revising management actions, and the exact information to be transmitted between subsystems (units, scales, etc.). Each of the separate sub-sections of Chapter 3 will describe in general terms the proposed approach to understanding key cause-effect relationships, with much more detail to be provided in Chapter 4 of the IAP.

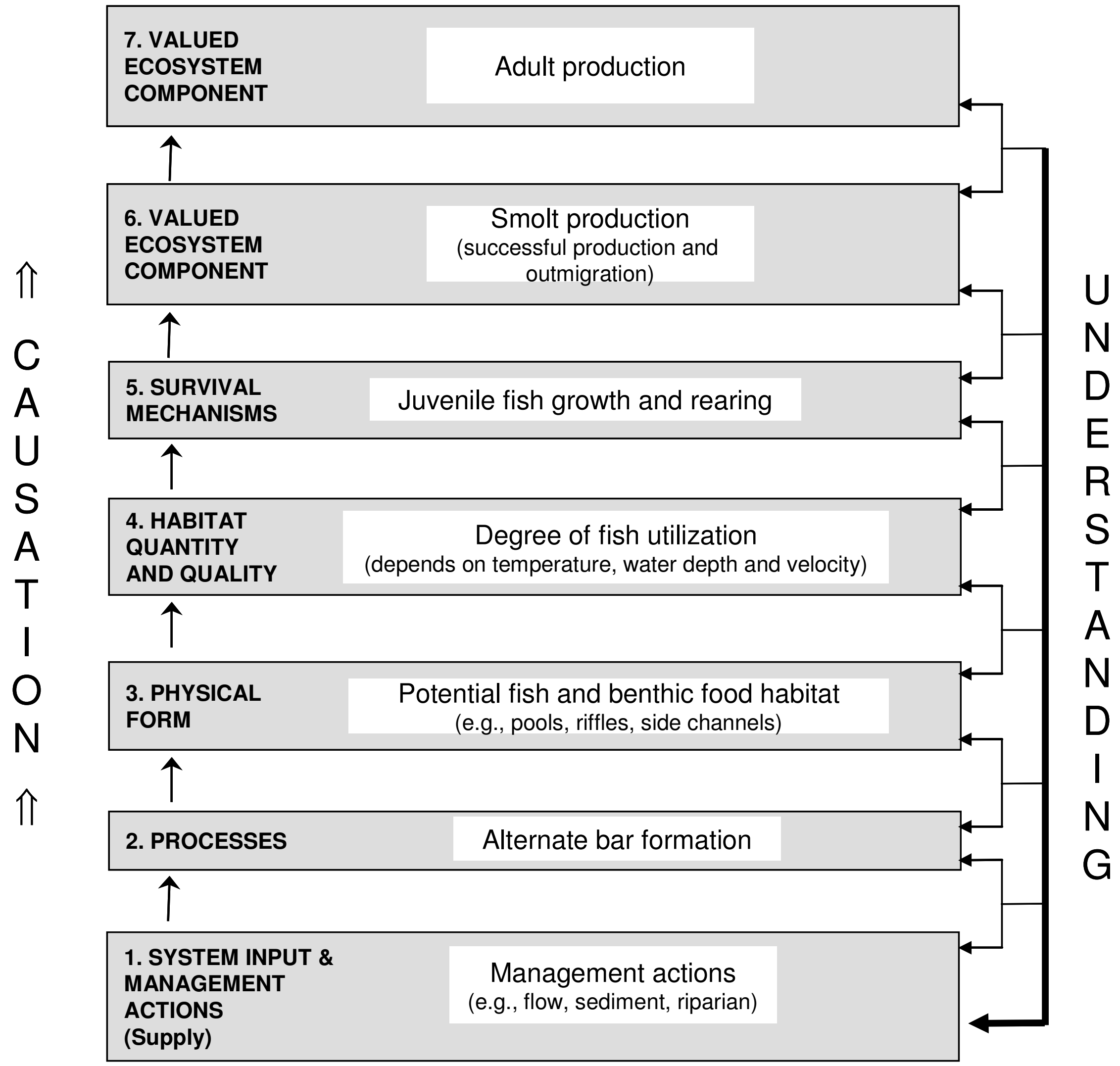

Figure 2.6. Understanding cause-effect linkages. A schematic diagram representing come of the cause effect linkages that lead from TRRP management actions through changes in fluvial geomorphic processes, physical form, habitat utilization and biological responses. The arrows on the left side represent the change of *causation* that occurs in nature. The arrows on the right side reflect efforts to break down the system into components that can be studied separately to gain *understanding* on cause-effect relationships, with the end objective of modifying the management actions at the bottom of the figure. Source: Adapted from the Conceptual Model document (TRRP 2005).

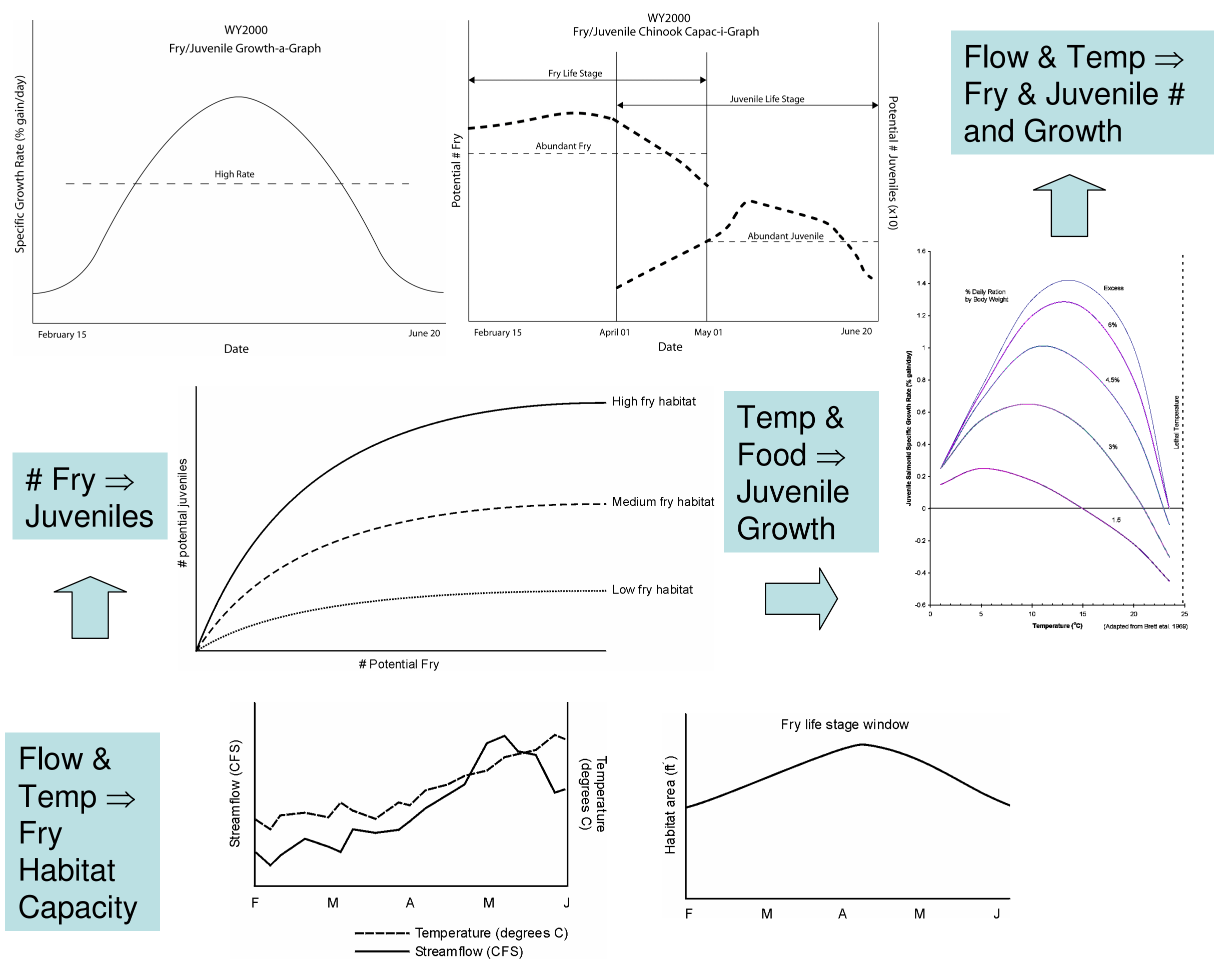

Figure 2.7. Examples of possible salmonid causal chains that could be explored through TRRP models. The text provides a short summary of these graphs; more details are provided in Appendix C.

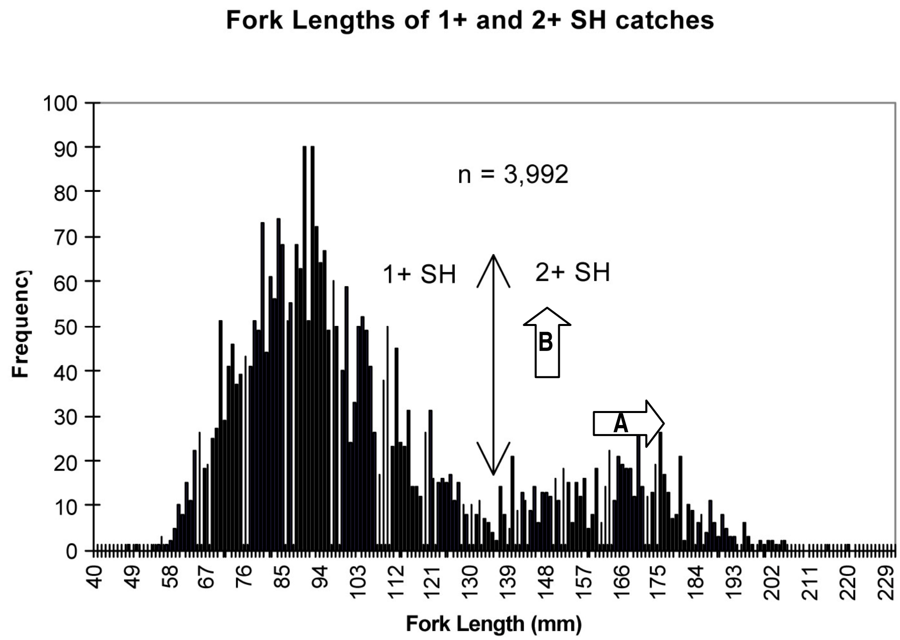

Figure 2.8. Example of size class distribution of steelhead juveniles and smolts with shifts upward and to the right to illustrate changes in capacity and productivity. Smolt to adult survival increases substantially when fork lengths are greater than 150 mm (Bill Trush, pers. comm.*)*, so shifting the size distribution to the right (A) and upwards (B) will improve adult returns. Further details are provided in Appendix C.

2.5.3 Development of performance measures, field measurements and assessments that serve multiple or complementary objectives

Performance measures and assessments can be designed to serve multiple or complimentary objectives. For example, if properly designed, maps of landscape units can support geomorphic, fish and wildlife assessments. This requires considerable interdisciplinary dialogue to ensure that all relevant landscape units are considered. Substrate assessments used to assess coarse sediment mobility can also provide information for assessing spawning habitat quality. Serving multiple objectives may require additional field measurements (e.g., permeability of redds) that might not be normally undertaken for geomorphic assessments. Again, this requires interdisciplinary dialogue. This kind of data sharing requires careful specification of the scales of interest to each assessment, which requires coordinated sampling design (Section 2.5.4).

2.5.4 Coordinated sampling design

Coordinated sampling design involves planning and making different types of observations at the same places and times (Simms and Thomas 1982; Parr *et al.* 2002; FEI 2007). This is required for four reasons. First, coordinated sampling design is required to develop the cause-effect relationships discussed above in Section 2.5.2 (e.g., flow and sediment transport measurements done at the same places and times can be used to develop bedload transport curves, fish habitat and fish utilization assessments in the same places and times allow inferences on preferred habitats). Second, contrasts are necessary to test hypotheses, and well-designed contrasts (over space and time) produce stronger evidence. Third, converging on common sites, variables and sampling periods allows the Program to satisfy multiple objectives and users without unnecessary duplication of effort or cost (Hicks and Brydges 1994; Parr *et al.* 2002; UNECE 2007). Finally, coordinated sampling design generates rigorous estimates at multiple scales of interest (site, reach, system). TRRP monitoring variables could be sampled/stratified in space in many ways, including: 1) at a series of **representative river sites or segments** that might later be extrapolated to the whole system scale (e.g., a rigorously selected probability sample of meso-habitat types); 2) a **census at the whole system** (40+ miles) **scale** (e.g., maps of habitat types, vegetation; spawner census, emigrant trapping), or 3) at **non-representative river sites or segments** chosen to understand processes and fine tune management actions at certain key locations (e.g., sediment transport at the Rush Creek delta).

The first two sampling methods can promote data sharing and application of inferences to multiple assessments at many different locations. However, the sampling strata must be carefully defined (e.g., a geomorphologist might be interested in assessing grain size distributions over a whole reach, while a fish biologist is only interested in grain sizes within spawning habitats). Insights from non-representative sites or segments (the third method described above) are by definition only applicable to those locations. These issues are addressed in more detail in Chapter 4.

2.5.5 Programmatic commitment to AEAM

For AEAM to succeed, the linkage of management actions, monitoring, assessments or evaluations, and decision making (Figure 1.2) needs to be pre-planned. If this is not done, then a number of problems can emerge, including (summarized from Bisbal 2001, and Walters and Holling 1990): confusing information for decision makers, poorly tied to goals and objectives; late recognition that the data collected are not amenable to useful analysis and interpretation; delays in evaluation of monitoring data; late discovery that monitoring did not address key management uncertainties; lethargic incorporation of environmental signals into policy; absence of a structured mechanism to introduce scientific/technical findings into decision making processes; and exacerbation of the uncertainty that typically surrounds policy decisions. Conclusions on the efficacy of TRRP actions, and the influences of confounding factors (i.e., bottom row of Figure 1.3) will only be as strong as the experimental design that generated them.

2.5.6 Compilation of key performance measures from multiple subsystems into a relational database

The IIMS is described briefly in Section 1.4. Its structure facilitates inter-disciplinary analyses and syntheses that would not otherwise be possible, and also ensures that the Program has a complete, well documented record of all performance measures over time, with consistent spatial / temporal co-ordinates and metadata. This is especially important in the event of staff turn over.

2.5.7 Coordination of management of issues not directly under TRRP control

Section 1.4 (and Table 1.4 in particular) discusses the primary hypothesis being tested by the TRRP (i.e., “H0: The quantity and quality of freshwater habitat for fry rearing as well as juvenile or adult life stages limits the rate of recovery of salmon and steelhead populations.”). It is however recognized that other factors (e.g., harvest, hatchery, Trinity watershed actions, Klamath River and estuary conditions, etc.) also affect Trinity River fish populations. Hence coordination with other management entities is very important, at the very least to exchange information and analyses. If Program actions and assessments provide compelling evidence against H0 (i.e., increasing habitat does not improve juvenile fish production), or indirect evidence suggests that factors other than habitat are strongly limiting the recovery of Trinity River fish populations, then the Program will need to urge other entities to re-examine current management practices, even though those practices are not under TRRP control.

3. Why is each assessment required and what does it involve?

3.1 Objective 1: Create and maintain spatially complex channel morphology

The TRFE (USFWS and HVT 1999) emphasizes the importance of creating and improving physical habitat for achieving the Program's goals. The TRFE concluded that smolt production from the Trinity River is limited by available fry rearing habitat, particularly between 300 cfs and 2,000 cfs, above which the riparian berms begin to overtop and fry rearing habitat availability increases (Figure 5.4 in TRFE). The TRFE recommended, and the ROD adopted, a restoration strategy where selective removal of the riparian berm, combined with flow and sediment management to create and maintain a complex alluvial channel, will increase channel complexity in a way that will increase fry rearing habitat availability, as well as habitat for other species and life stages.

By definition, the chief characteristic of an alluvial river is that the flow regime is competent to frequently mobilize channel sediment. In that case, channel form is ultimately determined by sediment transport processes in the mainstem. Sediment production and delivery processes in the watersheds and tributary channels are integral to the mainstem transport processes. In addition to these factors, the Trinity River has a significant amount of bedrock that exerts a great deal of influence on the channel form. The TRFE identifies another fishery resource stressor—loss of substrate quality associated with excessive fine sediment inputs to the Trinity River. Promoting the physical processes that create geomorphic complexity in the mainstem Trinity River and managing upslope sediment production and delivery are therefore among the key physical sub-objectives of the Program.

Assessments described in this section fulfill at least one of the following purposes: 1) track progress toward TRFE and ROD objectives that contribute to the Program goals; and/or 2) assess the effectiveness of specific management actions on TRFE and ROD objectives that inform and improve Program management for achieving Program goals. The AEAM strategy of the ROD encompasses both of these purposes. The basis of the strategy is the concept that management actions are driven by TRFE hypotheses regarding expected system responses, and assessments are designed to evaluate the validity of those hypotheses as well as performance towards Program goals. Physical process thresholds serve as intermediate management objectives as used in Table 8.2 and Tables 8.5-8.9 in the TRFE, and are an important component of developing and testing other priority hypotheses that may improve progress towards Program goals. Specifically, the TRFE recommended flows to:

- mobilize and scour the bed (flow release magnitudes ranging from 4,500 cfs to 11,000 cfs);
- transport coarse sediment through the mainstem at a rate equal to tributary input downstream of Rush Creek (5-day peak flow duration, but can vary depending on actual sediment delivery in a given year);
- transport fine sediment through the mainstem at a rate greater than tributary input downstream of Limekiln Gulch gaging station (flow release magnitudes and duration); and
- initiate bank erosion (flow release magnitudes ranging from 8,500 cfs to 11,000 cfs).

3.1.1 Sub-objective 1.1: Increase physical habitat diversity and availability

1.1.1 Increase the size, frequency and topographic relief of bar/pool sequences

1.1.2 Increase channel/thalweg sinuosity

1.1.3 Increase geomorphic unit and substrate patch diversity

TRRP management activities (ROD flows, coarse sediment additions, and mechanical actions) are intended to increase fluvial processes beyond key magnitude, duration, and frequency thresholds, preventing detrimental riparian encroachment and increasing the topographic and structural complexity of the channel through time. Together, these management action outcomes will increase and maintain high quality fish habitat. This hypothesis links to Sub-objective 2.1 (increasing and maintaining physical habitat) through the hypothesis that the quality and availability of aquatic habitat is directly related to geomorphic diversity, among other factors (water temperature, food sources, flow).

HYPOTHESIS:

Sub-hypotheses of TRRP management activities include:

- Increased high flows, coarse sediment augmentation, and reduction of erosion resistance at bank rehabilitation locations will increase channel migration rates, thereby increasing sinuosity, active bars, hydraulic complexity, and grain size complexity.
- Increased high flow regime and coarse sediment augmentation (1/2" to 4") will increase bed mobility, increase grain size complexity, and increase the size, frequency, and topographic relief of bar/pool sequences.
- Increased high flow regime and coarse sediment augmentation will increase geomorphic unit diversity and frequency, as well as substrate patch diversity.
- Increases in geomorphic complexity will increase physical habitat complexity, availability, and quality.
- Increases in channel complexity will propagate downstream from rehabilitation sites due to the rehabilitation activities, increased high flows, increased coarse sediment supply, and large wood augmentation. As bars form at rehabilitation sites, thalweg sinuosity increases, and hydraulic complexity increases, bars and other forms of geomorphic complexity should propagate downstream of the treated sites.

Additionally, as described in Section 3.5.2, there are two sub-hypotheses that differ on the level of risk to future detrimental riparian encroachment. This risk of detrimental riparian encroachment, by way of its role in channel simplification, is closely linked to physical habitat diversity and availability described in this section.

Proposed assessment strategy and rationale

Among the primary Program objectives of the TRFE (USFWS and HVT 1999), and incorporated in the ROD (USDOI 2000), is the creation and maintenance of spatially complex channel morphology in the Trinity River between Lewiston Dam and the North Fork Trinity River. This objective is motivated by the well-established principle that complex channel morphology provides the physical basis for diverse, high-quality aquatic and riparian habitat (Stanford *et al.* 1996; McBain & Trush 1997; Poff *et al.* 1997; Pitlick and Van Steeter 1998; USFWS and HVT 1999; Amoros 2001; Ward *et al.* 2002).

The proposed assessment strategy encompasses three critical components: 1) refining and testing of the geomorphic conditions that contribute most directly to ecosystem health and the production of anadromous salmonids in the Trinity River; 2) quantifying the abundance and quality of those geomorphic conditions; and 3) refining and tracking of the geomorphic thresholds needed to maintain the complex channel morphology and manage the risk of detrimental riparian encroachment. The TRRP needs to continue efforts to improve definition and quantification of the linkages between specific landscape elements and habitat, especially salmonid rearing habitat.

The assessment strategy needs to build from the understanding synthesized in the TRFE and, based on a careful process of identifying critical scientific and management uncertainties, focus effort on the specific analyses or performance measures needed to reduce these uncertainties and improve management success. The assessment strategy for components 1) and 2) will focus on periodic remote sensing approaches using aerial photographs, terrestrial LIDAR, and/or bathymetric LIDAR, as well as site-specific correlations between geomorphic conditions (e.g., mapping of geomorphic features and grain sizes) and abundance of fish spawning and rearing habitat. Section 3.1.2 describes the assessment strategy for component 3.

Spatially distributed data (described above) will need to be supplemented with measurements confined to localized areas or to fewer spatial dimensions (e.g., sub-sampling). These supplemental measures focus on bank rehabilitation sites, but may also include other features, such as naturally-formed bars, reaches downstream of bank rehabilitation sites where natural channel evolution is expected, and areas of potential riparian berm evolution. Plots, transects, or other forms of sub-sampling are needed to calibrate/validate map unit assignments when mapping vegetation patches, sediment facies, large wood, and other landscape features. Similarly, this sub-sampling provides a means to track topographic changes with greater spatial or temporal resolution than map-based methods, which will validate and quantify interpretations of imagery and other observations in years when comprehensive topographic data (e.g., LIDAR) are unavailable. It is recommended that the assessment strategy include a network of channel transects that are re-surveyed periodically within the GRTS sampling design. Where not currently established or maintained, such transects should be established or re-established as part of the implementation/effectiveness monitoring associated with channel rehabilitation projects. It will also be useful to obtain a longitudinal profile of the bed surface along the channel centerline on an annual or sub-annual basis to document temporal changes in topographic complexity of the streambed.

There needs to be an assessment of substrate size and patches by monitoring particle size patches or facies of the coarse sediment fraction of the mainstem bed surface. A field-based map would delineate patches of bed in which the grain sizes are relatively homogeneous. Grain sizes within patches can be summarized by a few standard quantiles, for example, the median grain size (D_{50}) and the 90^{th} percentile grain size (D_{90}) of the coarse sediment fraction. Substrate mapping over large areas would likely require a heavy reliance on visual estimation, combined with some level of “calibration” sampling through pebble count or photographic methods. Reach-averaged substrate size (using D_{50} and D_{90}) could be computed by a weighted average of the substrate polygon areas. However, the amount of sampling needed to track changes in a statistical manner will likely require substantial effort. Therefore, coarse sediment substrate mapping should be more rigorous at GRTS sampling sites where salmonid habitat assessments are conducted. Facies maps or grain size contour maps should be prepared at these GRTS sample sites, and data to describe the maps should be collected using pebble counts, photographs of the bed surface with computer-based determinations of grain size indices (e.g., D_{50} and/or D_{84}), or some other quantitative method to enable consistency and repeatability. This substrate mapping would be a subset of the geomorphic/habitat mapping used to assess channel complexity and physical habitat availability.

Lastly, several of the design elements of the bank rehabilitation projects need to be assessed to inform and improve the rehabilitation design process. Design elements include alcoves, berm notches, side channels, high flow scour channels, flattened tailings or pre-dam bars lowered to floodplains and others. The assessment strategy should focus on topographic surveys of the features over time to document physical evolution, and to correlate short-term and long-term changes with flow magnitudes, planform morphology, local sediment supply, and other driving factors. Assessments may also include documenting naturally formed and maintained features to better understand the mechanisms that are successfully maintaining them.

Proposed performance measures and analyses

Performance measures for proposed assessment strategy components 1) and 2) are not final. However, the remote sensing approaches proposed above will provide information for a variety of potential performance measures. A large number of additional layers and/or spatially distributed statistics will be generated, such as the number/area of bars/pools, bank lengths, planform statistics, hydraulic model outputs, indices of topographic variation. All these layers and outputs could readily be combined with additional data layers depicting physical attributes (e.g., valley confinement, bank materials, bedrock controls) or biological attributes (e.g., habitat suitability maps, snorkel surveys, cover types, spawning areas). Specific performance measures extracted from the data sets described above include:

- variability of bed elevations in a bathymetric digital terrain model;
- residual pool depths, variance in elevation, or auto-correlation analyses extracted from longitudinal profiles of the streambed;
- variability in channel width (or other aspects of channel geometry), as determined from air photos, surveyed bank lines, surveyed cross sections, or bathymetric data;
- variability in hydraulic parameters (i.e., depth, average velocity, average boundary shear stress) at cross sections as determined with a 1-dimensional hydraulic model;
- variability in spatially distributed hydraulic parameters (i.e., depth, depth-averaged velocity, shear stress) as determined with a 2-dimensional hydraulic model;
- frequencies, areas, or lengths of specific geomorphic features identified on geomorphic/habitat maps;
- frequencies or areas of bars or pools as mapped on air photos with or without field reconnaissance, preferably supplemented by bathymetry or other survey data;
- confining riparian berm lengths, as determined from air photos analysis or field survey of banks;
- confining riparian berm heights (and evolution), as determined from field-based cross section surveys;
- channel widths (450 cfs width, active channel, and/or bankfull channel, each of which need definitions for repeatable measurements over time);
- bank stability and/or erodibility index inventory that is descriptive of the type of bank stability (e.g., riparian berms, compacted mine tailings, bedrock, pre-dam grain size, and/or others);
- longitudinal profiles of water surface elevations and water surface slopes;
- channel sinuosity and/or radius of curvature determined from air photo analysis;
- frequency and location of thalweg crossings and/or hydraulic controls based on field mapping;
- large wood storage;
- area of spawnable gravels (defined by gravel size suitability criteria rather than flow depth and velocity criteria); and
- bed surface patch polygons or contour maps describing the D_{50} and D_{90} of the grain size of the sample site.

It may be infeasible to document all the above performance measures system-wide; therefore, a pilot project is recommended to evaluate and refine these performance measures. A short reach near Lewiston should be chosen to evaluate the performance measures, with criteria including: cost effectiveness, precision, repeatability, sensitivity of expected changes to management actions, and other factors.

Key performance measures

Measures of variability in bed elevations and channel geometry provide convenient metrics of channel complexity. A key performance measure should be a mapped area of active alluvial deposits above the 450 cfs water surface, where ‘active’ is the non-encroached bars that the post-ROD flow releases are maintaining via transport and deposition. The definition of active alluvial deposits will need to be refined to improve repeatability and consistency with repeat surveys. Time and budget may allow the addition of other performance measures. Section 3.1.2 describes key geomorphic threshold performance measures.

Candidate performance measures

No additional performance measures have been identified for this sub-objective, but others may be determined in subsequent RFPs that specify the details of required assessments.

Integration of performance measures with performance measures in other disciplines

A strategy to integrate geomorphic mapping with fish and amphibian habitat mapping and assessment has been developed and applied in a pilot habitat assessment project. The present mapping protocol combines a geomorphic map with a meso-habitat map, a habitat availability map based on habitat suitability criteria, and a map of bank/cover types. Riparian vegetation mapping integrates into this effort as well.

Key parts of the fish habitat assessment in Section 3.2.1 include: 1) quantifying system-wide and site-specific fish habitat quantity and quality for baseline conditions (pre-construction); 2) tracking habitat quantity and quality over time; and 3) developing potential habitat targets. Physical assessments can assist these efforts. Empirical analyses (described below) should improve our understanding of the relationships between management actions, bar development and channel width evolution, and the actual quantity and quality of suitable fish habitat created. Therefore, the longer term empirical analyses should inform the development of fish habitat targets and the likelihood of achieving them.

All bathymetric data collected for assessing channel complexity would have a wide range of applications. Topographic cross section surveys combined with data on vegetation colonization and mortality is a measure of geomorphic-riparian dynamics, and could be incorporated into habitat assessment efforts. New cross sectional geometry would be useful for updating a 1-dimensional hydraulic model for individual sites or the full project area, if needed.

Bathymetric data are valuable as a baseline for rehabilitation site design and are useful for constructing 1-D and 2-D hydraulic models. Two-dimensional hydraulic models have numerous applications, including predicting flow patterns and hydraulic variability, and the fish habitat consequences of alternative rehabilitation site designs and/or coarse sediment augmentation options.

The bed surface patch polygons or contour maps could be used as an overlay with the fish habitat mapping as a cover attribute (e.g., for spawning habitat criteria or fry rearing habitat criteria), and/or for 2-D habitat modeling as a grain roughness attribute (used to calibrate the 2-D hydraulic model to observed water surface elevations). The bed surface grain size maps and geomorphic unit polygons could also be overlaid with Yellow-legged Frog egg mass locations to correlate geomorphic changes with egg mass locations, numbers, and other parameters.

The riparian assessments (Section 3.5.1 and 3.5.2) will need the cross section and other topographic information, as well as substrate mapping information on bars and floodplains. The fish habitat assessment (Section 3.2.1) will require substrate information to assign cover values when defining habitat suitability, but those layers will be gathered by those conducting the habitat assessment rather than from the substrate maps at this time. Amphibian assessments (Section 3.6.4) would benefit from both the substrate mapping information and geomorphic unit mapping to correlate with suitable egg incubation areas.

Expected response

TRRP management actions should lead to an increase in the topographic and hydraulic variability of the channel, and in the frequency and diversity of geomorphic units. These changes should be most dramatic immediately after bank rehabilitation site implementation and, in the absence of detrimental riparian encroachment, should evolve due to ROD high flow releases and reach some form of equilibrium in 5–10 years (assuming a regular distribution of Normal, Wet, or Extremely Wet water years). The frequency and sequence of ROD flow releases, combined with coarse sediment augmentation and channel rehabilitation activities, should be sufficient to prevent detrimental riparian encroachment and corresponding channel simplification. However, if this is not the case and detrimental riparian encroachment does occur, we expect to see changes to channel morphology beginning within 5 years after plants along the low flow channel are three years old, and simplification of habitat occurring in a 5–10 year time frame afterwards. If these expected responses are not occurring, then ROD high flow magnitude and coarse sediment augmentation rates will likely need to be increased.

Analysis

This sub-objective includes, but is not limited to, two types of analyses: data reduction from the remote sensing information for producing performance measures, and analyses needed to close the loop between assessment results and adaptive management. The first step in the analysis would include GIS manipulations to select subsets of spatially distributed data, summarized in terms of absolute values (e.g., surface area), distributions, variances, or other appropriate statistics, as well as hydraulic modeling for deriving hydraulic characteristics from the topographic information.

Some performance measures chosen from the list above will be tracked as trends over time (e.g., time is the independent variable, and radius of curvature is the dependent variable), and some will be used to assess physical responses to a particular management action (e.g., peak flow magnitude as the independent variable and riparian berm heights as the dependent variable). Others will be used for analyzing both responses and trends (time or streamflow magnitude as independent variables and channel width as the dependent variable). The performance measures used for trend monitoring will be documented at the time intervals described below, stratified as needed by geomorphic reach, high flow regime, and/or sediment supply, then analyzed over time. Trend monitoring would emphasize spatial data (e.g., area of exposed active bars, lengths of eroding banks) as well as topographic data (e.g., riparian berm evolution on cross sections, topographic diversity).

The suite of potential performance measures listed above should be assessed for those measures which are most sensitive to a particular management action or are representations of long-term river trends. The performance measures that are effective representations of the system should be emphasized in trend monitoring. Proposed performance measures that respond quickly to management actions and are a direct result of a specific management action (e.g., changes in bed elevation or residual pool depths) should be identified, and the appropriate parametric or nonparametric multivariate analysis conducted to guide the selection of performance measures used in physical response monitoring.

Site-scale assessments of channel complexity should be integrated to the degree possible with channel dynamics and threshold monitoring (Section 3.1.2) and habitat assessments (Section 3.2.1). Cross section surveys will focus on documenting evolution in channel geometry at bank rehabilitation projects, but will also include additional cross sections placed in areas that have not been mechanically rehabilitated (but bars have formed) to assess whether channel morphology changes are propagating between rehabilitation sites. Because the total number of sample sites (rehabilitated and non-rehabilitated sites) is at least 46, the total number of established cross sections could also be large if all sites are selected and multiple cross sections are surveyed at each site. Therefore, a subset of rehabilitated and non-rehabilitated sites will be selected to enable expansion of results in a cost-effective manner. Site-scale assessments at channel rehabilitation sites will also include geomorphic mapping (geomorphic units, substrate patches, etc.) at those sites.

Site and/or reach-scale assessments of bed-surface grain size diversity should be analyzed by documenting temporal trends in patch size distribution. Estimates of reach-scale median grain size over time could be analyzed by computing a weighted average of grain size from the patch polygons. Site-scale analyses of grain size changes should be more precise given that a quantitative method will be used, which will also improve consistency and repeatability when grain size is determined over time. If facies maps are used, analysis would consist of documenting temporal trends in patch size distribution and grain sizes within those patches. If grain size contour maps are used, then changes in grain size can be analyzed by creating "cut and fill contours" of changes in grain size at the site. Refinement of the precise methods is still needed, specifically addressing sampling issues. Another approach may be to select specific geomorphic features for mapping and grain size quantification (e.g., pool tails, riffle crests) rather than all features within a given site.

This information will be used to assess the expected outcomes of management actions (predicted through a suite of conceptual and quantitative models), and if necessary, revise these actions to better achieve physical habitat diversity and availability.

Proposed space and time frames

Chapter 4 describes the specifics of sampling design for this sub-objective. Overall, rehabilitation sites will have more focused analysis in space and time (more detail, more frequent), with system-scale assessments being broader and less frequent.

Site and reach scale

Cross sections at rehabilitation sites and between rehabilitation sites will be re-surveyed on a rotating basis according to the length of time since they were last measured and the perceived magnitude of change. Site assessments should be scheduled to ensure that most, if not all, cross sections are re-surveyed within a 5 year period. Geomorphic and substrate patch mapping at rehabilitation sites should be mapped annually for the first few years following construction and less frequently thereafter (e.g., every five years). Bed surface substrate mapping should be prioritized in the reach between Lewiston Dam and Indian Creek, as well as at bank rehabilitation sites in the upper 40 miles, where we are expecting the most change due to ROD management actions. As is feasible, these site-scale assessments should be conducted under the GRTS sampling strategy described in Chapter 4.

System scale

System-scale, census-based assessments based on remote sensing will be conducted on a 3-5 year time-frame due to the cost of gathering the data; additionally, the expected effect size should be easier to detect over a longer time-scale. Some changes may also be more pronounced following Extremely Wet water years, and a system-scale assessment may be appropriate to detect these larger-scale changes. Aerial imagery (standard or infra-red) is currently acquired annually. Although current technology makes it possible to achieve good spatial accuracy without repeating the full orthorectification process, true orthorectification of the air photos should occur roughly every 5 years or following extremely wet water years.

LIDAR bathymetry data are being collected this year (2008). If sufficiently accurate, this method of developing two-dimensional topographic data between Lewiston Dam and the North Fork Trinity River will be implemented on an as-needed basis depending on sequencing of channel rehabilitation projects and high flow years. At the longest, system-wide topography should be updated roughly every 5 years. If LIDAR bathymetric data are not accurate enough to detect anticipated topographic changes (+/- 1 ft), then longitudinal bed profiles obtained from boat-mounted sonar will be used to document changes in bar/pool topography, and site-scale topographic surveys will be used to document change at bank rehabilitation sites.

System-wide geomorphic maps should also be updated approximately every 3-5 years or after larger channel-forming events. Annual site-scale monitoring will likely mean that some portions of these maps will be current at all times, so the system-scale update may not necessarily require remapping of the full 40 miles. System-scale geomorphic map updates can be deferred during periods of low flows if channel form does not change substantially.

System-wide assessments of the bed surface grain size distribution should be conducted every 5 years in conjunction with geomorphic/habitat mapping. The Lewiston Dam to Indian Creek reach is the highest priority because of the ability to detect changes as a result of TRRP management actions; the Indian Creek to North Fork Trinity River reach is the second priority due to the cumulative confounding effect of tributaries. Mapping over more limited area may be conducted at a site-scale more frequently as changes are observed. Current sediment transport theory holds that bed surface grain sizes represent an equilibrium condition with respect to the flow regime and sediment supplies, and are relatively stable over a number of hydrograph cycles (Wong and Parker 2006). The reach-averaged gradation of the coarse sediment fraction of the bed surface in the Trinity River is therefore expected to evolve relatively slowly.

Priority issues to address

Technical issues still to be resolved:

The primary issue to address is the risk of future detrimental riparian encroachment and risk of corresponding loss of channel complexity, as described in Appendix M. Both the concept and the terminology of Hypothesis 3.1.1 are derived from the TRFE. However, the TRFE provides scant guidance for interpreting the meaning of the term *complexity*. It has become increasingly apparent through the IAP writing process that the notion of channel complexity and its relationships to aquatic habitat require greater clarity. The long list of potential performance measures above is the manifestation of this lack of guidance in the TRFE. Complexity is here defined as spatial diversity in any of the physical characteristics of the stream system (water quality attributes are excluded). These elements include topographic and planimetric variability at all spatial scales (bars, pools, alcoves, side channels, bank crenulations, etc.), variations in materials (substrates, debris, etc.), and variability in the composition and structure of near-channel vegetation. A number of performance measures are available to assess channel complexity. The most suitable choice of measures depends to a large degree on which aspects of the riverine landscape relate most directly to the habitat characteristics the Program intends to create. We need to define which performance measures are most related to expected changes in fish habitat, and which, if any, are needed to define habitat or serve as input variables to a fish production model. If the fish group does not need these performance measures, then the priority of many of these potential performance measures and assessments will need to be lowered. The pilot project recommended above should help refine the performance measures chosen to assess changes in complexity, and relate those performance measures to changes in fish and amphibian habitats.

Differing views of the value of bathymetry constitute another priority issue in need of resolution. System-wide topography/bathymetry is extremely useful to the Program for 1-D hydraulic modeling and channel rehabilitation site designs, but it is also a moderately expensive item with uncertainty whether the elevational accuracy is sufficient to detect anticipated topographic changes or have adequate topographic accuracy for 2-D hydraulic models. The simpler alternative of using surveyed transects, total station surveys, or boat-mounted sonar surveys to characterize channel morphology has its own logistical problems – namely that a large field effort is needed to make reliable quantitative statements about system conditions – and could be extremely expensive for the spatial and temporal sampling periods recommended above.

The proposed assessment of the bed-surface particle size distribution requires a field method that is rapid, reasonably precise, and repeatable. There is general agreement that changes in bed composition should be assessed using a mapping-based approach, but the necessary degree of quantification and/or calibration needs to be refined. Bed particle sizes are quite variable, so that even using labor-intensive pebble counting procedures, an extremely large number of samples would be necessary to detect changes over large areas with a high degree of statistical confidence (Roper *et al.* 2002). Although even an experienced observer will have difficulty estimating grain sizes with a high degree of precision, visual estimates may be superior to any logistically-feasible sampling program for estimating grain sizes over large areas. Preliminary mapping efforts indicate that visual estimates generally yield grain size statistics within about 15% of those obtained by pebble count or other sampling protocols at a given location. A quantitative method for documenting grain size (pebble counts, photographic analysis) should improve repeatability and comparability of site-scale grain size assessments.

The TRFE identifies fry rearing habitat as the factor currently limiting smolt production in the Trinity River. However, as channel complexity increases, spawning habitat quantity and/or quality may become limiting in certain escapement years. Therefore, the importance of documenting spawning gravel storage and/or quality may become more important. Statistically significant sampling of spawning gravel quality can be a costly effort, so additional analyses and discussion is necessary to determine the importance of documenting spawning gravel storage and/or quality in the initial years of program implementation.

As part of assessing and interpreting topographic changes outside the low flow channel, additional definition is needed to help distinguish between desirable floodplain formation and undesirable riparian berm formation.

Policy issues still to be resolved:

There are several objectives and performance measures in the TRFE that need to be refined, such as routing coarse sediment through the Rush Creek delta backwater, transporting Rush Creek coarse sediment at a rate equal to transport on a yearly basis, and others. These objectives and performance measures need to be discussed in a technical forum first, and if there is strong scientific justification to refine them, then a policy process is needed where these changes are formally adopted, particularly if they deviate from the TRFE and ROD.

3.1.2 Sub-objective 1.2: Increase coarse sediment transport and channel dynamics

1.2.1 Increase and maintain target coarse sediment transport rates

1.2.2 Frequently exceed channel migration, bed mobilization, and bed scour thresholds

1.2.3 Encourage bed-level fluctuations on annual to multi-year time scales

1.2.4 Route coarse sediment through all reaches

Improved routing of coarse sediments delivered by tributaries, as well as that introduced through the coarse sediment management program, should improve channel dynamics under the ROD flow regime. Therefore, assessments are needed to evaluate the coarse sediment management program, and ensure that the intended fluvial processes are occurring in a manner that encourages complex aquatic habitats and reduces risk of detrimental riparian encroachment.

HYPOTHESIS:

Flow releases and coarse sediment additions will increase coarse sediment mobility and transport to support the dynamic fluvial processes that create and maintain channel complexity. Specific hypotheses from the TRFE include:

- The ROD flow releases will prevent further aggradation of the Rush and Indian Creek deltas by transporting, routing, and depositing coarse sediments downstream as bar features that provide complex habitat.
- The ROD flow releases, combined with coarse sediment augmentation, will enable full coarse sediment routing through all reaches (including tributary deltas) over the long-term.
- A shorter-term coarse sediment “transfusion” of materials between 5” and 3/8” diameter will greatly increase storage of alluvium of a size capable of transport, routing, and deposition under the ROD flow regime.
- The ROD flow releases will require coarse sediment augmentation of 7,000 to 13,500 yds^3/year (or 10,000 tons/year on average) to maintain increased storage in the reach from Lewiston Dam to Rush Creek.
- Coarse sediment transport and deposition due to ROD flow releases and coarse sediment augmentation, will increase magnitude and frequency of channel migration, particularly in areas where the riparian berm has been removed.
- Coarse sediment transport and deposition due to ROD flow releases and coarse sediment augmentation will increase amount of exposed active alluvial bars, and encourage bed-level fluctuations.
- Coarse sediment augmentation and subsequent transport/deposition will increase substrate patch diversity, and increase salmonid spawning and rearing habitat quantity and quality.

The last two hypotheses have already been described in Section 3.1.1; therefore, this section focuses on the first four hypotheses.

Proposed assessment strategy and rationale

As described in Section 3.1.1, the ROD restoration strategy for achieving channel complexity is to promote the fluvial dynamics that drive channel evolution through a combination of flow releases, gravel additions, and mechanical rehabilitation. The fluvial dynamics referred to here encompass a variety of processes, including various scales of bedload transport, vertical bed scour and fill, lateral bank erosion and accretion, and local scour and accretion around roughness elements (e.g., bedrock and large wood). Larger scale processes, such as channel avulsion, could happen with an effective combination of gravel augmentation (size distribution and volume), channel rehabilitation (selective increase of migration potential) and the ROD high flow regime. The rates at which these processes operate ultimately depend on the mobilization and transport of the sediments that compose the bed and lower banks of the channel. In gravel-bed streams, channel morphology is determined by the coarser fractions of the bed material that compose the structural framework of the substrate (McLean and Church 1999). Thus, the qualitative objective of encouraging fluvial dynamics in the Trinity River can be directly quantified by: 1) documenting the frequency of exceeding bed mobility and scour thresholds, 2) documenting thresholds and rates of bank erosion and channel migration, and 3) measuring the rate at which the gravel and cobble fractions of the bed are transported through the system.

The assessment strategy for 1) will initially focus on site-specific assessment of whether geomorphic thresholds identified in TRFE Chapter 8 tables are being satisfied by annual flow releases (bed mobility, bed scour, channel migration, floodplain inundation, prevention of riparian berm development, etc.). This strategy, which may include a combination of cross sections, tracer rocks, scour chains/cores, and site-scale geomorphic mapping, should be conducted under the GRTS sampling strategy to enable expansion of results to reflect conditions in the upper 40 miles of the Trinity River, and be co-located with fish and amphibian habitat assessments to the degree possible to facilitate cross-discipline integration. The TRFE developed quantitative functional relationships between several key fluvial processes (e.g., bed mobility, bed scour, deposition) and management actions (e.g., flow releases, coarse sediment augmentation). The TRFE did not specifically address large wood management, but the Program has recently included large wood placement into the channel rehabilitation site designs, and thus large wood dynamics and its role in habitat quantity and quality need to be assessed.

Based on (a) available data collected as part of the flow study by McBain & Trush (1997), Wilcock *et al.* (1995), and others, and (b) the inability to conduct controlled flow release experiments above 6,000 cfs during this time, there remains substantial uncertainty on some of these functional relationships, and whether the magnitude and frequency of fluvial processes will be sufficient to maintain the desired complex channel morphology. Sub-hypothesis #1 in Appendix M suggests that even though the ROD has improved the flow and sediment regime from post-dam conditions, there is a fine balance between the ability of the river to prevent detrimental riparian encroachment given how much the flow and sediment regime continues to be reduced by the Trinity River Division. Sub-hypothesis #1 also suggests that the risk of detrimental riparian encroachment occurring during a series of drier water years is high, leading to irreversible channel simplification. Sub-hypothesis #2 suggests that the risk of detrimental riparian encroachment is low, and even if it did occur after a series of drier water years, the channel would slowly evolve back to a desirable equilibrium. Therefore, particularly in the first five to ten years of ROD implementation, assessments will need to assess this detrimental riparian encroachment risk by investigating priority geomorphic relationships, particularly relating geomorphic thresholds (e.g., bed mobility and scour, channel migration) to riparian encroachment thresholds on exposed bar features in the upper 40 miles (see Section 3.5), and corresponding changes to channel morphology and fish habitat in the upper 40 miles. Over time, as we learn more about the effects of flow and coarse sediment management on geomorphic thresholds, and the level of risk we assume about detrimental riparian encroachment decreases, then the bed mobility and scour assessments may be simplified to a mapping-based assessment of riparian encroachment.

The assessment strategy for 2) will focus on a combination of periodic spatial tracking of channel locations from aerial photographs, as well as site-scale measurements of bank erosion using cross sections.

The assessment strategy for 3) will initially focus on measuring bedload and suspended sediment transport rates at selected locations between Lewiston Dam and Indian Creek during high flow releases from Trinity and Lewiston dams. Additionally, the ability of coarse sediment to route through the tributary delta backwaters will focus on the Rush Creek backwater (most severe), and will be initially assessed by placing instream bedload traps and tracer rocks immediately upstream of the deltas to document whether coarse sediment is being transported in the backwater reach. Full coarse sediment routing almost certainly occurs at Grass Valley Creek and Indian Creek deltas, so no assessment of routing is proposed at those locations.

Proposed performance measures and analyses

Key performance measures

- Flow magnitude needed to exceed ***bed surface mobility and scour thresholds of D_{50} and D_{84}*** on active bars, riffles, and pool tails as described in the TRFE.
- ***Channel migration rates, changes in sinuosity, and changes in radius of curvature*** to relate to changes in fish habitat and self-maintenance at channel rehabilitation sites.
- Measured and computed ***coarse sediment transport rates and annual loads for particles greater than 0.5 mm***, particularly in the reach between Lewiston Dam and Indian Creek.
- Maximum ***bedload grain size*** routed through the backwater of the Rush Creek delta.

Candidate performance measures

The underlying purpose of Sub-objective 3.1.2 (sediment transport) is to increase and maintain channel complexity, thus additional performance measures are those listed in Section 3.1.1. As described below, another potential performance measure will be shifts in coarse sediment transport rating curves.

Integration of performance measures with performance measures in other disciplines

Bed mobility thresholds, vertical bed scour thresholds, and lateral channel/bar migration are very important processes that greatly influence riparian seedling mortality along low flow channel margins (see Section 3.5.2). Increases in sinuosity and radius of curvature are likely important covariates that influence increases in fish and amphibian habitat quantity and quality. Other disciplines have little direct use for coarse sediment transport rates, but are indirectly influenced by transport rates as they influence channel complexity.

Expected response

The combination of more frequent bed mobility and scour, increased channel migration, increased coarse sediment transport rates, and full coarse sediment routing through all reaches will increase channel complexity. The change in achieving bed mobility and scour thresholds has already begun (annual basis) due to annual ROD high flow releases. Additional changes should occur in the next 5 to 10 years (assuming a regular distribution of Normal, Wet, and Extremely Wet water years) as the coarse sediment augmentation program increases coarse sediment storage/supply and reduces grain size for that supply. Mean annual coarse sediment augmentation target levels of 10,000 tons per year should reduce risk of detrimental riparian encroachment, reduce reach-averaged median size of the bed surface, and help increase and maintain overall channel complexity. The number and extent of active alluvial deposits should increase, and the number of side channels and alcoves should increase. The expected time frame for seeing the response from coarse sediment augmentation is likely in the 5 to 10 year range assuming a regular distribution of Normal, Wet, and Extremely Wet water years. If these expected responses are not occurring, then ROD high flow magnitude and coarse sediment augmentation rates will likely need to be increased.

Analysis

Bed mobility and vertical scour will be measured by a combination of tracer rocks, coarse sediment transport rates, scour cores, and scour chains. Analysis of these data will be done by: 1) graphically illustrating bed mobility and scour on a cross section for a given flow; 2) stratifying geomorphic surfaces monitored (e.g., low water edge of active bars, riffles, pool tails) and summarizing bed mobility and scour results for each feature for a given flow; and 3) summarizing percent mobility and depth of scour as a function of flow for a given feature and location on that feature (e.g., low water edge). The objective of the analysis is to refine and improve TRFE empirical based predictions of bed mobility and scour thresholds for different surfaces in order to improve the ability of annual flow releases to achieve bed mobility, bed scour, and riparian scour objectives. Hydraulic modeling, and corresponding bed mobility and vertical scour modeling, has been recently attempted, but at this time, does not provide needed precision to inform annual high flow release decisions; therefore, improvements to existing empirical relationships of bed mobility and vertical scour are recommended until modeling tools improve. Lateral scour will be analyzed by comparing changes in cross section geometry as a result of individual high flow events.

Channel migration rates will be measured at the system scale by digitizing the 450 cfs water surface edge over time from orthorectified aerial photographs. Analyses will include computing absolute values and rates of channel migration at various locations in the upper 40 miles of the Trinity River over time. Field measurements of bank erodibility index (as described in Section 3.1.1) will be related to observed channel migration. More precise measurements of bank erosion and channel migration rates will be documented with cross section based field surveys at locations where we expect migration to occur (see Section 3.1.1). Cross sections will be analyzed by assessing bank erosion rates as a function of individual flow magnitude and duration (per GRTS strategy in Chapter 4), as well as measuring bank erosion over time to provide a more precise longer-term rate than that provided by analyzing aerial photographs.

Coarse sediment transport (and mobility thresholds) will be directly assessed through the existing mainstem sediment monitoring program. Four mainstem sediment sampling locations have been established in the first 20 river miles below Lewiston Dam. From upstream to downstream, these four monitoring locations are referred to as Trinity River at Lewiston (TRAL), Trinity River at Lowden Meadows (TRLM), Trinity River at Limekiln Gulch (TRLG), and Trinity River at Douglas City (TRDC). Their positions with respect to Lewiston Dam and major tributaries are illustrated in Figure 3.1.

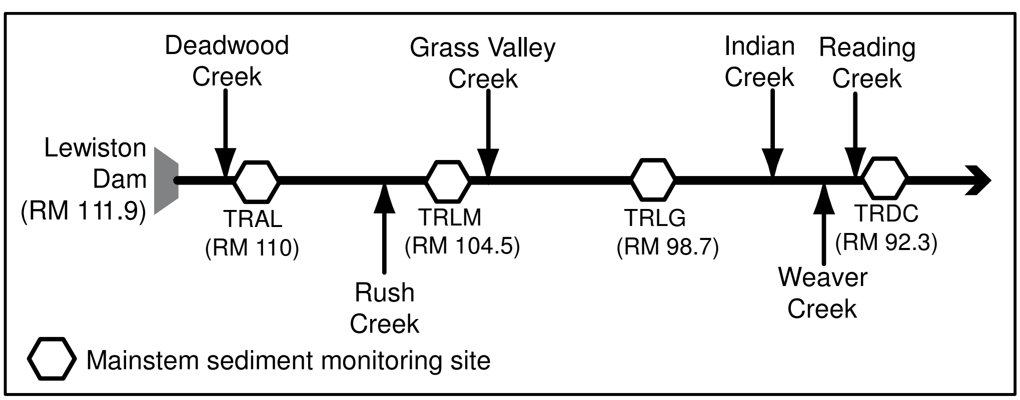

Figure 3.1. Schematic showing the downstream locations of major tributaries and mainstem sediment monitoring locations in the first 20 miles below Lewiston Dam.

Sediment transport rates at each of these four locations are sampled multiple times over the duration of the spring release using bedload samplers to quantify transport rates for grain sizes greater than 0.5 mm moving in the bottom 0.5 ft of flow. Suspended sediment is also collected. Following laboratory analysis of the sediment samples, the sediment transport data will be combined with water discharge information to compute the total loads of coarse sediment (>8 mm) transported past each monitoring location and to develop coarse sediment rating curves. For these analyses, coarse sediment is defined in the TRFE (USFWS and HVT 1999) as particles larger than 5/16" (about 8 mm) in diameter. The rating curves should change over time as they adjust to TRRP induced changes in high flow regime and sediment supply. Analyzing these changes in the rating curves will provide another approach for assessing progress toward attaining a more mobile bed. Reach-average particle size statistics should be generated from the map of bed surface grain-sizes in a GIS as described in Section 3.1.1.

Lastly, a coarse sediment routing model (GSTAR) was developed in the early 2000s to better understand and predict the relationship of flow release magnitude/duration with coarse sediment transport rates and coarse sediment augmentation needs (Collins and Wittler 2004). This need still exists, so a coarse sediment routing model should be revisited to assist the TRRP in managing flows and sediment on a 1-5 year timescale.

Proposed space and time frames

Site scale

Site scale assessments will focus on bed mobility and bed scour at bank rehabilitation sites between Lewiston Dam and the North Fork Trinity River on an annual basis, at least for the first five years, to better refine empirical relationships with high flow magnitude and better understand risk of detrimental riparian encroachment (see Section 3.5.2). Sites should overlay habitat assessment and riparian seedling assessment sites under the GRTS strategy as described in Sections 3.2.2, 3.5.2, and Chapter 4 to enable results at individual sites to be extrapolated to describe conditions in the upper 40 miles of the Trinity River. Site scale assessment of bank erosion will occur on the cross section re-survey rotation described in Section 3.1.1 and Chapter 4.

Reach scale

Coarse sediment transport monitoring will focus on the reaches between Lewiston Dam and Douglas City (Figure 3.1) because the effect of the upstream dams is most pronounced in this reach, and our ability to manage flow, sediment supply, and sediment transport is greatest in this reach. Likewise, if a coarse sediment routing model is redeveloped, it should focus on the same reaches. Because tributary contributions of coarse sediment near the dam are small, the Program's management actions to achieve adequate coarse sediment transport are especially vital, and the uncertainty regarding the proper actions to take is especially high. The Lewiston and Lowden Meadows coarse sediment monitoring locations are therefore assigned a slightly higher priority than the more downstream locations. The Limekiln Gulch monitoring location is well within the portion of the Trinity River where coarse sediment supply is limited, and the Douglas City location provides important information regarding the contributions of Indian and Weaver Creek, and reference transport rates against which data from the upstream locations can be compared. All four monitoring locations also provide data for assessing Sub-objective 3.1.4.

In most years, mainstem coarse sediment monitoring is necessary only during the few weeks of the spring release. Because large peaks in the mainstem caused by winter floods in the tributaries are relatively infrequent close to Lewiston Dam, the coarse sediment loads transported during the spring release approximate the total annual coarse sediment load at these sampling locations. However, additional mainstem sampling may be needed during brief periods when winter storms produce significant flows in the mainstem or when sediment-transporting flows are released from Lewiston Dam based on Safety of

Dams criteria. Mainstem sediment monitoring in Dry and Critically Dry years is a lower priority than Normal and wetter years because peak flow releases are too low to transport significant quantities of coarse sediment; however, Dry years still transport some fine bedload, so there may still be some value in measuring bedload transport in Dry years.

Lastly, determining whether coarse sediment is routing through the Rush Creek, Grass Valley Creek, and Indian Creek delta backwaters should be assessed during a Normal and wetter water year.

System scale

Channel migration, sinuosity, radius of curvature will be documented system-wide every 5 years based on the orthorectified aerial photographs.

Priority issues to address

Technical issues still to be resolved:

The required coarse sediment loads (combination of augmented and tributary-derived coarse sediments) necessary to support habitat creation and maintenance have not been firmly established, and need to be investigated and documented. Additionally, recent TRRP analyses have been conducted to refine annual coarse sediment augmentation rates that are slightly different than that recommended in the TRFE, and thus need documentation and peer review if desired to institutionalize these new augmentation rates.

The utility of annual bedload sampling, particularly during intervening years where TRRP management actions are not expected to induce changes to bedload transport rating curves outside the natural range of variability of sample data, needs continuing evaluation. If annual bedload sampling shows similar variation without significant change in rating curves, then a reduction in effort should be considered given the high cost of annual bedload sampling.

There are differing views on whether coarse sediment is routing through the Rush Creek delta backwater; however, planned monitoring in 2009 should help evaluate this difference. No additional work should be conducted on this topic until there is more discussion on the importance of coarse sediment routing through the delta backwaters as a rehabilitation objective.

3.1.3 Sub-objective 1.3: Increase and maintain coarse sediment storage

1.3.1 Increase bars, side-channels, alcoves, and other complex alluvial features

Trinity and Lewiston dams have eliminated coarse sediment supply from upstream sources, reduced the ability of the high flow regime to transport, route, and deposit coarse sediment supplied by tributaries, and abandoned coarse sediment potentially supplied by pre-dam bars and channel migration. A key objective of the TRFE and ROD is to increase alluvial storage within the mainstem Trinity River that is of a size frequently transported, routed, and deposited by the ROD high flow regime. This additional storage must be maintained by routing tributary coarse sediments and mechanically augmenting coarse sediment downstream of Lewiston Dam (achieving a long-term balanced coarse sediment budget). Therefore, changes in coarse sediment storage need to be assessed and related to changes in aquatic habitat dynamics.

HYPOTHESIS:

The overall hypothesis is that the combination of ROD high flow regime, coarse sediment augmentation, and channel rehabilitation activities will increase and maintain coarse sediment storage of alluvium whose size is commensurate with the ROD high flow regime, and that this increased coarse sediment storage with a grain size smaller than the pre-dam bed material will increase channel complexity and increase coarse sediment transport rates. Additional hypotheses include:

- A combination of coarse sediment augmentation and subsequent maintenance of that storage via long-term augmentation at a rate equal to or slightly greater than the ROD flow regime transport will increase and maintain coarse sediment storage.
- The increased flow magnitude, duration, and frequency of the ROD high flow regime will transport tributary-derived coarse sediments downstream at a rate equal to or greater than supply, increasing coarse sediment storage downstream of the tributary confluence and reducing backwater effect of tributary deltas.
- Increasing coarse sediment storage will increase bars, side-channels, alcoves, and other complex meso-habitats that increase salmonid rearing and spawning habitat.
- The combination of coarse sediment augmentation and ROD flows will degrade tributary deltas and fill backwaters with sediment to the point that coarse sediment routes through all reaches.

The additional hypotheses bulleted above have already been described in Section 3.1.1; therefore, this section focuses on assessing changes in coarse sediment storage.

Proposed assessment strategy and rationale

The Program intends to reestablish a balanced coarse sediment budget in different reaches immediately downstream of Lewiston Dam by adding coarse sediment to the river at a rate approximately equal to the long-term transport rates of the ROD flow regime. In other words, the total long-term quantity of coarse sediment added must be equal to the difference between the mainstem coarse sediment transport rates/loads discussed in Section 3.1.2 and the sum of upstream tributary coarse sediment inputs for a given reach. The TRFE implied a short time period for this balance (e.g., between 1 and 5 years), but the time period should probably be longer (e.g., 5–10 years). There are two assessment strategies for estimating changes in coarse sediment storage. First, as described in Section 3.1.1, surface area of exposed active alluvial deposits will be mapped over time as a system-wide index of coarse sediment storage (additional bars are a direct result of additional storage). Actual measurement of coarse sediment storage volumes in the channel is not recommended at this time because the depth of active coarse sediment is needed along with surface area, and estimating the "bottom" of alluvial deposits is uncertain. However, changes in site, reach, and system-wide coarse sediment storage volume between years may be possible depending on the accuracy of bathymetric LIDAR as discussed in Section 3.1.1.

Second, coarse sediment storage in the reach from Lewiston Dam to Douglas City will be computed based on site-specific measurements of coarse sediment transport rates and loads. This reach will be subdivided into four mainstem coarse sediment budget segments as shown in Figure 3.1; these segments are bounded at their downstream ends by mainstem coarse sediment sampling locations and at their upstream ends by either an adjacent sediment sampling location or by Lewiston Dam. Thus, the four coarse sediment budget cells are defined by the following stream segments: Lewiston Dam to TRAL, TRAL to TRLM, TRLM to TRLG, and TRLG to TRDC (Figure 3.1). These sediment budgets incorporate measured mainstem bedload fluxes, coarse sediment augmentations, and estimated bedload inputs delivered to the mainstem from Deadwood Creek, Rush Creek, and Indian Creek according to the general formula:

$$\Delta S = I_U + I_A + I_T - O$$

where I_U is the bedload input at the upstream boundary of the cell (zero in the case of Lewiston Dam), I_A is the quantity of coarse sediment augmentations in the cell, I_T is the bedload input from tributaries within the cell, O is the bedload output at the downstream boundary of the cell, and ΔS is the change in bedload storage in the cell.

Lastly, the TRFE recommended (and ROD adopted) that the duration of high flows be driven (at minimum) by the objective of annual mainstem high flow releases, and be of sufficient duration to transport the volume of coarse sediment delivered by Rush Creek as illustrated in Section 7.4.3 of Appendix C in the FEIS (CH2MHill 2000). Therefore, coarse sediment storage on tributary deltas will initially focus on the Rush Creek delta, and be quantified via high resolution topographic surveys from the Rush Creek confluence downstream approximately 1,500 ft following the ROD spring high flow release and repeating the surveys following the tributary winter storm season. The difference in the delta volume between the post-release surveys and the late winter surveys approximates the volume of coarse sediment delivered during the winter storm season when most tributary transport occurs (I_T). This biannual monitoring will enable measurement of how much coarse sediment the tributary deposited in the mainstem Trinity River, as well as how much coarse sediment mainstem high flow releases moved from the delta. The methods used for the delta surveys need to be reviewed, improved, and standardized to improve the accuracy and utility of repeat surveys. This annual tributary delta volumetric assessment will be combined with the volume of coarse sediment augmented by ROD activities to help develop the duration of annual high flow releases, as well as assessing whether the Rush Creek delta is aggrading or degrading over the long-term. In prior years, tributary coarse sediment delivery to the mainstem was also estimated by measuring bedload transport rates and computing loads; however, this method is more costly, has greater uncertainty (>100%) than the topographic assessment strategy, and is difficult to measure during the largest tributary flow events when it is most important. The Rush Creek delta topographic measurements should be conducted using a method that can predict deposited sediment volume within +/- 20% (e.g., ground-based LIDAR combined with bathymetric surveys). Some of the total amount of coarse sediment contributed to the mainstem Trinity River by Rush Creek will route downstream of the delta during the tributary floods; however, the management objective of annual high flow releases is to prevent future aggradation of the Rush Creek delta, so the assessment focuses on the coarse sediment deposited on the delta rather than the total amount of coarse sediment delivered to the mainstem Trinity River. In the near future, the high flow duration objective needs to be revisited and most likely shifted away from the Rush Creek delta, and focused instead on coarse sediment augmentation volumes needed to create and maintain complex habitat, and the flow duration needed to transport and route those coarse sediment volumes.

Proposed performance measures and analyses

Key performance measures

The proposed performance measures for this sub-objective are:

- ***Computed changes in gravel storage*** from coarse sediment transport measurements at the boundaries of the four coarse sediment budget cells between Lewiston Dam and Douglas City (Figure 3.1).
- ***Volumes of coarse sediment deposited in the mainstem Trinity River*** by Rush Creek (highest priority). Measurements are highest priority in Normal and wetter years, lower priority during Dry and Critically Dry years when coarse sediment delivery from Rush Creek is expected to be low or zero.
- ***Volumes of coarse sediment transported from the delta*** by annual ROD high flow releases to the mainstem Trinity River. Measurements are highest priority in Normal and wetter years, lower priority during Dry and Critically Dry years.

Candidate performance measures

Exposed active bar surfaces at 450 cfs index flow (office-based and with repeatable criteria to define "active bar surface") from air photos every five years as an index to changes in system-wide coarse sediment storage as described in Section 3.1.1.

Assessing the fate of bedload entering the backwater pool upstream from Rush Creek delta is linked to the TRFE objective of routing coarse sediment through all reaches. The concern is that bedload trapped in the pool is not routed through the delta, and therefore is removed from downstream supply. Past efforts to demonstrate that bedload is accumulating in the pool through repeat bathymetric surveys were inconclusive. Section 3.1.2 proposes a simple method to assess whether coarse sediment is routing through the tributary deltas, so measuring coarse sediment storage in the backwater pools is a lower priority until results from the simple method are obtained and the importance of this performance measure is reassessed.

Integration of performance measures with performance measures in other disciplines

Integration between computed changes in coarse sediment budget and performance measures with other disciplines (i.e., fish) needs refinement; however, the computed changes will be important in relating to other physical process performance measures. The primary integration of performance measures is to make statistical inferences between computed change in storage with changes in bar area and geomorphic complexity indices described in Section 3.1.1. These changes would then be related to changes in fish habitat to test our hypothesis that: 1) increased storage and transport rates lead to 2) increased bar formation, which leads to 3) increased channel complexity and increased fish habitat quantity over the 450–2,000 cfs range of flows where the riparian berm has had the most severe impact on fish (salmon fry rearing) habitat.

Expected response

Coarse sediment storage in the upper river will initially increase via larger initial volumes of coarse sediment augmentation and improved distribution of tributary deltas, and then maintained by continued coarse sediment augmentation. Computed changes in coarse sediment storage should be considered at a 5–10 year timescale because expected annual increases in storage for the Lewiston Dam to Grass Valley Creek reach are expected to be small. For example, an average coarse sediment augmentation rate 10,000 yd^3/year represents an average depth of 0.064 ft/year over this 8-mile reach. However, local increases of coarse sediment storage, particularly at and immediately downstream of coarse sediment augmentation locations, are expected to be more substantial (bars of 1–4 ft high should form) and occur on a more rapid time scale (1–5 years). Future declines in coarse sediment storage in the upper river over a 5–10-year timescale (assuming a regular distribution of Normal, Wet, and Extremely Wet water years) would indicate that either the gravel augmentation quantities should be increased and/or the grain sizes of augmented material should be adjusted. Aggradation at Rush Creek and Indian Creek deltas should cease, and begin to degrade over time and reach a new equilibrium that allows full coarse sediment routing of upstream coarse sediments through the backwater and delta. The time scale of restoring full coarse sediment routing through the Rush Creek backwater is expected to take many decades as upstream coarse sediments slowly fill the backwater. Manipulation of the Rush Creek delta and/or mechanical filling of the backwater would reduce the time required to achieve full routing in the 1–5 year time frame. Coarse sediment is likely already fully routing through the Grass Valley Creek and Indian Creek backwaters. Overall, the increase in coarse sediment storage and transport will increase geomorphic unit diversity and frequency, bed surface grain size patch diversity, channel complexity indices, and aquatic habitat quantity and quality over the next 5–10 years assuming a regular distribution of Normal, Wet, and Extremely Wet water years.

Analysis

Sediment budget calculations are described above. Analysis of the sediment budgets will include tracking computed changes in storage over time to relate to observed changes in active bar surface (described in Section 3.1.1). If a sediment routing model is redeveloped, then the predicted changes in reach-averaged sediment storage from the sediment budget equation will be compared with transect-based and reach-averaged predictions of sediment storage changes from the sediment routing model.

Measured coarse sediment deposition at tributary deltas will be analyzed over the winter period each year to estimate volume of coarse sediment contributed by the tributary. Using either the mainstem coarse sediment transport relationships and/or sediment routing model, gaming will be done each year to assess the effectiveness of how the coming spring ROD high flow release may affect sediment transport at the delta. This analysis should be used to develop a recommended combination of high flow magnitude and duration to best transport annual coarse sediment contributions from tributaries (particularly Rush Creek) while balancing other TRRP objectives. After the high flow release, the repeat delta topographic surveys will assess how well the spring ROD high flow release performed with respect to predictions from the transport rating curves and/or sediment routing model, as well as the overall management objective to transport the volume of coarse sediment contributed by the tributary.

Proposed space and time frames

Site scale

Site scale assessments focus on volumetric measurements of tributary-derived coarse sediment deposition at the Rush Creek delta, and perhaps Deadwood Creek and Indian Creek deltas. Deltas should be surveyed twice a year, and volumetrically assessed annually, particularly during Normal and wetter water years where tributary sediment contributions to the mainstem are more substantial. Dry and Critically Dry years may be a lower priority due to very small volumes of coarse sediment contributed by tributaries, and small volumes of coarse sediment transported by mainstem high flow releases during those drier water years.

Reach scale

Assessment of the coarse sediment budget should occur for river segments upstream from Douglas City (Figure 3.1). Assessment of coarse sediment inputs from tributaries is most relevant at Deadwood and Rush Creeks, as these are the first significant sources of coarse sediment downstream from Lewiston Dam. The sediment budget should be assessed yearly to assist annual high flow release magnitudes and duration, and over a longer time scale (5 years) to assess progress towards TRFE management objectives (balanced coarse sediment budget, coarse sediment routing through tributary deltas). Assessment of coarse sediment routing through tributary delta backwaters should focus on Rush Creek as described in Section 3.1.2.

System scale

The only system-scale assessment of coarse sediment storage is the active bar mapping described in Section 3.1.1.

Priority issues to address

Technical issues still to be resolved:

The TRFE recommends that the duration of annual high flow releases be directed by the objective of transporting coarse sediment at a rate equal to input as measured immediately downstream of the Rush Creek confluence. This management objective should be adjusted to include the volume of coarse sediment augmented above and below Rush Creek as part of ROD management actions. While the Rush Creek delta survey is a simple and convenient means to develop high flow duration, there may be additional objectives that should be considered with equal or higher priority (e.g., fine sediment transport). Overall, using Rush Creek delta as an annual management objective for developing the magnitude and duration of ROD high flow releases needs to be improved. Discussion at the October 2008 SAB workshop suggested an alternative approach that considers stable relationships between flow, slope, and grain size, as well as assessing the effect of supply on the formation of desirable alluvial features. Therefore, a priority issue is to identify a better management objective that defines annual high flow release duration, and to refine the assessment based on that improved management objective.

As mentioned at the end of Section 3.1.2, there is potentially a misunderstanding or disagreement among Program Partners, TMAG staff, contributing scientists, and the SAB regarding whether to compute changes in coarse sediment storage, or measure changes in coarse sediment storage. For the former, Input and Output would be measured in the field from bedload sampling, and ΔStorage would be computed mathematically. The SAB recommended this approach. Another prominent sediment transport researcher has recommended that we measure ΔStorage in addition to computing it to reduce uncertainty and improve understanding of sediment routing and storage through the reaches. Additional discussion between the SAB, the other researcher, and TRRP staff and partners is needed to better understand the added value provided by measuring ΔStorage.

A 1-dimensional sediment routing model (GSTARS) was developed in 2001-2004 for the reach from Lewiston Dam to Weaver Creek to help develop annual high flow release magnitude and duration, as well as predict areas of coarse sediment aggradation and degradation (Collins and Wittler 2004). This model has not been used as a management tool to date, yet there remains a need for such a tool.

As mentioned in Section 3.1.1, the importance of documenting spawning gravel areas may become more important in future years. Documenting storage can be easily accommodated in the geomorphic mapping effort in Section 3.1.1 if needed.

3.1.4 Sub-objective 1.4: Reduce fine sediment storage in the mainstem Trinity River

1.4.1 Transport fine sediment through mainstem at a rate greater than tributary input
1.4.2 Reduce fine sediment supply from tributary watersheds
1.4.3 Encourage fine sediment deposition on floodplains

Trinity and Lewiston dams have eliminated fine sediment supply from upstream sources, yet the reduced ability of the high flow regime to transport and route fine sediment supplied by tributaries has been greatly reduced, allowing fine sediment to accumulate in the mainstem Trinity River and degrade aquatic habitats. A key objective of the TRFE and ROD is to increase fine sediment transport rates/loads within the mainstem Trinity River at a rate greater than input from tributaries in order to reduce mainstem storage. Therefore, changes in fine sediment storage need to be assessed and related to changes in aquatic habitat dynamics, with focus on anadromous salmonid spawning habitat in areas with high spawner concentrations.

HYPOTHESIS:

The combination of watershed sediment control activities and ROD flow releases will reduce the quantity of fine sediment stored in the Trinity River between Lewiston Dam and the North Fork Trinity River, improving the quality of the substrate and other aquatic habitats in areas of biological importance.

Additional hypotheses include:

- Watershed rehabilitation will reduce fine sediment delivery to the mainstem over the long term.
- Continued operation and maintenance of Hamilton Ponds on Grass Valley Creek will reduce sediment delivery to the mainstem over the short and long-term.
- ROD release magnitude, duration, and frequency will transport more fine sediment than delivered by the tributaries, thereby decreasing fine sediment storage in the active channel over the long-term. This deficit in the fine sediment budget will be most pronounced immediately downstream of Lewiston Dam, and the deficit will decrease in the downstream direction due to cumulative fine sediment contribution from tributaries. Accordingly, the time needed to observe a decrease in fine sediment transport will be larger in downstream reaches than in upstream reaches.
- Reduced fine sediment in the active channel will improve spawning gravel quality, improve rearing habitat quality (lower embeddedness), improve yearling over-wintering habitat, and increase adult spring Chinook salmon holding habitat (increased pool volume).
- ROD high flow release magnitude, duration, and frequency will suspend fine sand and silt derived from tributaries and deposit it on constructed and natural floodplains, fostering new seedbeds for natural riparian vegetation germination (see Section 5.1).
- The reduction in fine sediment supply will reduce the risk of future riparian berm development. Riparian berm development risk will be lowest in the upstream reaches due to lower fine sediment supply, and higher in the downstream reaches as tributary-derived fine sediment supply increases.

Proposed assessment strategy and rationale

Fine sediment consists of particles less than 8 mm (about 5/16") in diameter, but those sediments finer than 2 mm (sand) are the focus of the discussion below. The TRFE (USFWS and HVT 1999), Wilcock *et al.* (1995), and many others describe an overabundance of fine sediments in the Trinity River downstream from Lewiston Dam, and one of the objectives of the ROD flow regime and watershed rehabilitation effort is to reduce fine sediment supply and storage in the mainstem Trinity River.

The assessment strategy focuses on: 1) documenting changes in surficial fine sediment storage in the mainstem Trinity River, prioritizing the reach between Lewiston Dam and Indian Creek due to greater ability to detect changes in surficial fine sediment storage that is a direct result of our management action (detecting a management-induced improvement outside the natural background "noise"); and 2) computing changes in fine sediment storage using the fine bedload and suspended sediment transport samples at the locations shown on Figure 3.1. Much like the assessment of coarse sediment particle size in Section 3.1.1, the spatial distribution of fine sediment on the bed surface would be field-mapped using a sampling scheme or a visual estimation of percent coverage. The volume of sand stored on the stream bed can be computed from equations that express sand volume as a function of percent sand coverage and the diameters of the median and 90th percentile gravel particles on the bed. The fine sediment storage assessment strategy focuses on the active channel between Lewiston Dam and Indian Creek on an annual basis, and from Lewiston Dam to the North Fork Trinity River every five years.

Computing change in fine sediment storage using mainstem fine sediment transport data is also recommended. Change in storage will be calculated in a similar manner to coarse sediment storage described in Section 3.1.3. Mainstem fine sediment monitoring makes use of the same bedload transport measurements needed for coarse sediment monitoring, plus concurrent sampling of the suspended load. The total fine sediment load is equal to the sum of the fine fraction of the bedload and the fraction of the suspended load greater than 0.5 mm in sieve diameter. Suspended sediments less than 0.5 mm are considered wash load in the Trinity River.

Assessment of fine sediment storage in the channel-bed should build from previous efforts of GMA (2001) and Frederiksen Kamine and Associates (1980) by collecting additional bulk samples in spawning habitat. The initial assessment should be a pilot effort that compared changes in fine sediment composition in spawning habitat at three sites between Lewiston Dam and the North Fork Trinity River. The objectives of this pilot effort would be to: 1) reoccupying sites from previous work to compare longer-term changes in fine sediment composition; 2) evaluate the current status of spawning habitat at individual sites (i.e., is gravel quality having a significant effect on predicted egg-to-emergence success); and 3) document site variability to enable sample size development for a more rigorous evaluation if Objective 2 indicates a biological problem. If Objective 2 indicates a biological problem, additional assessment should focus on upstream reaches where spawning density is highest. There is considerable variability in fine sediment proportions in alluvial deposits, therefore, the pilot effort will inform development of a cost-effective sampling plan that allows a rigorous statistical assessment of fine sediment storage in the bed at sample sites. This assessment will not only provide information on changes in fine sediment storage in the bed surface, but also provide information on spawning habitat quality and allow improved estimates on egg-to-emergence success (input variable into fish production model).

Previous efforts (e.g., GMA 2003; GMA 2005a, 2005b) have monitored fine sediment transport rates and loads in tributaries (Deadwood Creek, Rush Creek, Grass Valley Creek, and others), and this monitoring could theoretically be used to document expected reductions in fine sediment loading to the mainstem Trinity River caused by watershed rehabilitation activities. However, the watershed rehabilitation component in the ROD has not yet been fully implemented, and even if it had been fully implemented over the past few years, the expected response (reduced sediment supply) would take many years to be realized. Additionally, fine sediment supply from tributaries varies widely within year and between years, as the response time between sediment generation events in the watershed and delivery to the mainstem is rapid. Therefore, we recommend that fine sediment monitoring on the tributaries be deferred for at least 5 years or when full implementation of the ROD watershed rehabilitation efforts occurs. The fine sediment transport rates and loads collected to date provide high quality baseline data upon which future comparisons can be made.

Fine sediment stored in the berms and banks upstream from the North Fork Trinity River is also of interest for two reasons. First, the quantity of fine sediment stored in the riparian berms was estimated to exceed 1 million yd^3 in 1999 (USFWS and HVT 1999). A portion of this material will ultimately re-enter the wetted channel as higher ROD flows recruit fine sediment from the existing riparian berm, or re-activate bank erosion and other fluvial processes that erode the berm. Second, future riparian berm formation (or lack thereof) needs to be assessed to ensure that the ROD restoration strategy is being achieved. A system-scale assessment will be done by simple computations using estimates of the heights and percentages of sand in banks that are subject to erosion (done concurrently with the geomorphic mapping effort described in Section 3.1.1). Site and reach-scale assessments will focus on more precise measurements of berm evolution using the cross section monitoring network described in Section 3.1.1.

Proposed performance measures and analyses

Key performance measures

- ***Change in fine sediment storage on the bed surface*** (surface area).
- Change in fine sediment storage in a reach (computed volume).
- Change in fine sediment storage in banks, and floodplains (surface area, cross sectional area).

- Change in mainstem fine sediment transport rating curves and loads.
- Spawning gravel quality, quantified as a change in percent fines <2mm and other indices, as well as predictions of egg-to-emergence success based on the particle size distribution using Tappell and Bjornn (1983) regression equations.

Candidate performance measures

After 5 to 10 years, or after the ROD watershed rehabilitation effort is fully implemented, assessment of fine sediment transport rating curves for tributary streams should resume and be used as a performance measure to assess the effectiveness of the watershed rehabilitation effort on reducing fine sediment supply to the mainstem Trinity River.

Turbidity has been shown to correlate well with suspended sediment concentrations, and could be used as an economical surrogate for fine sediment supply and transport on tributaries and the mainstem Trinity River. Additionally, turbidity magnitude and duration can be used to predict changes in growth rates of juvenile steelhead, which directly affects survival and likelihood of successfully returning as adults. However, baseline turbidity data are sporadic or non-existent, so use of turbidity to assess pre-and post-ROD changes will be difficult.

Permeability of spawning gravel could also be used in addition to or instead of particle size distributions from bulk samples. For example, substrate permeability is believed to directly affect spawning success. A modified version of the method of Terhune (1958) was developed by Barnard and McBain (1994), and has previously been employed to assess substrate permeability in the Trinity River. Another important habitat attribute, substrate productivity, could be directly assessed by examining the macroinvertebrate populations supported by the substrate (Merz and Ochikubo Chan 2005).

Integration of performance measures with performance measures in other disciplines

The spawning gravel quality assessment plan must be integrated with the fish habitat assessment described in Section 3.2, as well as development/application of a salmonid production model (e.g., SALMOD). Additional discussion is needed to refine this plan, but pilot bulk sampling should be done at three sites between Lewiston Dam and the North Fork Trinity River in identified spawning habitat where historic bulk sampling by GMA (2001) or Frederiksen Kamine and Associates (1980) has been conducted. Bulk sampling should be done at an intensity that can determine future modest changes in spawning gravel quality within a desired coefficient of variation (not yet developed). This proposed approach would quantitatively describe gravel quality only at a site, and not necessarily allow extrapolation to a wider reach (which would limit use in a fish production model).

Fine sediment mapping on floodplains will be conducted as part of the riparian mapping effort (Section 3.5.1), and fine sediment monitoring on berms will be done as part of the cross section surveys described in Section 3.1.1.

Expected response

Fine sediment storage <u>on</u> the bed surface should decrease faster than <u>in</u> the bed surface, and the reductions in fine sediment storage should be most pronounced and fastest in the reaches closer to Lewiston Dam (5-10 years). Volume of fine sediment stored in pools should decrease, as should volume of fine sediment in riparian berms closer to the Lewiston Dam as ROD high flow releases begin to strip fine sediment from the berms. The most dramatic reductions in fine sediment storage <u>on</u> the bed surface and in pools have likely already occurred due to management of Hamilton Ponds on Grass Valley Creek and high flow events since 1991. Reduction in fine sediment storage in berms should take longer due to the hydraulic shielding effect of the vegetation. The time frame is expected to range from several Wet or Extremely

Wet water years closest to Lewiston Dam where supply is lowest, to 5–10 years after several Wet or Extremely Wet water years downstream of Grass Valley Creek. Longer time frames are likely in the downstream reaches (Junction City area) where fine sediment supply is highest. Changes in fine sediment storage in the bed surface should take much longer because scour and redeposition is required to expose the subsurface fine sediment and allow "flushing" to occur. The response should be faster in areas of high salmonid spawning use as the digging of redds exposes subsurface fine sediments to surface flows. The reduction in subsurface fine sediment storage will likely be modest, with greatest and most rapid changes occurring in the reaches closest to Lewiston Dam due to low fine sediment supply and "dilution" from clean coarse sediment augmentation. Downstream reaches should have more subtle changes in subsurface fine sediment storage due to cumulative effect of tributary fine sediment supply. Fine sediment transport rates in the mainstem Trinity River should continue to decline as the storage in the mainstem Trinity River and supply from tributaries decrease. Dramatic reductions (order of magnitude reduction in the 450–2,000 cfs flow range) in the fine bedload transport rates immediately below Grass Valley Creek have already occurred (measured at the USGS Limekiln Gulch gaging station), likely due to historic pool dredging, recent high flow events, and implementation/management of Hamilton Ponds. More gradual reductions in this and other reaches will likely occur in the 5-20 year time frame assuming a regular distribution of Normal, Wet, and Extremely Wet water years. Fine sediment loads delivered from tributary basins should slowly decrease once ROD watershed rehabilitation activities are fully implemented, but the response time could be lengthy (e.g., decades). If these expected responses do not occur within the expected time frame, then alternative approaches to reduce fine sediment storage will need to be considered (e.g., changes to ROD high flow release magnitude and/or duration, increased watershed rehabilitation efforts, fine sediment basins on certain tributaries, resumption of pool dredging effort on the mainstem Trinity River).

Analysis

Surficial fine sediment storage maps would be digitized, and areas computed. Areas would be tracked over time to assess spatial and volume changes in fine sediment storage, and related to computed changes in fine sediment storage from the sediment budget approach. During wetter years where upstream tributaries contribute a very large episodic supply of fine sediment, an additional mapping effort may be made after the tributary floods but prior to the ROD high flow release in order to assess the effectiveness of the ROD release in flushing this fine sediment out of the upstream reaches.

Changes in fine sediment on floodplains will be analyzed by comparing surficial polygons over time as described in Section 3.5.1. Changes in fine sediment in the banks at the system scale will be done in a similar manner (changes in surface area over time). Cross sections will be selected to document fine sediment storage in banks and riparian berms at a site-scale, and will be analyzed by comparing changes in cross sectional area over time, and relating those results to observed changes in the planform maps.

Mainstem fine sediment transport curves will be generated for the fine bedload fraction and coarse suspended sediment fraction. Analysis will also allow the fine component to be further defined as greater than 0.5 mm for bedload and less than 0.5 mm for suspended load. We hypothesize that these rating curves will shift over time as fine sediment storage and supply decreases, so the mainstem fine sediment transport rating curves will be plotted over time, and again related to observed changes in fine sediment storage from the maps.

Analysis of fine sediment composition in the channel bed will be done two ways. First, a pilot study should be conducted to gain a better understanding of gravel quality variability in the upper river, which will guide sample size needed in order to detect changes in gravel quality for a typical spawning gravel patch. Once the full study is implemented and bulk sample data gathered, the samples will be sieved, the particle size distribution computed, and indices of the distribution computed (e.g., D_{84}, D_{50}, %<2mm,

%<0.85 and 9.5 mm). Values of the particle size distribution for a particular patch will be tracked over time. Indices of particle size distribution will also be used to predict egg-to-emergence success using Tappel and Bjornn (1983) or other methods for use in a salmonid production model if needed.

Assessment results indicating an unacceptably high rate of fine sediment delivery, or that aquatic habitat is significantly impaired due to fine sediment storage in the river, could lead to management adjustments in a variety of areas. Modifications to the flow release schedule designed to flush more fine sediment downstream or mechanical actions to remove fine sediment from the system might be implemented. Likewise, indications that aquatic habitat is persistently impaired by fine sediment would provide a strong argument for placing more emphasis on watershed sediment source control activities.

Proposed space and time frames

Site scale

Spawning gravel quality assessments should be prioritized at the fish habitat mapping sites to improve integration and use with a salmonid production model, and should be prioritized in the upper reaches where spawning use is highest. Because changes in channel-bed grain size distribution require exchange (vertical scour and redeposition, channel migration, and/or bar formation) caused by high flows, changes in the subsurface grain size distribution are likely to require much longer time spans than surface changes, so sub-surface sampling could be conducted infrequently. Therefore, the bulk sampling should be conducted every 5 years, or after an Extremely Wet water year release, whichever is sooner. Sampling near Lewiston Dam would be of highest priority, since spawning is concentrated in that area.

As described in Section 3.1.1, cross sections used to document fine sediment storage changes at rehabilitation sites and between rehabilitation sites will be re-surveyed on a rotating basis. Site assessments should be staged to ensure that most, if not all, cross sections are re-surveyed every 5 years. Fine sediment mapping at rehabilitation sites should be mapped annually for the first few years following construction and less frequently thereafter (e.g., every 5 years).

Reach scale

Assessing changes to fine sediment storage should be applied to river segments upstream from Douglas City (Figure 3.1). The sediment budget should be computed yearly to assist annual high flow release magnitudes and duration, and over a longer time scale (5 years) to assess progress towards TRFE management objectives (fine sediment budget in deficit, fine sediment storage decreasing).

System scale

The quantity of fine sediment stored in the Trinity River is of concern throughout the system. However, controlling fine sediment inputs from tributaries is especially critical in the upper river from Deadwood Creek downstream to about Weaver Creek for several reasons. First, salmonid spawning is currently concentrated in the Lewiston area. Secondly, fine sediments in the lower river are derived from numerous tributaries, so reducing inputs from one or two tributaries may have a negligible effect on habitat quality. By contrast, eliminating an equivalent quantity of fine sediment in the Lewiston area may markedly improve habitat conditions. Finally, fine sediment introduced near Lewiston ultimately traverses the entire system, whereas fine sediments introduced far downriver affect a relatively small fraction of the system.

Storage of fine sediment on the bed surface can respond rapidly to sediment-producing events in tributary watersheds and mainstem releases, especially in the upper part of the river where much of the mainstem spawning occurs. It is recommended that fine sediment storage on the bed surface be assessed annually upstream from Indian Creek. Fine sediment inputs are more chronic downstream from Indian Creek, since contributions are derived from more and larger tributaries as well as from re-entrainment of fine sediments stored in the banks. Changes in bed-surface storage are expected to occur more slowly in this part of the river, so assessments could be conducted less frequently (e.g., every 3 to 5 years).

Priority issues to address

Technical issues still to be resolved:

As discussed in Section 3.1.2, there is uncertainty about the importance of monitoring coarse sediment transport rate on the mainstem Trinity River on an annual basis, as opposed to conducting monitoring at a future time when we expect measurable changes in the sediment transport curves. This uncertainty applies to fine sediment transport rate monitoring as well because similar methods are used for both.

The substrate bulk sampling assessment plan needs better integration with fish habitat and fish production assessments. Additionally, objectives of the substrate assessment need to be refined, and a substrate sampling plan needs to be developed based on these objectives. Obtaining the sampling density necessary for a meaningful bulk substrate assessment may be feasible only at relatively small spatial scales. Additionally, the sampling design needs to consider biologically meaningful effect size, which will inform the selection of a desired coefficient of variation for the gravel quality performance measure. Subsurface sampling is difficult and expensive, and the high spatial variability of substrate composition demands a large number of samples to characterize an area or detect change. There has been no discussion of the appropriate spatial scale for bulk subsurface sampling or of a suitable sampling scheme.

The proposed assessment of subsurface fine sediment storage prioritizes effort in spawning habitats because of the additional benefit to fish habitat assessments, and sees a broader sampling plan to document fine sediment storage in other geomorphic units as a lower priority. Regardless of whether one or both approaches are used, a sampling plan needs to be developed that can detect changes in fine sediment storage at a statistically significant level.

Once assessments of tributary fine sediment transport rates and loading resume, the methods of measuring and estimating fine sediment transport need refinement. Tributary fine sediment loads based on winter storm sampling contain a high degree of uncertainty. Fine sediment transport is determined by the quantity of sediment available for transport as well as by hydraulic conditions. Changes in supply make it possible for transport rates to be relatively low during a flood or relatively high during periods of moderate discharge. For example, tributary sampling might be conducted during a winter storm that triggers a landslide in the headwaters of the tributary basin, but the sediment mobilized by the landslide may arrive undetected at the sampling location days or weeks later. This difficulty is compounded because tributaries that can potentially deliver significant quantities of fine sediment to the mainstem number in the dozens. It is questionable whether any realistic level of sampling effort could produce satisfactory estimates of these inputs. Turbidity monitoring could be used as a surrogate for suspended sediment and fine bedload as an economical way to estimate fine sediment loading on a continuous basis, and at many more locations.

3.2 Objective 2: Increase/improve habitats for freshwater life stages of anadromous fish to the extent necessary to meet or exceed production goals

It is hypothesized that the current quantity and quality of available habitat within the Trinity River between Lewiston Dam and North Fork Trinity River limits natural production of anadromous fish, and that habitat potential was reduced post-TRD by reduction or elimination of fluvial processes. The Program intends to provide the habitat conditions necessary to meet natural production goals by re-establishing fluvial processes and returning alluvial function to the River, scaled to the geomorphic potential of the mainstem valley corridor and the five water-year type allocations (see USDOI 2000). The habitat assessments discussed below will enable us to address the critical link between Program management actions and changes in fish habitat. By employing various methods (e.g., Hardy *et al.* 2006, Cramer and Ackerman 2008a), we will assess changes in the amount, distribution and quality of habitat, and improve our understanding of the linkages between geomorphic complexity, habitat, utilization and fish production. Habitat assessments will serve three primary purposes with respect to the Program objectives (expressed in the TRFE (USFWS and HVT 1999) and in the ROD (USDOI 2000)):

1. Evaluate progress towards the system-wide objective of increasing and improving habitat.
2. Evaluate management actions for adaptive management purposes.
3. Provide guidance to rehabilitation site design.

The assessments will center on change in habitat availability over time. Since the Program goal is to provide enough habitat to meet or exceed specific fish escapement goals while also providing expanded harvest opportunities (see Section 3.4), we propose to assess the habitat potential of a scaled down Trinity River. Linking habitat availability (including the physical form and structure of the channel, flow hydraulics and temperature components), food availability, and meso-habitat scale habitat potential to carrying capacity and escapement goals will enable the Program to predict and monitor the extent to which these goals can be achieved. Habitat assessments will provide feedback to the AEAM process at three temporal scales: 1) long term assessment of systemic habitat availability; 2) assessment of effectiveness of channel rehabilitation actions; and 3) feedback on annual flow scheduling and influence on temperature.

3.2.1 Sub-objective 2.1: Increase and maintain salmonid habitat availability for all freshwater (in-river and tributary) life stages

- 2.1.1 Increase/maintain salmonid fry and juvenile rearing habitat in the upper 40 miles of the mainstem Trinity River by a minimum of 400 %[9] following rehabilitation of fluvial attributes
- 2.1.2 Increase/maintain spawning habitat quantity and quality to 2,550,000[10] square feet in the upper 40 miles of the mainstem Trinity River
- 2.1.3 Create channel form that reduces loss of fry to stranding in the upper 40 miles of the mainstem Trinity River following rehabilitation during high flows
- 2.1.4 Maintain or increase adult holding habitat from baseline conditions in the mainstem Trinity River
- 2.1.5 Minimize physical impacts to lamprey habitat
- 2.1.6 Minimize physical impacts to other native fish habitats
- 2.1.7 Maintain or increase tributary habitat

Rehabilitation of fluvial processes, through alteration of flow regimes, gravel introductions, and channel rehabilitation projects, is the major focus of our physical channel structure habitat component. Secondary rehabilitation actions focus on enhancing the habitat quality through flow and temperature management. The initial priority for rehabilitation is the creation of rearing habitat for salmonid fry through pre-smolt life stages. Hence, estimating the quantity and quality of suitable rearing habitat is the highest priority assessment. This does not preclude changes in priorities in the future as limiting factors change or other

[9] This is an interim target, and will be revisited and revised as we learn more; 400% is a starting point only for a measure of progress and does not reflect an estimate of the habitat increase needed to fully meet salmonid production goals.

[10] This is an interim target, and will be revisited and revised as we learn more.

anadromous species are studied. IAP authors have prioritized assessments of habitat for anadromous fish life stages and species in the following order:

1. salmonid fry;
2. Chinook/coho salmon juveniles;
3. 0+ and 1+ steelhead;
4. adult holding;
5. adult spawning; and
6. lamprey ammocete.

HYPOTHESIS:

Management actions will increase and improve both quantity and quality of habitat (especially rearing habitat for target fry and pre-smolt salmonids) from Lewiston Dam to the North Fork Trinity.

Proposed assessment strategy and rationale

The strategy for the proposed habitat assessments is to establish the current habitat availability and, as management actions are implemented over time, predict interim targets and measure progress towards these Program habitat targets, focusing on the trajectory and direction of change in habitat availability. The methods used for the steps below should be closely integrated (through the Generalized Random Tessellation Stratified (GRTS) design, see Chapter 4) with geomorphic assessments of channel complexity and fluvial processes (see Section 3.1). All potential methods for calculating quantity and quality of fish habitat have competing strengths and weaknesses (McDonald 2003; Parasiewicz 2003; SAB 2006a).

There are five steps involved in this assessment strategy:

1. *Quantify the baseline.* What is the current habitat availability and area (at the system scale) for all anadromous fish species and freshwater stages of interest? Establishing this baseline is essential if we are to evaluate change over time.
2. *Quantify and simulate habitat change over flow, time and space.* How much change in habitat availability occurs with different rehabilitation actions and flows? We need to quantify changes in the area of preferred habitat, and to evaluate habitat change at the reach/system scale for statistically valid assessments of progress towards longer term Program success.
3. *Determine interim quantitative targets.* Use Program escapement goals to back calculate initial interim habitat requirements. Periodic refinements of interim targets through AEAM process.
4. *Link habitat availability to physical form, structure of the channel, and flow hydraulics* We need to understand how geomorphology, flow hydraulics and temperature interact to create suitable habitat and determine fish abundance and distribution (e.g., Mossup and Bradford 2006).
5. *Assess objectives and predicted response of* ***site specific*** *rehabilitation actions, temperature and flows on habitat availability.*

Proposed performance measures and analyses

Key performance measures

- ***Habitat availability (quantity and quality over a range of flows and time***), represented by a variety of performance measures at different spatial scales; these may include:
    - Area of fry, juvenile, adult holding and spawning habitat (site, reach, and system scale).

Candidate performance measures

- ***Length of edge*** (system-scale) (note that this represents a very crude estimate since it does not account for bank slope (i.e. depths and velocities) and likely greatly over estimates available habitat).
- ***Suitable habitat days*** (reach-system scale) (total number of days per year an area has where suitable habitat exists).
- ***Potential habitat capacity (e.g., Williams et al. 2006)***.

Program scientists and external invited experts conducted a structured review of alternative methods of assessing habitat availability, including literature reviews and field comparisons, culminating in a workshop held April 1–4, 2008. The workshop participants suggested a hybrid approach (see Appendix L), involving two primary methods of assessment at site and system scales. Additionally, they suggested that these methods are complementary components of an overall habitat availability assessment. How to implement these in a complementary manner has yet to be determined.

1. *Suitability Based Habitat Mapping (SBHM)* - precise, field mapping of suitable habitat structure features of the channel at rigorously selected (see Chapter 4) sample of sites, using well-established suitability criteria for different life stages (building on Chamberlain *et al.* 2007).
2. *2-Dimensional Modeling of Suitable Habitat* to extend coverage of suitable habitat to the high water level and to estimate the hydraulic suitability of habitat as a function of river flow. Modeling will extend estimates to other species, life history stages, flows and locations not mapped by method SBHM.

Additional performance measures, as yet undetermined, may be identified in subsequent RFPs that more clearly specify the details of required assessments (see Chapter 4).

Integration of performance measures with performance measures in other disciplines

Change in habitat availability may be driven by the change in channel complexity resulting from management actions that influence fluvial and riparian processes (see performance measures identified in Section 3.1 and 3.5). Physical metrics such as number of bars, substrate maps, length of edge and bank type (reach and system scale) can be compared to distribution of available habitat. Fish habitat availability should be correlated with geomorphic/riparian assessments to provide a functional relationship between management actions, physical processes and habitat creation/maintenance. Physical and habitat monitoring sites will be co-located using a GRTS design in order to better develop these relationships. Quantification of carrying capacity for the study reach must also be integrated between physical and habitat monitoring efforts.

Habitat availability and capacity (Cramer and Ackerman 2008b) must also be integrated with fish juvenile production, growth, and health (see Section 3.3 and discussion in Appendix C). To assess the effectiveness of management actions designed to improve habitat, we need to assess how changes over time and space in the estimated area of preferred habitat (or number of suitable habitat-days) correlates with changes in fish utilization (site and sub-reach scale) and changes in juvenile fish production, growth or size distribution (Appendix C). These types of analyses will require careful design to ensure that the “x” and “y” variables are on congruent scales. The Looking Outward Matrix (Appendix F) describes what habitat information is required to feed into fish production analyses at different spatial scales.

Measurements of the area of suitable habitat at different flows (expanded to reach scales and system wide) could be used in fish production models (i.e., SALMOD) to explore the consequences of different escapement levels and flow and habitat scenarios on either survival or growth. Production models such as SALMOD (Stalnaker and Williamson 2000) permit examination of the linkages between habitat-flow relationships, temperature, and fish growth, movement and production. SALMOD was developed for the Trinity River to integrate and evaluate the relationship between physical habitat and salmonid growth and production (Bartholow *et al.* 1993; Bartholow 1996) (see Section 3.3.2). SALMOD was used to develop the interim habitat targets identified in the TRFE and could be used to refine these targets. Models such as this could help illustrate what specific changes to flow regime or habitat availability we could perform (as short-term adaptive management experiments) to get us closer to our production objectives. However, a rigorous cost benefit analysis needs to be done. Additionally, the certainty of predictions needs to be addressed.

Expected response

Quantify the baseline and changes through time. Habitat area and quality, availability, and capacity are all expected to increase on a systemic scale in response to all channel rehab actions.

Determine interim quantitative targets. The TRFE (USFWS and HVT 1999) predicted that a four-fold increase in physical habitat would be needed to produce a detectable increase in smolt outmigration. We predict that, as channel rehabilitation and restoration of fluvial process occurs, we will approach this initial target of 400%. Over time, as we assess the habitat interim targets in relation to fish production goals, we expect the need to refine these targets.

Link habitat availability to physical form, structure of the channel, and flow hydraulics. We predict that, as channel complexity increases, the habitat availability, diversity and complexity will likewise increase. We predict that elimination of berm related stranding features will benefit salmonids. However, some alternate features that "strand" fish may serve other critical ecological function. For instance, we predict that stranding in deep off-channel and groundwater-fed habitats that have been shown to be critical for coho salmon would be beneficial.

Assess objectives and predicted response of site specific rehabilitation actions. We expect the cumulative effects of treatments at the sites to increase habitat availability. Through detailed assessments of site features we could provide input to site designers on effectiveness at meeting objectives of both site and features. For example, we predict that side channels would meet specific objectives of increasing habitat availability. Interim targets will be developed. Replicates of these features could be assessed through implementation, effectiveness, and validation monitoring.

Analysis

Quantify changes through time. Estimates of habitat availability will be obtained from Section 3.3 and the hybrid method at a rigorously selected sample of sites (see discussion in Chapter 4), permitting statistically reliable extrapolation to reach and system scales and evaluation of changes over time. The GRTS rotating panel study design can provide a basis for evaluating the priority questions for the systemic habitat assessment including annual systemic estimates and trend evaluations. Systemic habitat estimates will be developed among panels within years. Trend analyses will be developed within panels among years. The revisit design will allow for investigation of short-term changes between two consecutive years and long-term trends when panels are revisited after five or more years. The revisit design specifies the rotation of sample effort among the panels. We developed a revisit design that will allow the development of annual systemic habitat estimates at summer base flow (450 cfs Lewiston release), and evaluation of short- and long-term habitat trends. Obtaining site, reach and system estimates will permit an assessment of habitat availability relative to longitudinal changes in geomorphology, temperature and flow. Habitat census approaches may be applied to remote sensing such as aerial photography or LIDAR to generate habitat area indices (e.g., length of edge, sinuosity) at the system scale.

***Determine interim quantitative targets*.** We will estimate how large an increase in habitat is physically possible within the existing landscape or under the constraints of ROD management. Thus, we propose to develop a habitat target based both on production levels that are back-calculated from Program escapement goals and the intrinsic potential (e.g. Agrawal *et al.* 2005) of the Trinity system. A "potential habitat capacity" assessment can be used to develop an initial target based on features such as valley confinement and channel complexity. This target first will be related to the ultimate size and complexity of the channel. Then it will be revised using carrying capacity to relate the habitat target to potential fish production. Habitat capacity and its interaction with carrying capacity are discussed further in Appendix C.

Link habitat availability to physical form, structure of the channel, and flow hydraulics. We propose to evaluate the potential linkages between geomorphology, habitat, and fish abundance and distribution. We propose to statistically compare fry abundance to measures of habitat and channel complexity. Regression analyses may yield potential effects of different scales of geomorphic features. These features and the processes driving them can then be linked to our management actions of adding gravel and flow (see Section 3.1).

Assess objectives and predicted response of site specific rehabilitation actions. Change in habitat availability in the sites due to rehabilitation actions should be analyzed after construction and after flows have worked the surfaces (see Section 3.1). We could also investigate whether longitudinal position in the river above the North Fork influences the effectiveness of the features. Confounding factors such as proximity to tributaries, tributary accretions, and radius of curvature can be incorporated into regression analyses. Through detailed assessments of objectives and interim habitat availability targets, we could provide input to site designers on effectiveness at meeting objectives of both site and features.

Proposed space and time frames

The spatial scale for our hypothesis is system wide; however, assessment of habitat change will be conducted at the site (and/or treatment suite), reach, and system scales. Temporally, we will establish an initial baseline and then update this at regular intervals. Use of GRTS sampling with an associated rotating panel design (see Chapter 4) will allow us to perform site scale assessments (to provide feedback to management actions) as well as provide estimates of habitat availability at the reach or system scale.

Site scale

Site scale habitat assessments are intended to evaluate the effectiveness of and provide adaptive management feedback on the effectiveness of particular management actions at producing habitat availability. Certain site-specific assessments will thus be temporally linked to rehabilitation project schedules (i.e., multiple before-after contrasts); these management actions will be assessed using the implementation, effectiveness, and validation monitoring approaches described in Chapter 2.

Reach scale

Stratification by reach might be based on confined stretches versus unconfined where we expect more change to occur (see Chapter 4 for additional discussions). Reaches can be stratified within an overall GRTS design if deemed necessary. Alternately, a census of coarser indices obtained from remote sensing could provide estimates of habitat. Reaches may also be assessed and compared with respect to suites of habitat rehabilitation projects constructed within them, to assess how geomorphic or management factors affect the rate of habitat creation.

System scale

System-scale assessments will include the establishment of (or use of existing information as) a one-time baseline of the amount of suitable habitat for various life stages, and periodic assessments of changes in these quantities over time. Broadly, our temporal scale for measuring the hypothesized system-wide change is multi-decadal.

Priority issues to address

Habitat assessment has recently received a great deal of attention (e.g., SAB 2006b), and alternative assessment methods have been closely scrutinized in IAP workshops.

Technical issues still to be resolved:

1. **Evaluate the compatibility of habitat assessment method(s).** This involves determining if independently derived habitat suitability maps and depth/velocity contouring using SBHM and 2-D modeling are compatible, and if so, determining how to integrate the methods to most efficiently provide the information needed for habitat assessments. There are a variety of issues to be resolved here, which will be worked out for a sample of sites in 2008 and 2009.
2. **Identify targets for how much habitat we need, and identify how much habitat we can potentially have based on geomorphic and hydrologic conditions.** While we will focus on establishing a baseline and measuring change over time, the methods to be developed for Step 3 will need to be expanded to allow generation and evaluation of habitat targets (e.g., through fish population models such as SALMOD).
3. **Explore metrics of habitat availability during fry/presmolt rearing period** (see Appendix C). Review literature and existing data to develop most appropriate link to fish production estimate.
4. **Develop and utilize an adaptive management capability for use in assessing channel rehabilitation projects.** It is vital to learn from existing projects, so that we can recommend changes in rehab project types or designs to the RIG in a timely manner, before all implementation funds are spent. An implementation, effectiveness, and validation monitoring (IEV) scheme has been proposed and must be carefully integrated with channel complexity and habitat availability assessments (Sections 3.1.2 and 3.2.1).
5. **Investigate cost benefit analyses and usefulness of production models (dependent on degree of certainty) for gaming** (see Section 3.3.1 and 3.3.2)**.**
6. **Evaluate the performance of LiDAR data for producing the topographic Triangular Irregular Network (TIN) within a 2D habitat model.** Compare results from 2009 LiDAR with measured habitat at a specfic site.

3.2.2 Sub-objective 2.2: Improve riverine thermal regimes for growth and survival of natural anadromous salmonids

2.2.1 Provide optimal temperatures to improve spawning success of spring and fall-run Chinook salmon

2.2.2 Improve thermal regimes for rearing growth and survival of juvenile steelhead, coho salmon and Chinook salmon

2.2.3 Improve thermal regimes for outmigrant salmonid growth and survival (dependent on water year)

2.2.4 Minimize temperature impacts to other native fish habitats

In-river water temperature is a key habitat condition for all freshwater lifestages of anadromous salmonids. Improving the thermal regime in the mainstem Trinity River was one of the major objectives that guided the development of the annual hydrographs recommended in the TRFE (USFWS and HVT 1999). Temperature influences the immigration behavior of adults and viability of their gametes, fry emergence timing, virulence of fish diseases, strength of fish immune response, and growth of post emergent fish (Rich 1987; Boles 1988; Armor 1991). Temperature provides emigration cues, affects the smoltification process, and influences the size that fish attain prior to leaving the Trinity River basin for the ocean (Folmar and Dickhoff 1980; Wedemeyer *et al.* 1980; Rich 1987; Hoar 1988). Improving thermal regimes for freshwater life stages of anadromous salmonids will minimize pre-spawn mortality, maximize egg viability, reduce mortality of freshwater life history stages, and optimize growth and smoltification for ocean survival.

HYPOTHESIS:

Flow management and changes in channel morphology and riparian community will improve water temperatures available to anadromous salmonids and other aquatic organisms throughout the duration of their in-river life histories.

Proposed assessment strategy and rationale

The existing interagency temperature monitoring network from the Klamath River estuary to Lewiston Dam will continue to be employed to longitudinally measure water temperatures faced by in-river salmonids. Detailed temperature modeling of the reservoir and river[11] allows inferences on temperatures between monitoring locations, and the ability to simulate the effects of alternative dam operations, hydrology and meteorology. The top priority for temperature assessments is to describe longitudinal thermal conditions at reach and system scales, compare these to established TRFE temperature objectives (Tables 3.1 and 3.2), and the resulting biological response of adult (Section 3.3.1) and juvenile (Section 3.3.2) salmonids.

The second priority is to characterize thermal heterogeneity at a site scale resulting from specific rehabilitation site designs so as to improve future designs. Thermal heterogeneity is another aspect of habitat diversity and while not extensively studied, Trinity River salmonid fry have been observed using backwater and edge habitats that were several degrees warmer than mainstem habitats (Gallagher 1999). This assessment requires a template of preferred levels of thermal heterogeneity from an ‘ideal’ location, so as to evaluate the adequacy of completed rehabilitation sites. Thermal variability will provide opportunities for salmonids and other key species (Western Pond Turtles, Foothill Yellow-legged Frogs, etc.) to “select” temperatures that optimize their metabolic rate for improved growth. Performance measures for site-level thermal diversity will be developed to characterize current conditions, and quantify change in response to rehabilitation.

Proposed performance measures and analyses

Key performance measures

- ***Water temperatures*** at specific times within specific reaches or at specific sites related to TRFE temperature objectives for salmonids (see Tables 3.1 and 3.2).

Table 3.1. TRFE water temperature objectives for adult salmonids.

Dates	Temperature objectives (ºF)

[11] RMA-2 (flow model) and RMA-11 (temperature model) are being used to model temperatures on the Trinity and Klamath rivers. These models can be expanded to 2 dimensions at particular sites (Mike Deas, pers. comm.).

	Douglas City (RM 93.8)	North Fork Trinity confluence (RM 72.4)
July 1 through Sept 14	60	n/a
Sept 15 through Sept 30	56	n/a
Oct 1 through Dec 31	n/a	56

Table 3.2. TRFE species specific and water-year type specific water temperature objectives at Weitchpec for outmigrant salmonids, and associated outmigrant dates for at least 80% of the spring/summer population.

Species	Date of at least 80% outmigration	Water temperature objective (ºF) for Extremely Wet, Wet, and Normal water year types	Water temperature objective (ºF) for Dry and Critically Dry water year types
Steelhead	May 22	<55.4	<59.0
Coho salmon	June 4	<59.0	<62.6
Chinook salmon	July 9	<62.6	<68

Candidate performance measures

- ***Thermal heterogeneity*** (site level)

Integration of performance measures with performance measures in other disciplines

While temperature metrics are part of the physical habitat experienced by salmonids and other riverine dependent organisms, temperature objectives which guided specific dam flow releases are based on an expected biological response. For the adult temperature objectives, the biological response metrics are pre-spawning mortality (also need to account for the magnitude of run size) and egg fertility. For the juvenile outmigrant temperature objectives the biological response is the timing, duration, health, and size of outmigrating salmonids. Additionally, evaluations of site level temperature heterogeneity will relate to information collected on geomorphic and habitat complexity, and an understanding of the influences of these metrics on thermal heterogeneity. The expected biological response to be evaluated would be site level microhabitat use incorporating a thermal component and possibly using other non-salmonid organisms (e.g., frog tadpoles, turtles, sucker fry) to evaluate the overall biological response.

Expected response

Flow management actions have a great influence on the thermal regime of the river and can be managed to provide temperature regimes that improve anadromous salmonid production. The variability in hydro-meteorological conditions, especially during the descending limb of the TRFE hydrographs, will continue to influence the attainment of outmigrant temperature objectives and the resulting biological response. It is expected that salmonid outmigration will be influenced by these hydro-meteorological cues. Since the dam releases are adjusted to assure attainment of adult temperature objectives, it is expected that pre-spawning mortality will be relatively low except in large run years when density-dependent stress tends to increase pre-spawning mortality. It is also expected that attainment of the adult temperature objectives will maintain high egg fertility. As the channel achieves increased complexity through rehabilitation actions, site level temperature heterogeneity is expected to increase which should benefit organisms by providing the opportunity to seek different temperatures to optimize growth.

Analysis

Annual system longitudinal thermal regime monitoring and model verification in response to dam releases will continue (Zedonis and Turner 2007). Relationships between the distance from Lewiston Dam, travel time, and the effect of radiant and solar heating in the current channel configuration are understood but it is unknown how much this may change over time as the channel changes. Additional sites for monitoring temperature may need to be considered as channel complexity increases.

Site level thermal heterogeneity is expected to increase with channel complexity. Metrics to describe this heterogeneity need to be developed so that we can quantify changes from current conditions. Examination of healthy reference areas, potentially sections of the North Fork Trinity or the mainstem Trinity below the confluence with the North Fork, could be used to develop metrics for temperature heterogeneity in sections of the river that exhibit geomorphic complexity.

The analysis of temperature effects on juvenile / adult fish production and health will likely require a weight of evidence approach with multiple methods. These methods could include development of indicators which integrate flow, temperature and habitat effects (e.g., # of suitable habitat days, see Appendix C), differences in fry and juvenile production / health between areas with different thermal regimes and levels of thermal heterogeneity; differences in smolt production and health between years with different thermal regimes (caused either naturally or deliberately), and fish production (i.e., growth and survival estimates from SALMOD) simulations calibrated to current conditions that explore the apparent influence of thermal regimes on fish survival and production.

Proposed space and time frames

Site scale

Thermal heterogeneity should be described at the scale of rehabilitation sites, both before and after rehabilitation actions, as well as at some reference sites. This will permit exploration of the relationships between rehabilitation actions, channel complexity and thermal diversity, with the objective of improving the design of rehabilitation sites over time. Long term monitoring of changes in fish habitat and geomorphology at the site scale should also include some level of measure of thermal heterogeneity.

Reach scale

If reach level thermal analyses are desired they can be provided by the system scale assessment since longitudinal temperature gradients are measured and modeled at the system scale.

System scale

The temperature objectives are system level objectives but apply to different areas of the river dependent on the different salmonid life stages addressed. The adult temperature objectives apply to the upper Trinity River, either North Fork Confluence (RM 72.4) or at Douglas City (RM 93.8), from July through December. The juvenile salmonid outmigrant temperature objectives apply to the Trinity River at Weitchpec (RM0) from April through early July.

Priority issues to address

Technical issues *still to be resolved:*

1. **Evaluation of cool water pool in Trinity Reservoir.** An evaluation of the capability of meeting temperature objectives under a scenario where multiple consecutive dry water year types occur should be conducted. Specific scenarios should be evaluated using models, such as whether or not the volume of carry-over storage between years in Trinity Reservoir is enough to ensure

availability of cool water and provide favorable conditions for salmonids in the Trinity River downstream of Lewiston Dam. This could lead to a management plan which would ensure that this critical component of fish habitat can be maintained during all years.

2. Develop metric to **define thermal heterogeneity** and investigate the use of infrared thermal imaging (e.g., FLIR) as a tool to collect these data. What metric could be developed to capture existing thermal heterogeneity (e.g., simple channel vs. hyporrheic zones, alcoves that warm, etc.)

3.2.3 Sub-objective 2.3: Enhance or maintain food availability for fry and juvenile salmonids

2.3.1 Increase and maintain macroinvertebrate populations

Aquatic and terrestrial macroinvertebrates commonly represent the bulk of prey consumed by juvenile salmonids. As a primary food base, these organisms must be sufficiently abundant to support millions of growing fry each year through the late winter and spring periods. Through the summer, fall and winter periods, food resources must also support rearing by juvenile steelhead and coho salmon. Habitat for many of the most important aquatic macroinvertebrate prey occurs in riffle areas, which are sensitive to flow management. During baseflow conditions, releases from Lewiston Dam offer substantial control over flows as far downstream as the North Fork Trinity; potentially, macroinvertbrate habitat throughout the Program area can be managed to optimize food availability (terrestrial and aquatic macroinvertebrate production) with respect to requirements of early lifestage salmon and steelhead. Riparian vegetation hanging over the river or grasses and shrubs on the floodplain during high flows are sources of terrestrial insects.

HYPOTHESIS:

Management of flow releases in association with construction activities (channel rehabilitation site construction, gravel placement, riparian planting) will increase quantity and availability of both terrestrial and aquatic macroinvertebrate habitat.

Proposed assessment strategy and rationale

The strategy for this assessment is to obtain baseline estimate quantity and availability of both terrestrial and aquatic macroinvertebrate habitat.. Macroinvertebrate habitat area, as it varies with discharge (e.g., total area of suitable habitat at predominant flows like 300 or 450 cfs), may be a predictor of food availability. However, these relationships are not always clear (Lammert and Allan 1999). Various predictive methods have been applied through the years to macroinvertebrates (e.g., Stalnaker *et al.*1995; Armitage *et al.* 1987; Hawkins *et al.* 2000). Numerous rapid assessment methodologies exist that might be employed to assess food quality.

Proposed performance measures and analyses.

Candidate performance measures

- ***Macroinvertebrate Habitat Area*** (e.g., extent and duration of inundation of specific habitats of use to invertebrates, substrate size and degree of embeddedness) (linkage to Objective 3.1).

Integration of performance measures with performance measures in other disciplines

Habitat to support key macroinvertebrate prey is found in the mobile depositional features, such as bar-associated-riffles, which are targets of rehabilitation efforts intended to increase habitat for pre-smolt salmon and steelhead. If properly selected, measures of fish habitat, such as the stage-discharge relationship, can potentially inform availability of habitat for key macroinvertebrates and therefore food availability for fish. Fish growth rates, survival, and condition are all expected to correlate positively to each of these invertebrate metrics. Invertebrate production will also be related to flow and temperature in the river.

Expected response

As channel complexity increases in response to management actions, habitat for aquatic macroinvertebrates will increase, leading to greater abundance of prey (as well as increased invertebrate species diversity as simple reaches become more structurally complex) for juvenile salmonids.

Analysis

Estimates of the area of suitable habitat for benthic production at different flows will be assessed initially and compared to locations of fry rearing habitat to see if they are close to one another. Aerial photographs showing locations of riffles and a well documented discharge-to-depth relationship in the riffles could provide insight into the effects of flow management on productive habitat.

Proposed space and time frames

Site scale

More intensive, data-demanding performance measures for macroinvertebrates (e.g., production, standing crop, diversity) can likely only be used to directly evaluate rehabilitation impacts at a rigorously selected subset of rehabilitation sites and reference sites (i.e., the same ones used for mapping suitable fish habitat). It may be feasible to extend the 2-D modeling described in Section 3.2.1 to estimate the *area of suitable habitat for benthic production* at these same sites.

Reach scale

NA

System scale

NA

Priority issues to address

Technical issues still to be resolved:

1. Determine what assessments are feasible at each scale, given the high natural variability of macroinvertebrate populations.

3.3 Objective 3: Restore and maintain natural production of anadromous fish populations

Quantitative annual assessment of both adult spawning escapement (natural and TRH spawning escapement) and juvenile production (natural and TRH production) will be essential to provide feedback on annual management actions and evaluation of long-term Program goals for natural fish production. The primary hypothesis identified in the TRFE (USFWS and HVT 1999) states that maximizing suitable rearing habitat area for Chinook salmon, coho salmon and steelhead, will result in increased growth rates, size at age, and production (TRFE Appendix O, pg. O-4). The cumulative effects of Program management actions are expected to increase natural production of anadromous fish populations; however, overall freshwater production is influenced by both anthropogenic and natural factors.

Assessments to identify and evaluate these factors will be critical in evaluating impacts of reach-scale and system-wide management actions on the natural production of anadromous fish populations.

Assessments of both early and adult salmonid life-history stages can provide mechanistic explanations and insight into potential limiting factors such as suitable habitat availability and water temperature. These assessments, combined with outmigrant population abundance estimates can provide model inputs and validation data sets for proposed fish production models (such as SALMOD). Assessing population size and survival between intermediate life-stages will improve understanding of habitat effectiveness, connectivity, and the potential role of biological factors in limiting natural production. For example, a fish production models such as that developed by Bartholow (Bartholow *et al.* 1993; Bartholow 1996) may illustrate the accumulated knowledge of the habitat-population link through empirical measures of fish habitat availability and use, fish movement and growth. Illustration of differences between and among years (after the fact) may prove useful for informing managers by use of time series comparisons over the biological year (freshwater period of the life history) for specific water years or alternative reservoir release patterns.

Although the Program does not advocate for recovery of certain anadromous fish species over others, key species have been identified to focus Program efforts to assess population responses to Program actions (both short and long-term). Based on the contribution to dependent fisheries, Endangered Species Act status, feasibility to assess and duration of freshwater rearing, the IAP authors have prioritized assessments of anadromous fish species in the following order:

1. fall Chinook salmon;
2. spring Chinook salmon;
3. coho salmon;
4. steelhead; and
5. Pacific lamprey and green sturgeon.

Cumulative effects of Program management actions are expected to increase natural production of anadromous fish populations; assessments to identify other factors will also be required. For example, the Trinity River Fish Hatchery was intended to mitigate for lost habitat and associated salmonid production upstream of Lewiston Dam (USFWS and HVT 1999). However, anadromous fish hatcheries may negatively influence the productivity of the native fish populations (Sweeting *et al.* 2003; Mobrand *et al.* 2005). Although the Program does not manage the hatchery, assessments of the impacts of hatchery fishes on natural production may be necessary to evaluate the potential for interference with the goals of the Program. Many of these complementary dependent assessments are based on data already collected as discussed in Section 3.3.3 and Section 3.4.

As with TRH management, the Program does not possess the authority to directly manage the harvest of Trinity River anadromous fish runs. The Program is charged with restoring production to achieve escapement targets for the species listed above, while providing restored harvest opportunities to affected tribal and non-tribal fisheries. Hence, meeting escapement and harvest objectives simultaneously should not limit one objective to benefit the other. In short, meeting mandated rehabilitation objectives *and* full participation of dependent tribal, ocean and sport fisheries in the benefits of rehabilitation are not mutually exclusive.

3.3.1 Sub-objective 3.1: Increase spawning, incubation and emergence success of anadromous spawners

3.1.1 Optimize adult utilization of suitable spawning habitat areas in the mainstem within 3-4 brood cycles following rehabilitation of fluvial river processes

3.1.2 Optimize adult utilization of suitable spawning habitat areas in tributaries within 3-4 brood cycles following rehabilitation of fluvial river processes

3.1.3 Reduce temperature related pre-spawning mortality and protect in-vivo egg viability of anadromous spawners in the mainstem Trinity River

Increased natural production of anadromous fry in the Trinity River is dependent upon the annual success of adult spawners, in-gravel egg incubation and emergence. We hypothesize that reproductive success and survival to emergence is largely dependent on abundance and distribution of spawners, the in-river thermal regime to which adults are exposed, and the quantity and quality of spawning habitat. Although adult escapement varies substantially from year to year, increased reproductive success should allow sufficient survival of early emergent fry to occupy and utilize newly created habitats along the river continuum.

PRIMARY HYPOTHESES[12]*:*

A. By increasing the quality and availability of spawning habitat area for Chinook salmon, coho salmon and steelhead, the Program will increase spawning success (and fry production) within 3-4 brood cycles following rehabilitation of fluvial river processes.
B. Increasing the longitudinal spatial distribution of spawners will reduce redd superimposition (reuse of redd sites by later-spawning fish) within 3-4 brood cycles following rehabilitation of fluvial river processes.
C. Reducing redd superimposition in the upper most 2 miles by 25% during normal runs.
D. Reducing fine sediment deposition in high use spawning areas below 15% will increase fry emergence success.
E. Improved tributary access and increased spawning habitat connectivity within the tributaries will improve spawning success for steelhead and coho salmon within 3-4 brood cycles following rehabilitation of tributary connectivity.
F. Achieving adult temperature objectives and increasing and improving holding habitat will minimize prespawn mortality, dependent on run size.
G. Achieving adult temperature objectives will ensure high in-vivo egg viability.

SECONDARY HYPOTHESES:

A. Gradually increasing Lewiston releases from September through December will better distribute salmonid spawners, increasing spawning success (USFWS and HVT 1999: Appendix O).
B. Broader distribution of redds will decrease the risk of redd scour during tributary related flooding events (USFWS and HVT 1999: Appendix O).

Proposed assessment strategy and rationale

Changes in the longitudinal distribution and abundance of spawners will be assessed as a basis for evaluating the success of the Program at maintaining and improving spawning success. These

[12] These are interim targets, and will be revisited and revised as we learn more.

assessments will require annual spawning and redd surveys. Spawning distribution and location of redds will be assessed to determine utilization of newly created spawning habitat as channel complexity increases. Concurrent assessments of spawning habitat availability and quality will compliment spawner distribution data and serve as a baseline for future comparisons. Additionally, these surveys can be used to assess changes in redd superimposition as habitat quality or quantity increases. Redd abundance and distribution in tributaries can be used to assess improved access to and spawning success within tributary spawning habitats.

Quantitative assessments of pre-spawn mortality will provide feedback on the physiological effects of maintaining TRFE water temperature criteria in late summer and fall. Assessing changes over time (and space) in indices of reproductive success and emergent fry survival rates will enable us to evaluate the cumulative influence of temperature, gravel augmentation, channel rehabilitations, and flows on spawning habitat quantity and quality.

The magnitude of fine sediment effects on egg incubation and fry emergence could potentially be elucidated by comparing indices of reproductive or emergence success and validated by measured emergent fry survival rates. However, the first step is to determine the potential magnitude of the problem. It is both infeasible and unnecessary to measure emergence success and fine sediment inputs/budgets on a reach or system scale. Site-scale impact assessments on emergence success as a result of tributary sediment input and mobilization of berm fines are much more practical. Major spawning areas could potentially be demarcated by synoptic sampling of percent fines in high use salmonid spawning habitats (pool tails, riffles, etc.). *If* these data suggest that there might be a fine sediment limitation on spawning or emergence success in these areas, *then* we would proceed to identify the specific locations of potential sediment sources (tributary inputs, berm mobilization) and estimate impacts to emergent success rates through surrogate measures of percent fines in redds (e.g., Tappel and Bjornn 1983). One serious challenge with this approach is the high spatial variability in % fines, requiring large sample sizes to show statistically significant differences across space or time (Table 3 in Roper *et al.* 2002).

Proposed performance measures and analyses

Key performance measures

- ***Density of redds*** per longitudinal river segment or reach, or tributary.
- ***Longitudinal distribution and abundance of redds*** in the upper 40 miles.
- ***Number of redds/spawning habitat*** in association with reach or river segment.
- ***Redd Superimposition*** (e.g., ratio of spawners to constructed redds, index of clustering, distance between redds).
- ***Number (proportion) of un-spawned or partially spawned females***.

Candidate performance measures

- ***In-vivo egg viability***.
- ***Index of reproductive or emergence success*** *(e.g., Tapple and Bjornn 1983).*

Integration of performance measures with performance measures in other disciplines

To explain long-term trends in the distribution and abundance of spawners, we require concurrent assessments of trends in the availability of suitable spawning habitats throughout the Program area (described in Section 3.2.1). Assessments of emergent fry density relative to adjacent spawners (e.g., fry/spawner) will also provide insights on reproductive success. Notwithstanding the sampling challenges (see end of Section 3.1.4), we would like to have synoptic assessments of spawning substrate composition and permeability to help identify what areas should be assessed in more detail for site-specific emergence success. If susceptible areas are identified, then it may be helpful to periodically quantify fine sediment deposition during the period when redds are present in conjunction with indices of emergence success (e.g., Tappel and Bjornn 1983), as a measure of Program success and feedback to management actions in reducing fine sediment inputs and impacts.

Assessing the biological effects of temperature on pre-spawn mortality and in-vivo egg viability depends on water temperature and habitat availability (holding, spawning) (see Section 3.2.1 and 3.2.2). Annual collection of redd distribution and abundance data can also provide empirical data inputs into a fish production model (i.e. SALMOD). Information about the effects of temperature on prespawn mortality and in-vivo egg viability is also required for a fish production model.

Expected response

Assuming channel rehabilitation and other management actions increases available salmonid spawning habitat area throughout the upper 40 miles by 400% from baseline conditions (an initial interim target), we expect the longitudinal distribution and abundance of redds to increase substantially. We postulate that increased spawner success will likely occur within 3-4 brood cycles following completion of channel rehabilitation and subsequent fluvial and geomorphic evolution. Increases in the longitudinal distribution and abundance of redds will be dependent on annual in-river run size and quantity, quality and distribution of available spawning habitat. As suitable spawning habitat distribution increases, through creation of a complex dynamic channel in the upper 40 miles, and spawners increase in number, we expect that distance between redd clusters (superimposition) will decrease indicating increased spawner utilization of available spawning habitat. As the longitudinal distribution of spawners changes, we predict a reduction in redd superimposition and an increase in emergence success (or fry emergence). We predict that emergence success, or a surrogate measure (see Section 3.1), will increase as fine sediment inputs from tributaries and mainstem storage are reduced. As tributary culverts and migration barriers that impede upstream migration of steelhead and coho salmon are replaced or rehabilitated we predict an increase in abundance of anadromous salmonids spawning in Trinity River tributaries. As the channel is rehabilitated and annual temperature targets are achieved, we predict that the proportion of un-spawned or partially spawned females will be minimized, dependent on the magnitude of the spawning escapement, and high in-vivo egg viability will be ensured.

Analysis

A common thread through all the hypotheses to be tested is that density dependent effects are likely to occur and thus must be accounted for within the analyses. To test whether increasing quality and availability of spawning habitat increases spawning success, we need an index of spawning or reproductive success. The ratio of emergent fry abundance to spawner abundance might serve as an index of reproductive success, which could in turn be compared to the abundance and distribution of suitable spawning habitat (i.e., with density dependence, we would expect the index of reproductive success to increase with the area of suitable habitat per spawner). For sites considered to be potentially susceptible to fine sediment stress, the index of reproductive success could be compared across spatial and temporal contrasts in % fines, deposition rates of fine sediments, or some other fine sediment index. This kind of analysis (if statistically valid, given spatial variability in fine sediment and measurement error in the index of reproductive success), would enable evaluation of the effectiveness of fine sediment control measures on a critical life stage.

Several analyses will be required to test whether increasing the spatial distribution of spawners reduces redd superimposition. First, changes over time in the distribution and abundance of spawners and redds will be examined using trend analyses and spatial analyses. Second, we would use clustering and distance between redds as annual *indirect* indices of the potential for redd superimposition. We would expect our index of reproductive and emergence success to increase with both the area and quality of habitat per spawner and the mean distance between redds, and to decrease with the amount of redd clustering. These analyses will be dependent on annual spawning and redd distribution surveys, as well as integrated fine sediment bulk sampling. Analyses of redd abundance and distribution over time, relative to culvert replacements and potential rehabilitation of the confluence to permit connectivity, can be used to assess spawning success in tributaries where access is restored.

Assessing the temperature effect on pre-spawning mortality and egg viability entails: 1) relating annual summer and early fall thermal regimes, including attainment of the temperature objectives, to observed pre-spawning mortality, while accounting for the magnitude and distribution of spawning populations; 2) relating annual summer and early fall thermal regimes to egg viability of fish spawned at Trinity River Hatchery; and/or 3) conducting laboratory studies to evaluate the effects of different temperatures or thermal regimes on adult survival and egg viability. The first two items require contrasts in temperature conditions, which may occur either naturally or deliberately, as discussed in Section 3.2.3.

Proposed space and time frames

Site scale

Site scale assessments of redd abundance and distribution associated with rehabilitation sites can be done on a case by case basis (e.g., to assess the effectiveness of certain design features meant to encourage spawning).

Reach scale

Annual reach and sub-reach assessments of redds and carcasses should be conducted on the mainstem Trinity River and in tributaries where feasible. Assessment area priorities are based on expectations of where Program actions will have the most effect on reproductive and emergence success.

Treatment reaches: annual reach and sub-reach assessments of redds and carcasses should be conducted on the Trinity River mainstem from Lewiston Dam to the North Fork. This stretch of the river is the area where Program management actions can have a substantial effect on reproductive success.

Control reaches: annual reach and sub-reach assessments of redds and carcasses should be conducted on the mainstem Trinity River from North Fork to Cedar Flat. Once escapement begins to approach TRD goals, we expect increased in spawning in these sections of river. Prior to that time, we do not expect significant change in this area from our management actions. Temperature effects extend into this reach. Annual reach and sub-reach assessments should be conducted on the mainstem Trinity River from Cedar Flat to Weitchpec. We do not expect a significant change in spawning habitat in this area as a result of our management actions.

System scale

Assessments of adult pre-spawn mortality should be conducted annually from Lewiston Dam to the North Fork Trinity confluence, with monitoring periods related to specific run-timing of the species of interest. Assessments dependent on changes in longitudinal distribution of spawners will be done from Lewiston to Weitchpec.

Priority issues to address

Technical issues still to be resolved:

1. Reaches not affected by TRRP management actions should be identified and considered as candidates for control reaches that can provide an historic record of redd distribution vs. habitat

availability, contribution of hatchery-origin adults (see Section 3.3.3 and 3.4 for additional metrics), prespawn mortality, etc. In the main Program area above the North Fork of the Trinity, control sites and reaches can be expected to gradually evolve as well, assuming that Program flow and sediment management actions are successful. This issue is discussed in Chapter 4.

2. It is important to work with geomorphologists to assess the statistical and logistical feasibility of identifying spawning areas vulnerable to fine sediment deposition, given the challenges outlined at the end of Section 3.1.4.
3. Need to calculate initial interim targets for performance metrics and how we would evaluate success.

A challenge is to determine the need for a fish production model. If it is decided that using a model would be beneficial to the Program, then a review of currently available fish production models should be undertaken to determine which one would best suit the needs of the Program. This should include a review of SALMOD, originally developed for the Trinity River. Many critical model components are planned or are currently in development by the Program including in-river and reservoir temperature models (e.g., SNTEMP, RMA), geomorphic river models, habitat assessments (EHM, 1-D and 2-D), and annual biological assessments. Each of these components should be evaluated to determine critical linkages and appropriate levels of precision and accuracy for input to SALMOD. Additionally, appropriate model calibration and validation steps should be identified and incorporated into future applications of SALMOD.

3.3.2 Sub-objective 3.2: Increase freshwater production of anadromous fish

- 3.2.1 Increase fry abundance, growth, physical condition, and health from baseline conditions in the mainstem Trinity River within 3-4 brood cycles following rehabilitation of fluvial river processes
- 3.2.2 Increase outmigrant juvenile life stage abundance, growth, physical condition and health from baseline conditions in the mainstem Trinity River within 3-4 brood cycles following rehabilitation of fluvial river processes
- 3.2.3 Improve juvenile fish production as a function of water temperature and habitat flow relationships from baseline conditions in the mainstem Trinity River within 3-4 brood cycles following rehabilitation of fluvial river processes
- 3.2.4 Reduce clinical disease incidence in Trinity River origin outmigrants in the Klamath River to less than 20% within 5 years[13]
- 3.2.5 Reduce fry stranding in the upper 40 miles of the mainstem Trinity River by 50% following rehabilitation of fluvial river processes[13]
- 3.2.6 Reduce non-native fish predation on naturally produced fish by 50% in the mainstem Trinity River within 3-4 brood cycles following rehabilitation of fluvial river processes[13]

One of the primary causal relationships underlying the Program is that increasing rearing habitat availability and quality will increase rearing and outmigration success and the freshwater production of natural salmonid populations. Assessing this primary causal relationship is fundamental to the Program and of highest priority for the successful implementation of the AEAM Program.

The TRFE hypothesized that improved natural salmonid production can be achieved by creating and improving salmonid rearing and spawning habitat and improving rearing and outmigrating thermal

[13] These are interim targets, and will be revisited and revised as we learn more.

regimes. Biological assessments that evaluate the physiological response of anadromous fish populations to improved rearing conditions are fundamental to evaluating the effectiveness of Program management actions. Additionally, the Program must assess other biological impacts on salmonid production. Recent research on disease levels in the Klamath River (Foott *et al.* 2002; Stocking *et al.* 2006) has raised concerns for the survival of salmonids produced from the Trinity, as they rear in and migrate through the lower Klamath River to the ocean. However, recent evidence indicates that Trinity River hatchery-produced Chinook salmon are healthier than their Klamath River counterparts (Nichols and True 2007). Improved growth, health, and condition of fry and juveniles will likely improve their ability to fight disease organisms and increase the survival of naturally produced Trinity salmonids as they migrate through the lower Klamath River and estuary. Furthermore, assessments to quantify impacts from non-native fish predation and competition with naturally produced salmonids may be necessary to understand other potential limiting factors affecting Program fishery rehabilitation efforts. Implementation of ROD flow ramping rates are believed to reduce fry stranding impacts, and improved riverine and floodplain connectivity resulting from channel rehabilitation activities should also reduce fry stranding impacts. Assessments of fry stranding impacts will determine if TRFE management objectives are achieved.

PRIMARY HYPOTHESES[14]:

A. Increasing the quality and availability of suitable fry and juvenile rearing habitat (including water temperature) by at least 400% (interim target) will increase size, growth, condition and overall health of natural fry and juvenile salmonids.
B. Improving growth, size and condition by 10% will increase survival of naturally produced fry and juvenile fish in the upper Trinity River.
C. Increased size, improved physical condition, will result in improved survival to the estuary.
D. Delayed outmigration timing, during Normal and wetter years, will result in a 5% increase in outmigrant size due to extended freshwater rearing, leading to increases in survival during the early ocean life phase.
E. Clinical disease incidence within Trinity River salmonids in the lower Klamath River will reduce by 20% within 5 years.
F. ROD flow ramping rates and improved riverine and floodplain connectivity resulting from channel rehabilitation activities will reduce fry stranding by 50%.
G. Non-native fish populations will impact natural production through predation and competition with endemic fry and juveniles.

SECONDARY HYPOTHESIS:

A. Delayed outmigration timing, will result in decreased survival rates from the Klamath-Trinity confluence downstream to the ocean due to water quality and fish pathogen conditions in the lower Klamath River.

Proposed assessment strategy and rationale

Hypotheses A, B, C and D:

To test these critical hypotheses (which are primary causal relationships for the Program), we need to assess the relationship between {growth rate, size, condition and abundance of salmonid fry and juveniles} and {the amount of suitable habitat for these life stages}. These biological performance measures, assessed for different reaches, will provide feedback on the local quality and availability of

[14] These are interim targets, and will be revisited and revised as we learn more.

rearing habitat. Assessing salmonid fry and juvenile salmonid movement downstream and abundance in different reaches will provide feedback on habitat use.

Changes in the abundance of emergent fry and juveniles over time and in relation to parental spawner abundance produced from the upper Trinity River is the primary metric proposed for assessing whether rehabilitation and flow actions have increased natural salmonid production. Assessing salmonid outmigration timing and duration as well as condition and size, through the lower Trinity River where flows are managed to provide improved thermal regimes will provide feedback on the biological effect of temperature management. The condition of smolts as they enter the ocean influences their survival to later life stages; studies have documented the relationship between size of smolts entering the ocean and survival to adults (Unwin and Glova 1997; Jokikokko *et al.* 2006). Additional assessments should determine if a detectable increase in the health and condition of outmigrating anadromous fish has been achieved as a result of improved rearing habitat conditions and rearing water temperatures.

The purpose of TRFE outmigrant water temperature objectives (Chap.3.2.2) is to provide improved thermal regimes to increase the health and survival of outmigrating juvenile salmonids through the lower Trinity River. Additionally, the thermal regimes associated with ROD flows are expected to provide better growth condition for juvenile salmonids that rear over the summer and fall seasons. Providing favorable thermal regimes for these life stages, as well as better rearing conditions, should increase anadromous fish production from the Trinity River. While dam releases are actively managed to meet the adult temperature criteria at the compliance points, which results in minimal variability in thermal regimes, flow schedules that are expected to meet the outmigrant temperature objectives are set in April and the actual thermal regime varies due to annual hydro-meteorological variability. Quantification of the growth of salmonids with extended freshwater rearing in the mainstem Trinity River (coho salmon, steelhead, and stream-type Chinook salmon) will enable assessment of the effects of water temperature.

Hypothesis E:

Out of concern that pathological factors could potentially undermine efforts to reestablish and maintain production of Trinity River anadromous fish populations, the Program has participated in collaborative assessments of disease prevalence downstream from the North Fork through the lower Klamath River to the estuary. The size and condition of Trinity River outmigrants and subsequent survival in the lower Klamath Rivers are important factors for assessing the effects of various environmental conditions (such as flow regimes) upon rates of survival to adulthood. Hypotheses C, D, and E all affect smolt to adult survival rates (typically measured by # recruits/smolt), as do other factors such as ocean conditions. A key question is whether the positive effects of larger sizes and improved physical condition (hypotheses C and D) will more than compensate for disease and stress effects (hypothesis E). Teasing apart the independent effects of these different factors would require significant year to year contrasts in their magnitude, which may or may not occur.

Hypothesis F:

Previous studies have estimated mortality impacts as a result of fry stranding (Chamberlain 2003). Periodic assessments of fry stranding following major flood events and Safety of Dam flow releases may be needed following completion of all 47 channel rehabilitation sites. Post-rehabilitation fry stranding assessments can be compared to pre-rehabilitation assessments to determine if floodplain connectivity has been achieved.

Hypothesis G:

Quantitative assessments of non-native predation and competition to measure impacts on natural fish production will be needed to determine non-habitat factors limiting fry and juvenile salmonid production.

Although lower priority at this time, these assessments may determine that substantial predation and competition impacts severely limit the ability of natural fry and juveniles to utilize desired habitat, and realize their production potential.

Proposed performance measures and analyses

At meetings held in 2006 and 2007, Program scientists identified the following key performance measures:

Key performance measures

- ***Fry density, abundance***, ***standing stock*** (site, reach).
- ***Presmolt and smolt condition*** or ***overall health*** (reach, system).
- ***Fry and juvenile size distribution*** (reach, system).
- ***Salmonid presmolt and smolt abundance*** and ***survival*** (reach, system).
- ***Outmigration timing*** (system).
- ***Outmigration duration*** (system).
- ***Incidence*** and ***severity of infection*** of *Ceratomyxa shasta* (system).
- ***Incidence*** and ***severity of infection*** of *Parvicapsula minibicornis* (system).

Candidate performance measures

- ***Predation rate on fry and smolts*** (site, reach).
- ***Fry and juvenile (early life-history) growth rate*** (reach, system) based on ***otilith analysis*** of returning adults or looking at changing seasonal ***fry and juvenile size distribution***.
- ***Number of ocean recruits / smolt* (see below).**

At a workshop held January 15-18, 2008, Program scientists examined these performance measures in greater detail, and proposed the following elaborations to the above list:

1. Juvenile fish assessments would focus first on Chinook salmon, both because of their primary importance to dependent fisheries, and to refine assessment methods before moving on to other species. However the Program currently is studying coho salmon juveniles, due to the status of this species as federally threatened.
2. Chinook salmon juvenile production would be monitored through three complementary performance measures:
    a. The number, size and health of Chinook salmon fry, pre-smolts, and smolt-equivalents[15] on the mainstem Trinity River at the North Fork confluence and at the lower Trinity monitoring site (near Willow Creek). The first location reflects the cumulative effects of all Program actions, while the other location detects and quantifies the effects of the Program's outmigrant temperature management actions.
    b. Fry standing stock at multiple co-located sampling sites rigorously selected to be representative of the entire river between Lewiston and North Fork, to demonstrate the effects of spawner abundance, temperature, area of suitable habitat and other covariates on fry abundance. Spatial contrasts within each year will provide an indication of action effectiveness.

[15] Fry are defined as < 50 mm. Smolt-equivalents are a weighted combination of fry and pre-smolts which reflects the lower survival of fry to ocean entry (e.g. 0.4 * fry + pre-smolts).

   c. An estimate of fry outmigrating downstream past Douglas City (e.g., rotary screw trap, frame net, other methods) providing a system level production index for the major spawning areas in the 18 miles immediately below Lewiston Dam (i.e., the bottom of Region 2 delineated in Figure 3.4 of the IMEP (TRRP, ESSA, NSR 2006).
3. The above performance measures would be compared to the number of contributing spawners in the appropriate upstream region (e.g., fry / spawner, or graphs of fry vs. spawners).
4. The Program would develop system and reach scale indices of the suitability of the annual temperature regime (e.g., total degree days deviation from the optimum temperature for juvenile salmonid growth), to use as covariates in explaining annual variations in biological responses. Similarly, the Program would need a system wide annual index of the area of suitable habitat, or number of days with sufficient habitat area and appropriate temperatures given the number of fry present in that year (see Appendix C).
5. Estimating survival rates along the Trinity River (i.e., Douglas City to North Fork to Willow Creek to Weitchpec) would require a coordinated effort. Due to advances in radio tag size and battery duration, recent radio telemetry studies on coho salmon in the Klamath and Trinity Rivers showed a 35% survival rate from the Trinity Hatchery down to the estuary (Beeman et al. 2009).
6. Estimated growth rates during the early life history, estimated from otoliths taken from a random sample of returning adults, to help determine critical sizes for good ocean survival. This performance measure requires further development.

Integration of performance measures with performance measures in other disciplines

Assessments of how fry density and growth respond to changing rearing habitat quality and availability are critical. Trinity smolt survival in the lower Klamath River and estuary may provide feedback on a potential significant source of mortality of Trinity fish. The escapement of natural spawners (and the number of spawners by reach) will influence the abundance and distribution of fry, and is therefore a key covariate. Water year type and accompanying changing flows in tributaries may have an influence on steelhead and coho salmon smolt abundance.

Temperature and flow monitoring data are needed as covariates to help explain the health, condition and migration timing of juvenile fish, and thereby evaluate the appropriateness of TRFE temperature criteria. To determine if temperature objectives have been met for the majority of the outmigration period, the Program needs to monitor the health/condition of smolts, mainstem water temperatures at Weitchpec (see Section 3.2.2) and the outmigration timing of salmonids through the lower Trinity River. Additionally, managers must determine the appropriate application of river temperature and reservoir temperature models for managing flows to achieve smolt temperature criteria as defined in the TRFE.

The Program would develop system and reach scale indices of the suitability of the annual temperature regime (e.g., total degree days deviation from the optimum temperatures for juvenile salmonid, Foothill Yellow-legged Frog tadpole and Western Pond Turtle growth), to use as covariates in explaining annual variations in biological responses. Similarly, the Program would need a system wide annual index of the area of suitable habitat, or the number of days with sufficient habitat area and appropriate temperatures given the number of fry present in that year.

Expected response

We expect the following responses:

- Fry and juvenile salmonid density, abundance and survival will follow a positive trajectory as ROD rehabilitative actions are implemented (Figure 3.2).

- Condition, growth rates, size, and overall health of both fry, juveniles, presmolts, and smolts will improve as the quality and availability of rearing habitat improves (Figures 3.3 and 3.4).
- Outmigration timing will be delayed and outmigration duration will be extended in Normal, Wet and Extremely Wet years, relative to dryer years (though this depends on flow release schedules and hydrometereological conditions during a specific year).
- Improved thermal regimes will improve the condition, growth rate, and size distribution of juvenile salmonids, increasing smolt abundance and survival for a given level of spawning (Figure 3.2).
- As the condition and overall health of Trinity Smolts improves, there will be a reduced incidence and severity of infection of *Ceratomyxa shasta* and *Parvicapsula minibicornis* during transit through the Trinity River and the lower Klamath River.

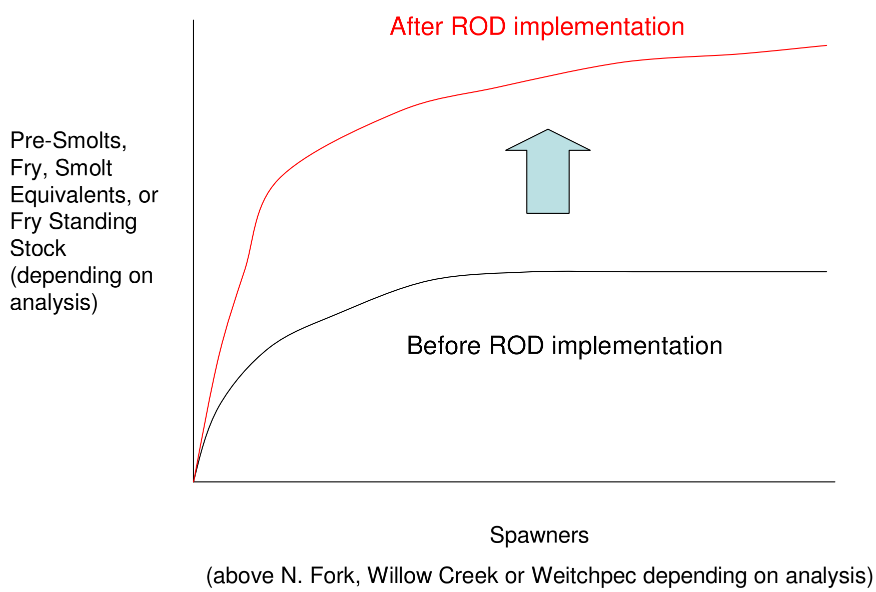

Figure 3.2. Expected response in fry and juvenile salmonid densities with ROD actions.

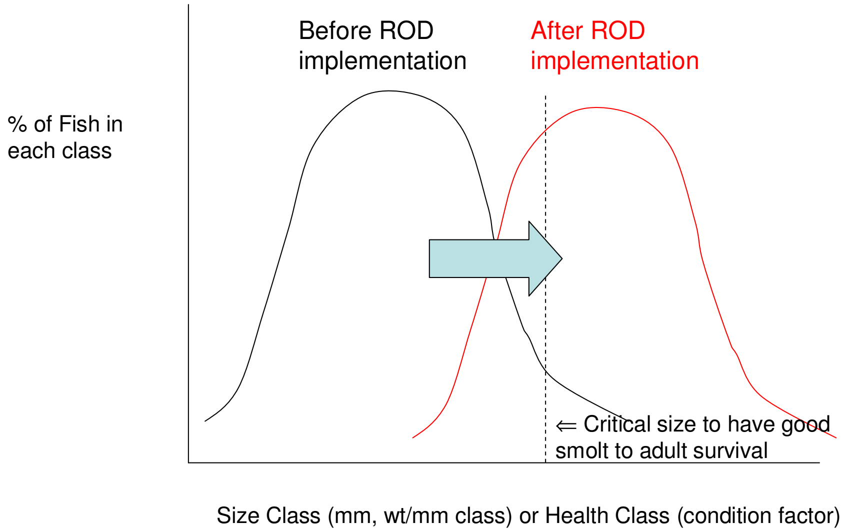

Figure 3.3. Expected improvement in the condition / health / size of juvenile salmonids with implementation of ROD actions.

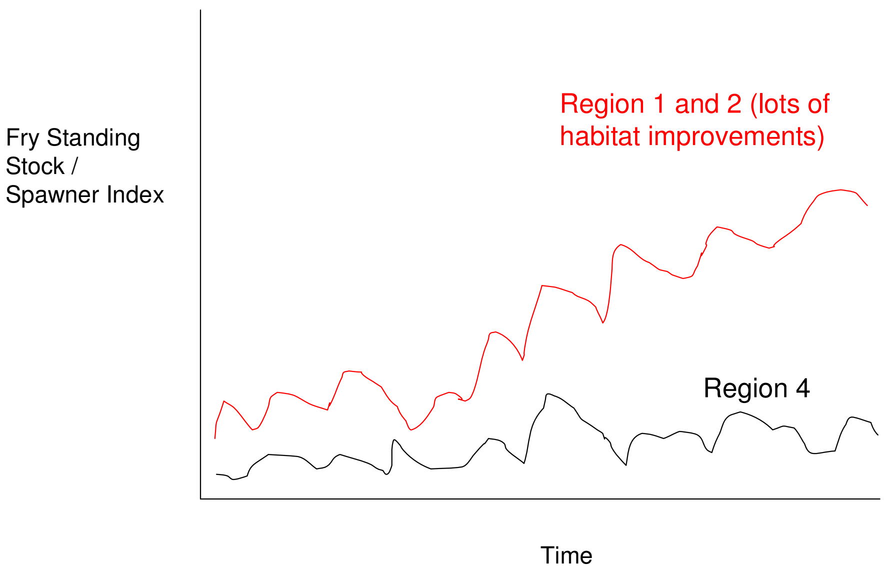

Figure 3.4. Expected improvement in fry / spawner ratio in treated areas, relative to control or reference areas (see Figure 3.4 in IMEP (TRRP, ESSA, NSR 2006) for a map of proposed geographic regions).

Analysis

The juvenile fish assessments fall into 2 categories; those that can be sampled using a GRTS Panel design (see Chapter 4) and those that have specific spatial methodologies (i.e., outmigrant monitoring). Assessments of density, survival, size, growth, condition and overall health of natural fry and juvenile salmonids would be co-located at sites where geomorphic and habitat assessments are conducted. Using a GRTS design for the assessment of certain habitat, physical, and juvenile fish performance measures will allow us to examine the potential linkages between alluvial processes and natural fish production.

The basic analysis strategy is to use temporal contrasts across years in flow and temperature conditions, and spatial / temporal contrasts in habitat conditions, to assess changes in recruitment relationships over time (e.g., Figure 3.2 and Figure 3.4 above; Bradford *et al.* 2005). Including spawners as an explanatory variable in these analyses is critical because of both the huge variation in spawner returns / ocean survival and density dependence. Changes in size distribution and increased health (condition factor) (Figure 3.3) could be used to compare pre-ROD to post-ROD conditions or among water year types. Additionally, changes in size, growth and condition as smolts migrate can provide insight into how well they will survive as they move down river to the estuary. Analyses at or above the North Fork are meant to assess changes in habitat, spawners, and temperatures. Analyses at Weitchpec are mainly looking at temperature effects.

We plan to use multivariate analyses of multiple years of data to assess how changes in fry size, growth, condition, and overall health affect fry density, abundance, and survival. These analyses will include, but not be limited to the following explanatory variables: escapement of natural spawners; temperatures at Douglas City, North Fork, and Weitchpec; fry and juvenile rearing habitat quality and availability; and flow. Analyses of initial fry abundance and spatial distribution will give the Program a baseline from which to assess future changes in patterns of fry habitat use and survival/mortality. These analyses will be used to evaluate effectiveness of the Program at creating high quality habitat (see Section 3.2.2).

Multivariate analyses of the response of fry and pre-smolt abundance, condition, size, and growth rates to temperature, flow and habitat conditions may enhance our understanding of the mechanisms by which the Program may increase natural production. Analyses of outmigration timing and duration in response to flow releases will allow evaluation of the effectiveness of these flows in providing suitable thermal regimes for outmigrating salmonids. Comparisons of actual water temperatures and smolt outmigration timing with the temperature objectives and target dates for each species will be used to evaluate if Program objectives are achieved. Assessing the biological effects of these criteria (and the associated flow releases) entails: 1) evaluating the variability of outmigration timing under the new flow regime and varying hydro-meteorological conditions (with varying return probabilities); 2) evaluating the size, health and condition of fry and pre-smolts in relation to annual variations in the thermal regime and outmigration timing; 3) analyzing the response of fry standing stock to spatial contrasts in nearby spawner abundance, area of suitable rearing habitat, and other covariates (e.g., secondary productivity) from multiple sites above the North Fork; and possibly 4) evaluating the temperature objectives for Trinity River basin salmonids. Assessing the influence of the summer/fall thermal regime on the growth rates of juvenile salmonids with extended freshwater rearing, primarily steelhead and coho salmon, will entail comparisons of growth rates under different summer/fall thermal regimes.

As discussed at the start of Section 3.3, we may use a fish production model (i.e., SALMOD) as an exploratory tool to understand factors affecting juvenile salmonid production, make testable predictions of size or number of smolts at the North Fork, do gaming of effects of changes in flows / temperatures / habitat, and explore possible targets for fry / spawning habitat area. These model applications need to ensure that the assumptions are reasonable for the Trinity River, particularly for key functional relationships that affect decisions.

The incidence and severity of infection by pathogens and their impacts on Trinity River natural fish production will be used to evaluate a potential source of significant mortality for Trinity smolts. We will evaluate the effects of increased abundance, size and condition of naturally produced pre-smolts and smolts from the Trinity River on survival through the lower Klamath River and estuary as part of a larger coordinated effort on the Klamath.

Many of the sites chosen for rehabilitation are known stranding areas. As we improve riverine and floodplain connectivity we expect less stranding. Direct quantitative estimates of fry and juvenile mortality as a result of stranding will be sufficient to determine site-scale impacts. These mortality estimates can be compared to rates from the 1990 period prior to the ROD flows and rehabilitations. Population level impacts could be assessed during extreme events using standardized fish kill mortality estimation techniques and analyses (AFS 1992).

Proposed space and time frames

Site scale

Fry standing stock measurements, obtained from a rigorously selected set of channel rehabilitation and reference sites (see Chapter 4), are the most applicable performance measure at the site scale. Site scale contrasts in performance measures derived from fry standing stock measurements (e.g., fry density, size, condition) can be used to infer the apparent influence of Program actions (e.g., area of suitable habitat) in the context of other factors (e.g., distance to nearest major spawning area). Treatment-control comparisons need to carefully consider the level of geomorphic, riparian and biological evolution of each site within each year.

As to the time frame, fry standing stock would logically be sampled at one or more of the following times (listed in order of priority): 1) fall Chinook salmon (Jan-March); 2) spring Chinook salmon (Jan–March), probably February; and 3) coho salmon (March-May). Hatchery spring and fall Chinook salmon young-of-year are released on June 10th, so any measurements after that will include some non-natural production. Steelhead and coho salmon are released in March.

Reach scale

Assessments of fry and juvenile density/abundance, size, growth, condition and overall health are of highest priority in the upper 40 miles of the river (the main focus of Program actions). There are currently two ‘control points’ for measuring fry/pre-smolt outmigration: (1) the North Fork for assessing the overall impact of ROD actions on outmigrating fry and pre-smolts; and (2) Willow Creek for assessing long term changes in spawner-smolt recruitment (longest time series here), smolt size/health/condition, outmigration timing, and the effects of temperature management. At some time in the future this lower river monitoring site may be moved to Weitchpec, to better assess smolt size/health/condition just before Trinity fish enter the Klamath. An additional site at Douglas City should be considered for assessing fry production per spawner within the top 18 miles (reaches 1 and 2 delineated in Figure 3.4 of the IMEP (TRRP, ESSA, NSR 2006)).

In terms of time frame, reach scale assessments should be conducted annually following fry emergence (typically January-April dependent on species) and coordinated with rearing habitat assessments to facilitate integration of sampling designs. Subsequent assessments should be conducted during rearing and outmigration life-stages. Species specific life-history periodicities for Trinity River salmonids have been identified in the TRFE (USFWS and HVT 1999).

System scale

Priority life-stage specific assessments of abundance, growth rates, condition and size should be completed at the system-wide scale (i.e., Lewiston to North Fork) to evaluate cumulative restoration effects on natural fish populations. Changes in abundance, growth rates, condition and size should also be assessed between the North Fork, Willow Creek and Weitchpec, though the statistical feasibility of detecting biologically significant changes in these measures requires more careful review. Long-term trend analyses of the production of natural anadromous fish will occur over a multi-year scale (about every 10 to 15 years), but are dependent on the consistent annual collection of empirical data to capture biological and physical variation within the system. Dry and Critically Dry years may have substantial effects on natural production by reducing fry and smolt survival, size, growth rates, and condition. In these years it will be critical not just to assess adult survival but also to assess fry health/condition and prevalence of disease within the Trinity River and lower Klamath River migration corridor.

The temperature objectives for adult salmonids also provide thermal benefits for over-summer rearing juveniles. Prescribed adult temperature objectives and corresponding recommended flows are the same for all water year types and pertain to the upper Trinity River (either Douglas City or the North Fork Trinity confluence).

Outmigration temperature objectives also address conditions in the mainstem Trinity River to its confluence with the Klamath River at Weitchpec. The temperature objectives for outmigrants apply to the entire Trinity River, with the monitoring location at Weitchpec, from April through July. Current outmigrant monitoring is conducted at the established Willow Creek site and continued through August to assess when 80% of the outmigrants pass through the lower Trinity River during periods when the temperature objectives are in effect.

Priority issues to address

Technical issues still to be resolved:

1. The accuracy and precision of all applied or suggested population estimation techniques should be rigorously evaluated and compared. Power analyses have not been completed for many of the population performance measures. Ratios (e.g., fry / spawner) could fluctuate considerably if measurement error or process error (year to year variation) is large, making it hard to assess trends in these ratios over time, or comparisons across space. We need to review the percent change desired in key performance measures and ratios to meet escapement targets. How many years will it take to reliably detect biologically significant changes in key measures (e.g., fry/spawner) between segments or over time within one segment?
2. More work is required to refine methods for assessing fry standing stock. While some earlier fry standing stock data exists, it's not clear that these can be used as baselines since the methods were quite different and the river channel has changed. Utilizing a GRTS rotating panel sampling design it is possible to sample many locations each year, including both repeated and new sites, since the river will continue to evolve. However, it is not clear how to combine standing stock and emigrant trapping estimates.
3. Various fish health/condition indices have been suggested as part of the on-going Outmigration Monitoring review being conducted by Northstate Resources environmental consultants. Further discussion of which performance measure is most appropriate to measure fish health/condition is required.
4. There is a need to determine how to identify hatchery and naturally produced juvenile Chinook salmon (only 25% cwt) for development of a healthy smolt index. Currently, both TRH and natural production are lumped together, making it impossible to evaluate any differences in health index (there could be substantial differences between TRH fish and natural fish).
5. Need more clarity on the use and application of SALMOD (see Section 3.3.1 Priority issues to address).
6. Need to calculate initial interim targets for performance metrics and how we would evaluate success.
7. Quantitative targets for life-stage specific fish production are not available at this time; these need to be linked to habitat availability as well as to other targets (i.e., if escapement and harvest goals

are adopted (by TMC), then quantitative targets for juvenile production need to be evaluated and linked).

Policy issues still to be resolved:

1. Development of a cold-water pool management plan should be initiated (including any reservoir temperature model development) to ensure that sufficient cold water is preserved in the event of a multi-year drought.

3.3.3 Sub-objective 3.3: Minimize impacts of predation and genetic interactions between and among hatchery and natural anadromous fish[16]

3.3.1 Limit impacts of hatchery fish predation on naturally produced juvenile salmonids to less than 20% over the 40 miles

3.3.2 Increase proportion of Natural Influence (pNI) to 0.7 or greater

The Trinity River Hatchery is used to mitigate the loss of salmonid production above Lewiston Dam and Trinity Dam. Hatchery propagated fish have known impacts on natural production (e.g., Chilcote *et al.* 1986, Waples 1991; Reisenbichler and Rubin 1999; McLean *et al.* 2003; Naman 2008). These assessments focus on the degree to which Trinity River Hatchery fish interfere with rehabilitation of naturally produced fish populations through behavioral and genetic interactions. The presence of a large proportion of hatchery fish in inter-annual returns of adult fall- and spring-run Chinook salmon, coho salmon, and steelhead can alter the expression of life-history traits of natural populations (Myers *et al.* 1998).

Although the Program does not manage the hatchery, assessments of the effects of hatchery fish on natural production may be necessary to evaluate the potential for interference with the goals of the Program. Natural production can be limited due to the presence of hatchery fish in the system (HSRG 2004; Mobrand *et al.* 2005; Araki *et al.* 2007a, b; and others). The concern for this Program is that hatchery impacts may explain a significant amount of the variability in natural salmonid production. Hatchery fish can alter measures of spawning success such as: day of initiation of courtship/nesting; redd location; females courted/males courting; or gamete retention (Fleming *et al.* 2000). Hatchery males may be less aggressive (Fleming and Gross 1993), and fitness may be less (Chilcote *et al.* 1986; Reisenbichler and Rubin 1999; Fleming *et al.* 2000). Assessments should be conducted to determine potential impacts of a high proportion of hatchery fish spawning in natural areas or hatchery steelhead remaining to prey on natural juveniles. These assessments could provide insight into potential negative interactions between natural and hatchery fish (e.g., McMichael *et al.* 1999; Mclean *et al.* 2003; Narum *et al.* 2006). Selection in captivity during hatchery breeding may reduce fitness in the natural areas (Ford 2002). Ford (2002) developed a useful index to quantify the impacts of hatcheries on composite population, pNI (HSRG/WDFW/NWIFC 2004).

While the hatchery is an important focus for most of these assessments, concerns have been raised about other management actions that may result in loss of genetic diversity such as hybridization resulting from operations of the Trinity Division. Upstream from Lewiston Dam, spring Chinook salmon lost historic spawning areas in the East Fork, Stuart Fork, upper Trinity River and Coffee Creek (Moffett and Smith 1950; Campbell and Moyle 1990), forcing spring Chinook salmon to overlap spatially with fall Chinook salmon. Although past studies found genetic differentiation between Klamath Chinook salmon stocks and

[16] These are interim targets, and will be revisited and revised as we learn more.

stocks in other basins (see review in Myers *et al.* 1998), and between the spring and fall-runs on the Trinity River (Yip 1994; Yip *et al.* 1996), mixing of the runs is a concern. Kinziger *et al.* (in press) recently found evidence for the presence of a hybrid zone among Trinity adult fall and spring Chinook salmon. It is currently unknown if levels of hybridization are stable, increasing or decreasing, however preliminary analysis by Kinziger (unpublished) is suggestive of a very slight increase in levels of hybridization.

HYPOTHESES[17]*:*

A. Predation by adult and rearing juvenile hatchery-origin fish occupying natural rearing areas is severe enough to reduce natural fry abundance by 20% and decrease overall production.
B. Increasing Proportion of Natural Influence (pNI) to 0.7 or greater will ensure that natural selective forces drive adaptation and fitness of the composite population (both hatchery and natural origin).
C. Maintenance of a stable hybrid zone between spring and fall Chinook salmon may be negatively influenced by fall flows.

Proposed assessment strategy and rationale

The proportion of natural spawners composed of hatchery origin fish must be less than the proportion of a hatchery broodstock composed of natural-origin fish to overcome the potential effects of domestication selection and divergent natural selection at the hatchery and in natural areas (HSRG 2004; Mobrand *et al.* 2005). Proportion of Natural Influence (HSRG 2004; Mobrand *et al.* 2005) requires data collected by the program on (1) proportion of hatchery spawners in natural areas and (2) proportion of natural spawners in Trinity River Hatchery (see Tables 3, 4 and 5 in CDFG Annual Report 2005-2006). Trinity specific data analyzed by A. Kinziger suggest that the current pNI is close to 0.23 and that a value closer to 0.7 would represent a level aimed at ensuring that natural selective forces drive adaptation and fitness of the composite population of fish that spawn both in hatcheries and natural areas. Since these data are collected annually (see Section 3.4), we can compare proportions from 1982 forward (Chinook salmon) or from 1995 forward (Coho salmon) and examine the trends. Initial assessment of the degree of residualization of hatchery steelhead indicates that these steelhead may have a substantive predatory effect on smaller juvenile salmonids present in the river (Naman 2008). Assessing whether hatchery steelhead returned to the river spawn in tributaries with natural spawners provides additional feedback on negative effects on natural spawning. Assessments of interactions (e.g., pNI, predation rates) between and among hatchery and naturally produced anadromous fish at all life stages in the Program area may assist the Program in providing mechanistic explanations if natural populations fail to increase after substantive rehabilitation actions have been implemented.

Loss of historic species and racial diversity as an unintended outcome of management actions must also be explored. For example, assessments exploring hybridization of spring and fall Chinook salmon would be aimed at determining the extent of hybridization and possible contributing causes. In addition, concerns over the effects of an increasing brown trout population should be explored.

Proposed performance measures and analyses

Key performance measures

- ***Predation rate by hatchery reared fish (primarily steelhead) on natural salmon and steelhead fry***.

[17] These are interim targets, and will be revisited and revised as we learn more.

- ***pNI***; a metric of the degree of domestication.

Candidate performance measures

- ***Extent of species or racial hybridization pre-dam and hatchery, and of contemporary populations.***
- ***Increase in abundance of hatchery steelhead straying into tributaries and mainstem spawning areas***
- ***Increase in abundance and distribution of brown trout adults and/or juveniles***

Integration of performance measures with performance measures in other disciplines

Proportion of hatchery to natural fish in the hatchery and natural areas is a performance measure derived from run size and escapement estimates (see Section 3.4). Section 3.2 discusses potential effects of predation on fry.

Expected response

If the predation rate by hatchery fish on natural juveniles is over 20%, we predict that this would significantly reduce the abundance of natural fry. We predict that pNI will increase from the current level of 0.23 when the proportion of natural origin spawners increases. Over time if we increase natural salmonid production we predict that this metric will approach 0.7, a level aimed at ensuring natural selective forces are in play. Past investigations reveal that the contribution of hatchery-origin adult Chinook salmon spawning in natural areas is considerable in the first 5-10 river kms downstream of TRH. However, the contribution of hatchery-origin spawners declines appreciably with distance from Lewiston; in the last 12 miles of Trinity River, immediately upstream of Weitchpec, hatchery-origin Chinook salmon carcasses are very seldom encountered during redd surveys. We predict that, as the cline of hatchery origin spawners decreases, due to an increased proportion of natural origin spawning in the upper 10 miles, that pNI will improve towards 0.7.

The slight difference in maturation timing (1-2 weeks) is the only mechanism precluding large-scale interbreeding between spring and fall-run Chinook salmon. However, ancillary flows, to encourage fall Chinook salmon migration from the lower Klamath River, may move fall Chinook salmon prematurely into areas occupied by holding adult spring Chinook salmon. We predict that hybridized Chinook salmon are less well-adapted to Trinity River conditions and consequently would exhibit lowered productivity when compared to either fall or spring Chinook salmon.

Analysis

Analyses will include calculating predation rates on different salmon species by hatchery fish (e.g., residualized or other steelhead), and assessing whether the total loss represents a significant percentage of fry production. Calculating the percentage of the population lost to predation (mortality rate) will require an assessment of fry abundance. The proportion of Natural Influence in a composite population of adult anadromous fish including those of hatchery and natural origin may be expressed as: pNI = *pNOB/(pNOB+pHOS)*. Where: 1) pNI ("proportion of natural influence") expresses the percent of time that genes are in the wild; 2) *pHOS* is the proportion of hatchery origin fish spawning in the wild; and 3) *pNOB* is the proportion of natural origin brood stock in the hatchery. The proportion of Natural Influence varies from 0-1; the closer to 1.0, the lesser risk of departing from the natural genotype. Decomposition of the long term data (Crawley 2005) may indicate how the annual variability in abundance of natural spawners influences pNI.

The presence of a hybrid zone has been demonstrated for fish returning to TRH, regardless of origin. Further investigations may be necessary to determine the extent and consequence of hybridization in naturally reproducing populations of spring and fall Chinook salmon. Understanding the mechanisms leading to hybridization will inform future management actions.

Proposed space and time frames

pNI is calculated for the total run and is thus system wide. Since the data are collected annually, the proportion can be calculated annually. Assessment of hatchery interactions is of greatest interest within 10 miles of Lewiston Dam. However, comparison to the areas downstream of the Program area may also be informative. Biotic interactions (e.g., predation) are predicted to be highest closest to the Lewiston Dam.

Reach scale

Once the effects of predation by hatchery fish on fry abundance have been estimated, a reassessment of the effects will not be necessary until significant changes in hatchery operations occur. The effect of hatchery fish predation on natural fry is best evaluated in the reach below the hatchery where we have a preponderance of predatory fish and natural fry.

System scale

Assessment of pNI is based on data collected at the system level every year. Although the ratio can be calculated every year, the analyses would be of long term trends.

Determining the presence and causative mechanisms for hybridization should be explored on a system scale. However, it is likely that evidence for hybridization of fall with spring Chinook salmon would most commonly be found in the upper 40 miles above North Fork.

Priority issues to address

Technical issues still to be resolved:

1. Determine whether we need additional genetic studies on other salmonid species.
2. Fall flow releases may negatively influence hatchery/natural interactions in the hybrid zone near the TRH in Lewiston. The presence of a hybrid zone found at TRH (which receives natural-origin adult fish) suggests that the problem of hybridization transcends that facility, and includes fish spawning in natural areas where hatchery-origin fish spawn with natural-origin fish. Although the Program does not utilize TRRP flow releases to encourage fall Chinook salmon migrations, those actions have been taken by the Department of the Interior in the past. Furthermore, fall flows may not be the only management action responsible for hybridization; limited access to historic spring Chinook salmon spawning habitat and the persistence of a stable hybrid zone are other contributing factors.

Policy issues still to be resolved:

1. Integration of the Program with TRH management should be considered as a policy issue by the TMC.

3.4 Objective 4: Restore and sustain natural production of anadromous fish populations downstream of Lewiston Dam to pre-dam levels, to facilitate dependent tribal, commercial, and sport fisheries' full participation in the benefits of restoration via enhanced harvest opportunities

This assessment tracks progress towards the major long-term goal of the Program to "*restore and sustain natural production of anadromous fish populations downstream of Lewiston Dam to pre-dam levels, to facilitate dependent tribal, commercial, and sport fisheries' full participation in the benefits of restoration via enhanced harvest opportunities"* (Section 1.2 of the IAP, 1996 Trinity River Basin Fish and Wildlife Management Act (TFWMA) Amendment (P.L. 104-143, ROD USDOI 2000). To track progress towards the Program goal, the Program must conduct annual quantitative population assessments for both natural and hatchery components of the total run. These population assessments can include: population growth rate (e.g., Jennings *et al.* 1998; Musick 1999; Myers *et al.* 1999); abundance of ocean recruits, recruitment (e.g., Ricker 1975; Rickman *et al.* 2000; Myers 2001); production (e.g., Ricker 1968; Mantua *et al.* 1997); and productivity (e.g., Adkison *et al.* 1996; Katsukawa *et al.* 2002). To assess the effects of management actions under the ROD and other environmental parameters on anadromous stocks, we need to relate individual cohort (brood year) performance and run size to climatic effects and in-river conditions (e.g., Lawson 1993; Koslow *et al.* 2002; Logerwell *et al.* 2003; Lawson *et al.* 2004; Zabel *et al.* 2006; Taylor 2008). Population assessments will improve our understanding of factors that influence in-river escapement of natural anadromous fish, and help the Program evaluate flow and physical habitat manipulations.

To track progress toward the Program goal, the Program also needs to quantify the contribution of both natural and hatchery produced Trinity River anadromous salmonids to ocean and in-river fisheries. The harvest of Trinity River fall Chinook salmon is managed as part of the Klamath River basin stock, within an integrated harvest management process for ocean and in-river fisheries. The harvest of Klamath River basin natural fall Chinook salmon is managed to achieve a brood escapement rate of 33 to 34% of potential spawners while protecting a minimum of 35,000 adult spawners annually to natural spawning areas within the Klamath River basin, including the Trinity River (PFMC 1994). Estimated abundances above these thresholds are allocated to tribal and non-tribal fisheries on a 50/50 sharing basis. Similarly, though currently not managed for Klamath River basin escapement rates or minimums, spring Chinook salmon are caught in ocean and in-river fisheries. Additionally, Klamath River basin recreational and tribal fisheries harvest quantities of all Trinity River produced anadromous stocks.

Thus, the assessment of Trinity River anadromous populations must account for current harvest management processes. This assessment tracks progress towards facilitating full participation in dependent tribal, commercial, and sport fisheries. In order to assess the contribution of Trinity River stocks to harvest; it is necessary to estimate the disposition, whether it is ocean or in-river harvest or escapement, of all Trinity River produced stocks. Adult spawning escapement objectives are based on the spawning escapement goals adopted by the Trinity River Restoration Program's Trinity River Task Force.

We have grouped our objectives and sub-objectives below (order implies priority) for Chinook salmon, coho salmon, fall steelhead, Pacific lamprey and green sturgeon, since assessment strategies will be similar for most species.

3.4.1 Objective 4.1: Increase naturally produced fall-run Chinook salmon adult production to the extent necessary to meet or exceed escapement objectives and facilitate expanded harvest opportunity

4.1.1 Increase escapement of naturally produced fall-run Chinook salmon to 62,000 adults

4.1.2 Increase harvest of naturally produced fall-run Chinook salmon adults

3.4.2 Objective 4.2: Increase naturally produced spring-run Chinook salmon adult production to the extent necessary to meet or exceed escapement objectives and facilitate expanded harvest opportunity

4.2.1 Increase escapement of naturally produced spring-run Chinook salmon to 6,000 adults

4.2.2 Increase harvest of naturally produced spring-run Chinook salmon adults

3.4.3 Objective 4.3: Increase naturally produced coho salmon adult production to the extent necessary to meet or exceed escapement objectives and facilitate expanded harvest opportunity

4.3.1 Increase escapement of naturally produced coho salmon to 1,400 adults

4.3.2 Increase harvest of naturally produced coho salmon adult salmon adults

3.4.4 Objective 4.4: Increase naturally produced steelhead adult production to the extent necessary to meet or exceed escapement objectives and facilitate expanded harvest opportunity

4.4.1 Increase escapement of naturally produced steelhead to 40,000 adults

4.4.2 Increase harvest of naturally produced steelhead adults

3.4.5 Objective 4.5: Increase naturally produced Pacific lamprey adult production to the extent necessary to meet or exceed escapement objectives and facilitate expanded harvest opportunity

4.5.1 Increase escapement of Pacific lamprey adults

4.5.2 Increase harvest of Pacific lamprey adults

3.4.6 Objective 4.6: Increase naturally produced green sturgeon adult production to the extent necessary to meet or exceed escapement objectives and facilitate expanded harvest opportunity

4.6.1 Increase escapement of green sturgeon adults

4.6.2 Increase harvest of green sturgeon adults

The hypotheses listed below are grouped due to the similarity among species. We present a single overarching hypothesis which will need to be refined into testable hypotheses for the different species.

HYPOTHESIS:

Rehabilitation actions implemented under the ROD will increase annual recruitment of naturally produced anadromous species to achieve both escapement goals and enhanced harvest opportunities for dependent tribal sport and commercial fisheries.

ALTERNATIVE HYPOTHESES:

A. Recruitment of Trinity River anadromous fishes will not increase due to limitations in spawner escapement caused by excessive fishing mortality.
B. Recruitment of Trinity River anadromous fishes will not increase due to limitations imposed by lower Klamath River, Klamath estuarine and/or ocean conditions.

C. Recruitment of Trinity River anadromous fishes will not increase due to limitations imposed by density dependent habitat constraints.

D. Recruitment of Trinity River anadromous fishes will not increase due to limitations imposed by hatchery–natural interactions (Section 3.3.3).

Proposed assessment strategy and rationale

We plan to determine whether our rehabilitations and flows are having a beneficial effect on the recruitment of naturally produced anadromous fish. We propose to continue the annual in-river estimation of naturally produced adult anadromous fish on the Trinity River, and to collect available information on the harvest of Trinity River naturally produced fish occurring in areas other than the Trinity River. Annual run-size (harvest and escapement) estimates, combined with the total marking of hatchery coho salmon and steelhead, and 25% constant fractional adipose fin clip and coded-wire tag marking of Chinook salmon, allow us to estimate contributions of hatchery- and natural-origin fish. These data facilitate an assessment of the effects of ROD flows and rehabilitation actions on natural production of spring and fall Chinook salmon, steelhead, and coho salmon. Supplemental data on primary tributary escapement both below and above the North Fork are supplied by various Program partners. Additionally, disaggregating these runs into age-structured components will allow for evaluation of the brood year performance for Chinook salmon and coho salmon natural runs, which can then be correlated to instream and out-of-basin conditions and management manipulations (i.e., flows, temperature, spawning gravel infusions, etc). Separating the variation in the runs due to factors we cannot control (e.g., harvest, out of basin conditions) may enable us to more accurately evaluate the effects of controlled rehabilitation actions on natural production. These analyses will permit assessment of whether flow, temperature and other habitat manipulations lead to increased adult ocean recruitment, harvest and escapement of salmonids. At this time, assessments of neither Pacific lamprey nor green sturgeon are a high Program priority.

Proposed performance measures and analyses

Key performance measures

- ***Adult anadromous spawner escapement*** of adult anadromous fish, specifically:
    - ***62,0000 naturally produced fall Chinook salmon****;*
    - ***6,000 naturally produced spring Chinook salmon****;*
    - ***40,000 naturally produced steelhead****; and*
    - ***1,400 naturally produced coho salmon***.
- ***Contribution of Trinity River naturally produced anadromous fish*** to dependent, sport and commercial fisheries and recruitment.
- ***Proportion of hatchery to natural adult anadromous fish.***

Candidate performance measures

- ***Annual in-river estimation of naturally produced adult anadromous fish on the Trinity River***
- ***Brood-year specific recruits*** per spawner.
- ***Population growth rate*** (r).
- ***Percent of variation in the brood year performance*** attributable to in-river conditions and ocean conditions.
- ***Cohort performance or year class strength*** derived from cohort reconstructions for Chinook and coho salmon.
- ***Trinity specific number of age 3 ocean recruits*** of fall-run Chinook salmon.

Integration of performance measures with performance measures in other disciplines

Sections 3.3 to 3.4 contain the primary metrics for measuring the success of the Program in restoring natural fish populations and dependent fisheries. The performance measures discussed in this section enable us to estimate productivity (smolt/spawner, recruits/spawner) and survival (adult recruits/# of smolts). Assessments that require integration with other sections include:

1. Smolt/spawner assessment (see Section 3.3.2) to evaluate our rehabilitation and flow actions which we hypothesize will lead to higher freshwater productivity. In order to analyze the effects of management actions on smolt to spawner ratios, we require information about abundance of smolts, condition of smolts, instream flow, indices of habitat complexity, habitat availability, and index of bar distribution and size (or other performance measures listed in Section 3.1). Section 3.2 and 3.3.2 discuss fish habitat and smolt abundance and outmigration assessments respectively.
2. Distribution of spawners in association with holding and spawning habitat (Section 3.3.1 and 3.3.2). We hypothesize that, as we approach the Program fisheries goals, spawning will be more widely distributed and holding habitat more critical to survivorship prior to spawning (pre-spawn mortality).
3. Ratio of hatchery/naturally produced fish and proportion of hatchery-origin/natural-origin fish occurring in spawning areas to assess the change in percentage of natural production over time is listed in Section 3.3.3. The first assessment is dependent on static hatchery release numbers. We hypothesize that, as we improve habitat, the percentage of natural production will increase.
4. Estimates of pre-spawning mortality address adult temperature objectives at Douglas City and North Fork Trinity River confluence (Section 3.2 and 3.3.1).

Expected response

As management actions are implemented and we create more in-river habitat for anadromous fish, we predict increased recruitment of naturally produced Trinity River anadromous adult salmonids. Chinook salmon and coho salmon population metrics will likely be the most readily available for testing expected responses. We predict an increase in the number of smolts per (effective female) spawner, or the smolt to spawner ratios, or the abundance and distribution of spawners. If we assume equal impacts from various factors such as harvest, predation, poor ocean conditions, and degraded habitat for hatchery and natural Chinook salmon, then as in-river conditions improve, we should see an increase in the ratio of natural to hatchery fish returning to the Trinity River from baseline (return years 1991- 2003) (assuming static hatchery release and marking) and an increase in harvestable Trinity River produced Chinook salmon compared to pre-treatment levels. We also predict positive recruitment, population growth (r), and an increase in brood year performance and year class strength if our management actions are successful in increasing natural salmonid production. We predict that, as we reestablish the salmonid runs, the contribution of Trinity River natural anadromous fish to dependent, sport and commercial fisheries will increase over time. Green sturgeon are also expected to benefit from rehabilitation actions that improve spawning habitat such as cooler temperatures and reduced sediment, but we do not propose any performance measures to assess green sturgeon directly.

Analysis

We plan to analyze the change over time in the proportion of hatchery to natural adult anadromous fish (see Section 3.3.3), the number of hatchery- and naturally-produced adult anadromous fish, year class strength and recruitment (Quist 2007) in the Trinity River basin. To estimate changes in dependent, sport and commercial fall Chinook salmon fisheries, we propose to use harvest data from 1991 through 2000 as the base period to estimate contribution of Trinity River fall Chinook salmon to dependent, sport and commercial fisheries before ROD flows. Harvest data from 2001 forward would be used for the post

ROD flows comparison. Currently for fall Chinook salmon only, integration of age-structured harvest estimates and age-structured spawning escapement estimates may provide a complete assessment of the stock productivity of Trinity River basin naturally produced and hatchery produced fishes.

Cohort reconstruction, based on fishery-specific estimates of harvest and spawning escapement, may be used to determine the fishery-specific contributions of Trinity River produced fishes (KRTAT 1986). A Trinity specific cohort reconstruction may be used to assess the abundance of ocean recruits over time, as well as the productivity of the stock (recruits per spawner). With data currently available, the ability to develop a Trinity specific cohort reconstruction is limited to fall-run Chinook salmon and coho salmon. The proportions of naturally produced fish relative to hatchery produced fish may be adjusted annually for performance of hatchery brood years of concern. The performance of individual brood years of naturally produced fish is of importance to the analyses. Brood year spawner reduction rates and allowable annual ocean/in-river harvest rate combinations will allow for assessment of the Program objectives in the context of existing or developing harvest management plans.

Due to the sport harvest restrictions on steelhead (no retention of natural fish) and coho salmon (no directed harvest), the assessment of these two species will, in the near term, have to focus on evaluating the increase in spawning escapement, while accounting for hatchery production, tribal harvest and harvest impacts that do occur as incidental mortality from fishing related activities. Assessing total steelhead escapement and harvest may be infeasible due to river conditions (i.e., winter flows for weir operation). Additionally, land ownership issues make it difficult or impossible to conclusively survey tributaries and the extensive duration and geographic area where harvest occurs.

Due to both measurement error and natural variation, it can take a long time to detect changes in escapement following habitat improvements (Korman and Higgins 1997). The historical level of natural variation in the Trinity River escapement data can be used in analyses to determine how many generations will be required to detect different trends in adult escapement. We can also assess population change relative to ROD flows and rehabilitation actions on a shorter time frame, using annual estimates of escapement for our target populations, and other covariates to separate the ROD signal from the noise of other factors. Brood year performance of each natural run and recruitment of fall Chinook salmon should respond positively to management manipulations (i.e., flows, temperature, spawning gravel infusions, etc). By disaggregating the runs into age structured components, we can calculate the brood year performance for Chinook salmon and coho salmon, and ocean recruitment for fall Chinook salmon. Analyses using spawner recruit models (e.g., Myers *et al.* 1999; Deriso *et al.* 2001) would provide insight into how the relationship changes over time as improved habitat conditions develop.

Additionally, we plan to calculate the *percent of variation* in the brood year performance attributable to in-river conditions and ocean conditions. We are developing performance measures such as: Index of El Niño /La Niña Conditions; Index of ocean conditions; Flows at Lewiston, Hoopa and Terwer at critical times of the year; temperature in different reaches and temperatures at critical times; and spawner density. These covariates can be used to explain variation in escapement among years or, more appropriately, changes in brood-year specific recruits per spawner, and help to isolate the effects of ROD management actions.

Proposed space and time frames

Assessments will be undertaken over multiple years, and cover varied spatial scales ranging from sub-basins (for spring-run Chinook salmon and summer run steelhead), and basin-wide (spring and fall Chinook salmon, summer/fall steelhead and coho salmon). Annual population assessments will coincide with run-timing for the species of interest. Realistically, 15 to 20 years may be required to distinguish between ocean and climatic effects and the effects of TRRP in-river management actions on salmon and steelhead escapement. The spatial scale includes spawning areas throughout the Trinity River basin and areas where Trinity River anadromous salmonids are harvested (within the Trinity River basin, in the lower Klamath River below the confluence of the Klamath and Trinity Rivers, and in coastal fisheries in Oregon and California).

System scale

Assessments discussed in this section cover multiple years, so they can include several brood years (~10 years, dependent on the species), but they are entirely dependent on annual data. Annual population assessments coincide with run-timing for the species of interest. The time frames and spatial analyses are as follows:

1. Realistically, 15 to 20 years may be required to distinguish between ocean and climatic effects and our in-river rehabilitation actions.
2. The long term average annual abundance of ocean recruits provides a baseline from which to compare a potential catastrophic biological event or to assess extremely high run size.
3. Sub-basins: Since the targets are for the entire Trinity River below Lewiston Dam, production data for the spring-run Chinook salmon and summer run steelhead in the sub-basins can be incorporated into the run size data generated from the operation of the weirs. These data are collected by Program partners.
4. Basin-wide: Escapements of fall Chinook salmon, summer/fall steelhead and coho salmon are monitored from August through November at Willow Creek, capturing the migration period. This location enables the Program to measure progress towards the basin-wide Program objectives for escapement for the Trinity River, including its major tributaries.
5. Upstream of the North Fork: spring Chinook salmon monitoring at Junction City captures the majority of spring escapement for the Trinity River and its tributaries, except the South Fork population and other tributaries which are monitored by the California Department of Fish and Game (CDFG), the USFS and others. The highest priority period runs from May through September. However, if a specific smolt/spawner ratio is required for coho salmon, steelhead and fall Chinook salmon above Junction City, then the season would need to continue through November to capture the run timing of these species.
6. Harvest of fishes originating from the Trinity River basin occurs throughout the Trinity River and its tributaries, along the lower Klamath River below the confluence of the Klamath and Trinity rivers, and in the ocean, primarily from the Oregon/Washington border to Monterey, California. While some fisheries (primarily those harvesting spring and fall Chinook salmon) are sufficiently monitored to assess harvest of Trinity River basin fishes, others receive less monitoring effort (winter steelhead and coho salmon), limiting the ability to effectively assess the contribution of fish produced from the Trinity River basin.
7. Annual monitoring of these fisheries must occur to allow for the cohort reconstruction analysis. Assessment of progress towards enhanced harvest opportunities will occur over a longer period of time (5-15 years) to account for variable maturity schedules and survival, and over an even longer period (15-25 years) to assess the success of full implementation of all rehabilitation actions.

Priority issues to address

Technical issues still to be resolved:

1. Currently, integration of age-structured harvest estimates and age-structured spawning escapement estimates may provide a complete assessment of the stock productivity of Trinity River basin naturally produced and hatchery produced fall Chinook salmon. Can this be expanded

to natural spring Chinook salmon? Other projects that contribute to these assessments are the marking of hatchery produced fish at Trinity River Hatchery and Iron Gate Hatchery (on the Klamath River), coded wire tag recovery programs, ocean and lower Klamath River harvest monitoring programs, and age composition programs.

2. Developing methods to estimate winter/spring steelhead run-sizes and age structure, and determining whether or not we can develop smolt/spawner indices based on the current accuracy of those data.
3. The validity of using Trinity specific cohort data to evaluate rehabilitation effects needs to be investigated further.
4. Need to calculate initial interim targets for performance metrics and how we would evaluate success.

Policy issues still to be resolved:

1. The Trinity Management Council in June 2008 (Trinity Management Council meeting minutes June 16-17, 2008, Weaverville, CA) chose not to include numeric harvest goals in the goals for the TRRP. Furthermore, the Department of Interior's Office of the Solicitor (March 12, 2008) supported this TMC decision.
2. While a coordinated harvest management plan exists for Klamath River basin (including Trinity River) fall Chinook salmon, there is no Trinity specific harvest plan and the current plan for fall Chinook salmon does not recognize the Program's spawning escapement goals as a management target.

3.5 Objective 5: Establish and maintain riparian vegetation that supports fish and wildlife

Riparian zones are areas of direct interaction between aquatic and terrestrial environments, and contribute to the total health and integrity of both types of habitat. The terrestrial portions of riparian areas often exhibit high species richness and exceptional biological productivity (Sparks 1995). Riparian vegetation improves aquatic habitat through numerous mechanisms, such as providing cover used by fishes, enhancing invertebrate production (Schaffter *et al.* 1982), moderating water temperature through shading (Gregory *et al.* 1991), and fostering recruitment of organic material (Junk *et al.* 1989) or woody debris (Harmon *et al.* 1986). It is therefore an objective of the Program to promote patchy, diverse, heterogeneous riparian vegetation (i.e., healthy) throughout the riverine corridor through flow releases, sediment management, and rehabilitation activities (USFWS and HVT 1999). Program activities should also foster new riparian areas, particularly on higher elevation surfaces (upper bars and floodplains), such that these new riparian areas more than offset any reductions associated with the channel rehabilitation activities.

On unregulated alluvial and semi-alluvial rivers, the balance between sediment regime, flow regime, and riparian plant species creates structurally complex, spatially heterogeneous vegetation on various alluvial and depositional features (Malanson 1993; Scott *et al.* 1996). During drier years with smaller floods, the riparian vegetation grows down onto lower surfaces; during wetter years with larger floods, the river pushes growth back towards the upland. The net result can be described as healthy riparian vegetation for that given river. On the Trinity River, pre-dam air photos suggest this long-term process caused riparian vegetation to establish over an elevational continuum, ranging from sparse, low lying, herbaceous plants near the water's edge to local concentrations of tall woody plants on high flow scour channels, floodplains, and terraces. The semi-annual cycle of riparian plant colonization, mortality, and disturbance created and maintained a patchy, heterogeneous vegetation pattern. Floods typically caused disturbance in riparian corridors through inundation, scour, deposition, and desiccation. The magnitude of disturbance is related to many factors, including high flow magnitude, flow duration, channel morphology, bank material, amount and size class distribution of coarse sediment mobilized and transported, and others. Flood disturbance creates gaps (through scour or toppling), forms and maintains seed beds/nursery sites (through scour, deposition, and inundation), and creates new seedbeds via channel migration and subsequent bar/floodplain formation on the inside of the migrating bend. Floods also recharge local shallow groundwater tables, increase local soil moisture, and deliver seeds from seed sources to nursery sites (Scott *et al.* 1996; Poff *et al.* 1997; Mahoney and Rood 1998). Many riparian plant species have evolved with annual patterns of rainfall and snowmelt hydrology, and have coincident life history traits with annual snowmelt hydrographs (Bradley and Smith 1986; Scott *et al.* 1993). Healthy riparian vegetation on the mainstem Trinity River is patchy, spatially variable (both in height and growing locations), and comprised of multiple age classes and cover types that create and maintain high quality habitat for aquatic and terrestrial species.

The continuity of riparian vegetation within a river corridor is important to birds, mammals and herpetofuana. Future riparian vegetation patches distributed across upper bars, floodplains, and high water scour channels will provide a continuous vegetation corridor without forming a dense band of trees and shrubs along the low water fringe (detrimental riparian encroachment). Recovery of riparian vegetation temporarily removed during channel rehabilitation project implementation is important to restore some of the beneficial attributes currently associated with the existing riparian vegetation, and will also maintain wildlife populations that may be adversely affected by channel rehabilitation actions.

Some wildlife species benefit from larger patch sizes where a greater interior area is created. Riparian vegetation patches typically have a lot of edge around an interior portion (Figure 3.5). A large percentage of riparian vegetation patches on the mainstem Trinity River are currently narrow and elongated, where long bands along the low water fringe are many times longer than wide, and rarely more than two alder tree canopies wide. There are few locations where riparian vegetation patches are shorter and wider with a greater proportion of interior area to edge.

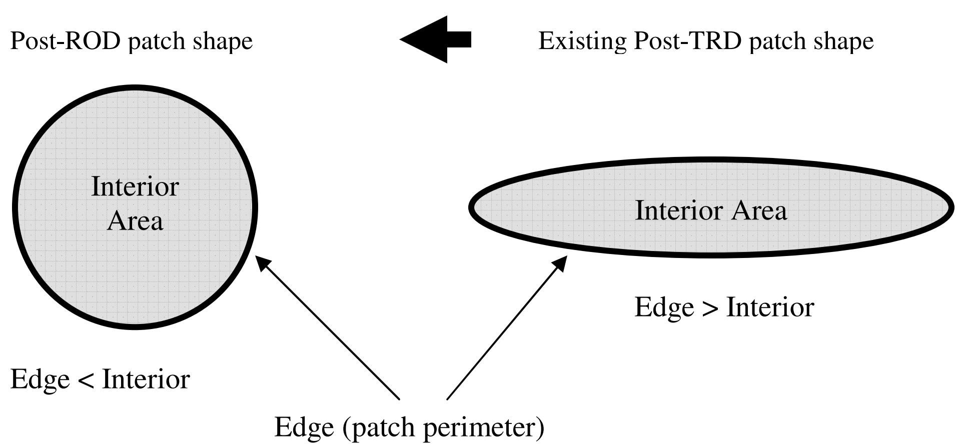

Figure 3.5. Illustration of expected evolution of riparian patch types with implementation of the ROD, where existing long and narrow patches have a large amount of edge relative to interior area versus wider patches with less edge relative to interior area.

With coarse sediment augmentation, ROD high flows, and physical rehabilitation, patches of riparian vegetation should become wider and less elongated. Riparian vegetation should also become less dense, more patchy, and heterogeneous within the active channel. On higher surfaces, riparian vegetation should expand onto adjacent floodplains and upper bars. The continuity of riparian vegetation should be recovered at rehabilitation sites while also increasing riparian vegetation width, thereby increasing the amount of patch interior throughout the river corridor.

The ecological balance between flow regime, sediment regime, and riparian vegetation is disrupted by large dams (Ligon *et al.* 1995; Power *et al.* 1996; Gordon and Meentemeyer 2006; Richter and Thomas 2007). Thirty years of near constant flows of 150 cfs allowed a dense, continuous, and homogeneous riparian vegetation to grow along the water's edge that was detrimental to aquatic habitat (Ritter 1968; Pelzman 1973; Evans 1980; Wilson 1993; McBain & Trush 1997; USFWS and HVT 1999; Bair 2001).

Maintaining patchy heterogeneous riparian vegetation within the active channel (defined as the portion of the channel with active bedload transport, i.e., approximately the portion of the channel inundated by 2,000 cfs) without detrimental riparian vegetation encroachment is a TRRP management target. On more dynamic, less regulated rivers, the active channel is characteristically the area where bedload transport causes bed mobility, scour, and deposition, creating patchy, sparse, heterogeneous riparian vegetation. Riparian vegetation can persist in hydraulically sheltered safe sites within the active channel where the dynamics of channel bed scour and deposition are insufficient to cause frequent mortality and mechanical damage. On the highly regulated Trinity River, channel dynamics have been greatly reduced, and the channel area within the 450–2,000 cfs inundation zone is most prone to the re-establishment of dense continuous bands of perennial vegetation that reduce flow velocity, induce fine sediment deposition, and form berms (defined as detrimental riparian encroachment). While these continuous bands of riparian vegetation may provide short-term fish habitat benefits, there is high risk that they will ultimately cause channel simplification and loss of fish habitat over the long-term.

Detrimental riparian vegetation encroachment on the mainstem Trinity River occurs on alluvial surfaces within the active channel (approximately 450-2,000 cfs inundation elevation) and is dense, continuous, and mature enough to:

- be unable to be physically removed by ROD flow release magnitudes via vertical scour, lateral scour, local scour, toppling, and other mortality mechanisms; and
- initiate a morphologic change to the channel that will eventually be detrimental to fish habitat, including fine sediment deposition and berm building, erosion on the inside edge of the riparian band, simplification of hydraulics in the 450–2,000 cfs inundation zone, and ultimately evolution to a rectangular channel similar to that observed during the post-dam, pre-ROD flow regime (c. 1965–2003); sediment trapping and berm building within the riparian band reduces depth-velocity combinations that define suitable fish habitat.

Riparian vegetation within the bankfull channel provides a natural and valuable component to high quality fish habitat. However, if the species composition, age, density, and continuousness of the riparian band along the low flow channel has crossed the encroachment threshold as defined above, the risk of channel simplification and riparian berm formation is greatly increased, correspondingly inhibiting the effectiveness of the TRRP restoration strategy.

The TRFE found that infrastructure and operational limitations (Trinity Dam outlet works, houses, bridges, etc.) restricted high flow releases to a magnitude less than necessary to substantially remove existing mature riparian berms along the summer water's edge (USFWS and HVT 1999), and also severely limited the ability of high flow releases to remove establishing riparian vegetation older than three years of age (Bair 2001). Therefore, the TRFE recommended and the ROD adopted a strategy of: 1) selective removal of riparian berms and associated vegetation to rapidly convert the channel to a more desirable morphology; and 2) managing high flow releases and coarse sediment augmentation to improve and maintain long-term channel complexity, thereby increasing and maintaining high quality aquatic and terrestrial habitats.

Objective 5 is divided into three sub-objectives:

- Sub-objective 5.1 focuses on monitoring strategies that can detect whether management actions are promoting riparian vegetation increases and enhancing aquatic and terrestrial habitats within the Trinity River corridor.
- Sub-objective 5.2 focuses on monitoring strategies that can detect whether management actions are inhibiting riparian vegetation within the Trinity River active channel to reduce risk of detrimental riparian encroachment and associated aquatic habitat degradation.
- Sub-objective 5.3 focuses on monitoring strategies that can detect whether riparian vegetation that has been removed during bank rehabilitation efforts is recovering or being replaced through natural recruitment (compliance monitoring).

3.5.1 Sub objective 5.1: Promote diverse native riparian vegetation on different geomorphic surfaces that contributes to complex channel morphology and high quality aquatic and terrestrial habitat

5.1.1 Increase species, structural, and age diversity of riparian vegetation to improve and maintain wildlife habitat

5.1.2 Encourage establishment of riparian species on surfaces within the future channel migration corridor that will recruit LWD

5.1.3 Encourage establishment of vegetation that provides habitat for anadromous fish, aquatic organisms and aquatic/riparian wildlife

Many aquatic and terrestrial species rely on or benefit from riparian vegetation. Since the completion of Trinity and Lewiston dams, the amount of riparian vegetation along the low flow channel from Lewiston Dam to the North Fork Trinity River has increased (Ritter 1968; Pelzman 1973; Evans 1980; Wilson 1993), thus increasing the available habitat for some terrestrial organisms while decreasing available habitat for others (Wilson *et al.* 1991; Lind *et al.* 1992; Wilson 1993; BLM 1995; Lind *et al.* 1996).

Objective 5.1 promotes a diverse assemblage of riparian plant species on upper bar surfaces and floodplains per the TRFE recommendations. The physical processes fostering this riparian diversity (as described above) historically benefited many aquatic and terrestrial species. Riparian birds are one of the many beneficiaries of Objective 5.1 because they utilize a broad range of plant species of varied age classes and growth characteristics. Historically, fry and juvenile salmonids were also beneficiaries of healthy riparian vegetation along the mainstem Trinity River; velocity refugia, food sources, and quality habitat were provided over the elevational continuum from summer water's edge up to floodplains.

Additionally, future introduction of large wood should contribute to long-term channel complexity. Large woody debris (LWD) is a product of riparian vegetation growing on floodplains; it is introduced to the river as the channel migrates. Black cottonwood is the largest/tallest riparian hardwood growing along the mainstem, yet shiny willow, grey pine, and other upland and riparian species may also contribute to future large wood supply.

HYPOTHESES:

The following flow magnitudes and frequencies, and corresponding hydrologic and fluvial processes were identified in the TRFE as necessary to promote the establishment and maintenance of healthy riparian vegetation (USFWS and HVT 1999):

A. Peak flow magnitudes in Extremely Wet water year classes are large enough to create gaps in colonizing riparian vegetation less than 3 years old.

B. Peak flow magnitudes in Extremely Wet, Wet, and Normal water years are sufficient to create and maintain seed beds on upper bars and floodplains.

C. Peak flow duration in Extremely Wet, Wet, and Normal water years is sufficient to transport water-borne riparian plant seeds to seed beds/nursery sites on upper bars and floodplains.

D. Peak flow timing in Extremely Wet and Wet water years coincides with the seed dispersal period for riparian plants whose life history success is tied to the snowmelt hydrograph.

E. Bench flow magnitudes and durations in Extremely Wet, Wet, and Normal water years are sufficient to germinate target riparian plant species seeds on upper bars and floodplains and prevent their germination lower in the channel (Extremely Wet years are priorities).

F. Flow recession rates from the bench to summer low flow in Extremely Wet, Wet, and Normal water years are sufficient to initiate target riparian plant species' seeds on upper bars and floodplains (Extremely Wet years are priorities).

G. Peak and recession flows in all water year classes are large enough and late enough to recharge soil moisture and groundwater to establish and maintain initiating riparian vegetation throughout a prolonged hot, dry summer and fall.

H. Implementation of the ROD streamflows should increase the types and spatial coverage of riparian vegetation on a wide variety of geomorphic surfaces.

I. Promoting healthy riparian vegetation should establish the plant species necessary to contribute large woody debris to the mainstem Trinity River.

J. Structurally complex, spatially heterogeneous vegetation provides a greater diversity of habitats for aquatic and terrestrial animals than a dense continuous band of vegetation.

Proposed assessment strategy and rationale

Long-term trend assessment of riparian vegetation should be assessed by field-based mapping at two spatial scales. System-scale field-based mapping should be used to quantify the overall amount of riparian vegetation in the Trinity River corridor over longer time periods (i.e., >= 5 yrs), and site-scale field mapping should be used to quantify annual changes at local scales for compliance needs and evaluating program objectives at GRTS selected sites. System-scale mapping should quantify the general spatial extent and arrangement of riparian vegetation throughout the corridor. Site-scale mapping should be more detailed, focusing on the near-bank region where: 1) existing vegetation has been removed (either mechanically at bank rehabilitation sites or from newly created natural gravel bars); and/or 2) where young vegetation is in the process of initiating or establishing (gravel bars and floodplains). Site-scale band transect sampling should be used to verify or expand upon the species, age classes, and other attributes assigned to vegetation patches mapped at the site-scale, as well as integrate with bed mobility and scour assessments in Section 3.1.2.

System-scale monitoring to assess progress towards long-term objectives includes:

1. Map riparian vegetation every five years to document long-term riparian vegetation trends between Lewiston and the North Fork of the Trinity River using a consistent corridor boundary

and alliance classification (e.g., McBain & Trush 2005). The alliance classification defines polygons based on overstory species dominance and commonly associated plants. System-scale mapping would provide data for interpreting general trends in vegetation overall, but specifically gains and losses of heterogeneous patchy riparian vegetation within the active channel and floodplains.

Spatially variable riparian vegetation is easily inventoried through mapping at a system-scale. A qualified vegetation ecologist should conduct mapping largely or entirely in the field, as patches composed of plants younger than five years and patch compositions are difficult to detect using aerial photos alone. Patch type polygons and attributes should be drawn on aerial photos, field verified, then digitized into a GIS. Each vegetation patch identified on the map would be assigned attributes identifying dominant canopy species, and the degree of development (as a surrogate for stand structure). The habitat value of mapped riparian vegetation would be ascertained by qualified wildlife and fisheries biologists. Digitized field maps can be queried to produce the number, frequency, abundance and planform locations of different patch types. Once riparian vegetation mapping attributes are selected, they must remain consistent between mapping events to make data comparable over time.

Site-scale monitoring at GRTS selected sites to provide short-term AEAM feedback includes:

1. During Extremely Wet and Wet water years when riparian hardwood recruitment on higher geomorphic surfaces (upper bars, high flow scour channels, and floodplains) is targeted, use predictive models to predict riparian hardwood species' initiation response to proposed managed streamflows at GRTS selected sites.
2. Sample vegetation along transects placed on cross sections at GRTS sites. GRTS selected sites would include both bank rehabilitation sites and unrehabilitated sites where bars have naturally formed. Band transects would provide a detailed view of riparian vegetation demographic and physical structure, and provide insight into hydrogeomorphic-vegetation relationships. Band transects will also provide information after Extremely Wet or Wet year ROD flow releases to assess model predictions, and document whether the high flows and recession limb have initiated riparian vegetation on higher geomorphic surfaces.
3. Map alliances, species, and/or age class patches every year at GRTS selected sites to complement band transect sampling. Riparian mapping would assess natural riparian initiation objectives (Section 3.5.1) as well as assess bank rehabilitation site riparian vegetation compliance objectives (Section 3.5.3). Site-scale mapping entails mapping riparian vegetation, including exotic hardwoods, on the most recent orthorectified aerial photographs at the same scale, but in greater detail, as those used in the system-scale riparian vegetation inventory (McBain & Trush 2005). Therefore, site-scale mapping would be more detailed than system-scale by including age classes, substrate patches, large wood storage, and potentially other details.

Site-scale monitoring will employ the GRTS sampling design discussed in Chapter 4 and will include both bank rehabilitation sites and un-rehabilitated sites. Site scale monitoring should employ a combination of mapping and cross section based assessments, and annual predictions of woody plant species response to proposed streamflow actions. Site-scale monitoring and assessment should evaluate:

1. How ROD releases and channel rehabilitation site designs lead to successful germination, initiation, and establishment of riparian vegetation on various alluvial and depositional features, including modes of mortality.
2. How riparian plant habitat evolves and is used by terrestrial species (e.g., Foothill Yellow-legged Frogs, Western Pond Turtles, and birds).
3. Whether mature plants are contributing to the large wood supply.

Site-scale mapping should quantify areas of substrate, gaps in established vegetation, area of potential seed beds, areas of initiating and establishing woody riparian vegetation, and conversion of one patch type to another to assess whether the implementation of ROD streamflows is increasing the types and spatial coverage of structurally complex, spatially heterogeneous vegetation on a wide variety of geomorphic surfaces. Riparian vegetation mapping is adequate at illustrating the system-wide trend of plant colonization, establishment, and disturbance but is inadequate at illustrating or quantifying the structural complexity, species richness, and plant succession dynamics critical for differentiating habitat attributes important to many reptiles, amphibians and birds. Therefore, site-scale monitoring and assessment should also include sampling along vegetation transects to enable cause-and-effect comparisons between flow releases, channel geometry, and riparian plant colonization, establishment and structural evolution. Plant sampling transects overlaying a cross section is one simple and widely used method to provide this cause-and-effect assessment (Bendix 1994; Auble *et al.* 1997; Auble and Scott 1998; Shafroth *et al.* 1998; Auble *et al.* 2005; Katz *et al.* 2005; Scott and Reynolds 2007). Two cross sections selected for monitoring geomorphic/physical objectives should be randomly selected within GRTS selected sites to best characterize conditions at mapped sites. Cross section-based assessments should document species composition, age class diversity, and structural development, and be capable of relating each to site level topographic, substrate, and hydrologic conditions. Riparian sampling design issues are discussed further in Section 4.1.8 and Appendix L.

Proposed performance measures and analyses

Key performance measures

Key system-scale performance measures should include:

- ***patch type frequency, abundance, and spatial and size distribution*** within a consistently defined riparian corridor;
- ***patch type interior area****;*
- ***unvegetated cover type frequency, abundance, distribution, and area*** within a consistent definition of riparian corridor; and
- ***large wood storage.***

The key site-scale performance measures should include:

- ***patch type frequency, abundance, and spatial and size distribution*** at GRTS selected sites within a consistently defined riparian corridor;
- ***area, frequency, and abundance of established riparian patches*** on constructed upper bar and floodplain surfaces at individual bank rehabilitation sites;
- ***common species*** associated with recruited patch types;
- ***species richness****;*
- ***age class distribution****;*
- ***patch type boundaries****;*
- ***region of river bank above summer baseflows*** *where woody riparian plant species are initiating and establishing; and*
- *zones and abundance of* ***frequently sampled riparian plant species.***

Candidate performance measures

No additional performance measures have been identified for this sub-objective, but others may be determined in subsequent RFPs that specify the details of required assessments.

Integration of performance measures with performance measures in other disciplines

Evaluating the development of spatially heterogeneous riparian vegetation and relating it to specific management actions should require several data sources and performance measures, some of which may come from Section 3.1 performance measures, and others that may be better generated as part of the riparian assessment:

- Geomorphic surface and substrate patch mapping that includes areas from the low flow water surface up to and including floodplain surfaces (e.g., identify areas of fine sediment deposition that should contribute to new seedbeds, identify grain size patches to estimate soil moisture properties for the Tool for Achieving Riparian Germination and Establishment of Target Species (TARGETS) model. TARGETS does not currently use this information, so the model would need to be updated based on WY 2006 monitoring results.
- Channel and floodplain geometry/topography (for TARGETS model and for assessing zones of initiating and establishing plants and relating those zones to life history characteristics).
- Stage-discharge relationships for monitored cross sections (for TARGETS model, for assessing zones of initiating and establishing plants and relating those zones to life history characteristics).
- Annual high water and low water survey at monitored sites (to calibrate 1-D hydraulic model for assessing zones of initiating and establishing plants and relating those zones to life history characteristics).
- Areas of inundation by peak flow during Extremely Wet water year releases (for assessing zones of initiating and establishing plants and relating those zones to life history characteristics).
- Annual hydrographs (for TARGETS model, assessment of zones where plants are initiating and establishing).

Some performance measures generated by the riparian vegetation establishment assessment are essential for describing fish, herpetofauna, and avian habitat. Riparian vegetation colonization and development provides a wide array of age classes and patch types that a wealth of species should exploit. The quantity, location, distribution and structural characteristics of riparian vegetation at specific sites can be of value to several other disciplines:

- within inundation zones at specific sites, as a covariate in assessments of fish habitat availability and use by different life stages over a range of flows;
- throughout the river corridor, for calibrating a predictive model of avian habitat use and availability and assessing river wide field observations of avian habitat use;
- at bank rehabilitation sites, for assessing avian habitat use and demographics; and
- at bank rehabilitation sites, for assessing amphibian (Foothill Yellow-legged Frogs, bullfrogs) and reptile (Western Pond Turtles) habitat availability, quantity, location, and quality.

Expected response

As ROD streamflows, coarse sediment augmentation and channel rehabilitation projects are implemented, riparian vegetation should expand to occupy upper bars, floodplains, high-flow scour channels, and side channels. In the short term, Extremely Wet (and possibly Wet and Normal) water years should lead to successful initiation and establishment of target woody riparian species on upper bars and floodplains, and other water years should initiate and establish woody riparian vegetation on lower geomorphic surfaces. With time, the number of patch types should increase as riparian vegetation expands onto a broader range of geomorphic surfaces, and species diversity should also increase.

Over the next two decades, the area of white alder, mixed willow and narrowleaf patches should decrease, and their contribution to total riparian acreage should decrease as representation from other patch types increases. Riparian vegetation expansion onto floodplains and upper bar surfaces should not only increase the total area of riparian coverage compared to the narrow riparian berm, but also increase the interior area of patches (more expansive vegetation on other surfaces away from the low water edge, with greater interior areas). The abundance of less disturbance oriented species (e.g., Himalaya berry) present in the riparian vegetation understory should decrease, and the abundance of disturbance dependent (i.e., ruderal) species whose life histories are closely tied to the snowmelt hydrology should increase.

With future increases in channel migration and channel complexity, the frequency of large wood introduced to the mainstem should also increase. The successful outcome of managing riparian vegetation should foster a general increase in the size of large wood recruited, and help maintain a long-term large wood supply. This improvement in natural large wood recruitment via channel migration into newly established vegetation may take many decades to begin providing benefits. Furthermore, anticipated future large wood contributions from this effort will largely be lower quality riparian wood rather than the historic coniferous large wood sources from the upper watershed. Future natural recruitment of newly established riparian hardwoods will not replace the historic source’s magnitude, quality, or overall benefits, but rather help to mitigate its loss.

Analysis

At the site scale, riparian hardwood initiation response to managed streamflows should be predicted using a subset of cross sections and the TARGETS model. Then, if an Extremely Wet water year occurs, the TARGETS model should be used to conduct adaptive management experiments as follows:

1. develop rehabilitation site input data (pre-flow topography, stage-discharge relationships with 1-D hydraulic model, soil moisture predictions based on local substrate, riparian seed dispersal period for target species, etc.);
2. run TARGETS model for various flow release scenarios, coordinate with flow needs for other discipline-specific objectives, choose release hydrograph, and re-run TARGETS model to predict where target riparian species should initiate on the cross section(s);
3. monitor release flows, seed dispersal, river water surface and groundwater elevation, soil moisture, air temperature, and root growth of initiating seedlings.
4. monitor riparian seedling initiation at end of summer, overlay on cross sections, compare with predicted results, and attempt to explain successes and shortcomings based on cause-and-effect monitoring (e.g., did soil moisture drop faster than root growth rate?); and
5. update functional relationships within TARGETS model (if needed) to improve future predictions.

The evaluation of the specific predictions and the annual and long-term effects of flows on the recruitment and development of riparian vegetation are best performed using channel cross sections and vegetation transects. Relating the frequency, abundance and bank location of colonizing, establishing, and maturing riparian vegetation to annual hydrology and changes in local channel morphology would provide useful information to the adaptive management process.

Cross section and vegetation transects should be used to evaluate the cause-and-effect relationship of flow management, channel rehabilitation site design, and riparian initiation and establishment. Cross section and vegetation transects use geomorphic surface, inundation zone, and location along the cross section where plants are initiating and establishing in the analysis. For each vegetation transect, the following should be summarized and plotted as a function of time, annual hydrology, bank position and inundation zone: 1) patch type boundaries; 2) species bank location; 3) zones of initiated or established woody riparian plants; 4) age class distribution; and 5) species richness.

Using the maps developed for each site, summarize and plot as a function of time and inundation zone: 1) the species composition, age class distribution, and area of patch types; 2) the proportion of patch perimeter to internal patch polygon area (i.e., a measure of patch interior); and 3) species richness. Generate summary statistics including the range, median, and standard deviation of patch size and the proportion of patch perimeter to patch area.

Additional site-scale analyses that would inform the adaptive management process include:

- number, frequency, size, and species of large wood introduced from local riparian vegetation; and
- the residence time of LWD by species, size, and source (to derive riparian hardwood target species for establishing and maintaining large wood source inventory).

At the system scale, summarize and plot as a function of time, reach, and/or river mile, the following: 1) total and cumulative area of riparian vegetation; and 2) distribution of patch types, patch size and the proportion of perimeter to patch area. Summary statistics, including the range, median and standard deviation of patch size and the proportion of patch perimeter to patch area, should be calculated. The relationship between channel locations and inundation patterns where patch types establish should be assessed using an overlay of riparian vegetation maps, topography, and index water surface elevations (i.e., 450 cfs water surface elevation, 2,000 cfs water surface elevation, 4,500 cfs water surface elevation etc.).

Proposed space and time frames

Site scale

Site-scale assessments should occur annually at GRTS selected panels for 3–5 years after the site is physically rehabilitated to document riparian initiation and establishment on lower geomorphic surfaces, or after an Extremely Wet water year to document riparian initiation and establishment on upper bar and floodplain surfaces. Due to time and budget constraints, all bank rehabilitation sites will be mapped, but only GRTS selected sites will have cross section-based vegetation assessments. Annual mapping monitoring at a site scale should decrease after 3-5 years, and only occur after Extremely Wet water years or floods greater than the 10-yr recurrence interval (measured at the USGS above the North Fork Gage). Intensive site-scale monitoring should end as determined by the GRTS sampling design, and when the site has recovered the riparian vegetation required for bank rehabilitation site construction permits.

System scale

System-scale mapping should occur every 5 years, or after an Extremely Wet year or flood greater than the 10-year recurrence interval (measured at USGS above the North Fork Gage), whichever comes first, to be able to document significant system-wide changes.

Priority issues to address

Technical issues still to be resolved:

1. Desired riparian vegetation conditions and quantitative vegetation targets, linked to a suitable ecological model describing how desired conditions should be achieved and maintained.

2. Additional patch attributes that should be associated with the system and site scale mapping.
3. The number and location of sites to be monitored.
4. Determining the appropriate frequency of site scale assessments, recognizing that mapping and transects may occur after different time spans and water years.

3.5.2 Prevent riparian vegetation from exceeding thresholds leading to encroachment that simplifies channel morphology and degrades aquatic habitat quality

5.2.1 Manage flows, coarse sediment augmentation, and channel rehabilitation that cause sufficient riparian plant mortality along low water margins to prevent channel simplification leading to degraded fish habitat

The TRFE cautioned that, based on experimental evidence and observation, annual ROD hydrographs would not remove existing berms, nor eliminate the possibility of future detrimental riparian encroachment. Forecasting the likelihood and extent of riparian encroachment was envisioned to be a critical scientific endeavor for the success of the Program. The balance between woody riparian colonization and detrimental riparian encroachment, played out on bars at a site and river wide, will largely determine whether salmonid habitat availability is reestablished and maintained. Some contemporary mainstem point bars below Dutch Creek have been colonized by woody riparian vegetation, but have not yet formed prominent berms. These bars appear capable of increasing the availability of high quality fish habitat. If exceeding the threshold for detrimental riparian encroachment is inevitable wherever bar surfaces are created naturally or through mechanical rehabilitation, habitat availability will hover at pre-ROD levels and Program goals may not be achieved. If the annual ROD hydrographs, coarse sediment management, fine sediment management, and channel rehabilitation design can keep woody riparian vegetation colonization below detrimental riparian encroachment threshold levels, then anadromous salmonid habitat availability should improve significantly and our chances at achieving Program goals will improve.

The TRFE found that the riparian berm morphology caused the greatest impact to fry and juvenile salmonid rearing habitat availability at flows between 450 cfs and 2,000 cfs (see Figure 5.18 in the TRFE). Thus, increasing and maintaining high quality fish habitat over the 450-2,000 cfs inundation zones (i.e., on bars and other geomorphic features within the active channel) will require that the Program prevent establishing woody vegetation from reaching encroachment thresholds leading to channel simplification. Several physical processes produce mortality agents that can potentially prevent riparian vegetation from crossing detrimental riparian encroachment thresholds:

- *Surface scour of stationary bars:* young vegetation is removed from non-migrating bars by shallow scour associated with movement of the active sediment-transport layer. This is the prevalent process for preventing vegetation encroachment discussed in the TRFE.
- *Prolonged inundation of potential seed beds:* inundation of potential seed beds physically prevents seed fall and germination of riparian plants. The 2,000 cfs bench in most water years is a strategy employed in the TRFE to reduce the time that low-lying bars are viable seedbeds during the narrowleaf willow seed dispersal period. Narrowleaf willows are native pioneer species that initiate the detrimental riparian encroachment process that the TRFE and ROD are trying to prevent.
- *Lateral scour:* riparian vegetation becomes established on the surfaces of building bars. This vegetation matures and develops on these new floodplains as the active channel migrates away and consumes older surfaces elsewhere. Ideally, the channel will migrate back through this riparian vegetation and prevent it from reaching encroachment thresholds; however, lateral scour via channel migration is not currently a prevalent process maintaining riparian vegetation

heterogeneity along the mainstem Trinity River, so the contribution of this process to healthy riparian vegetation along the mainstem Trinity River is uncertain.

- *Scour and redeposition:* local areas can be alternately scoured and filled to considerable depths based on the complex hydraulics around local roughness features (e.g., large wood).
- *Prolonged water inundation of established plants:* mortality caused by inundation of plants for many months due to prolonged flow releases and/or increases in water surface elevations and/or water table due to increases in bed level or downstream hydraulic controls. Previous studies on the Trinity River have shown that inundation of narrowleaf willow and black cottonwood seedlings for 3 months or more in the spring and summer is still insufficient to cause mortality, so this mortality agent may be limited (McBain & Trush unpublished data 1991; Bair 2001; McBain & Trush 2006).
- *Desiccation:* reductions in water surface elevations and/or shallow groundwater table due to rapidly reduced releases, and/or lowering of bed elevations or downstream control elevations. However, the prevalence of adequate soil moisture 1-2 ft below the ground surface (McBain & Trush 2006) may limit this mortality agent to first-year seedlings.
- *Burial:* bars are usually depositional features where vegetation can be buried. Relatively small plants may be laid flat by flow during the burial process. In the mid-1990s, studies at the pilot bank rehabilitation site showed that deposition of 2-3 ft was required to cause significant mortality in young narrowleaf willow seedlings growing between 450 cfs and 6,000 cfs (Bair 2001).
- *Mechanical damage:* riparian plants can be battered and damaged by bedload, and are sometimes sheared off at the base, either killing the plant or suppressing annual growth. This process was widely observed at pilot bank rehabilitation sites in the mid 1990s and after the 1997 flood, and possibly could suppress riparian vegetation from reaching encroachment thresholds in wetter water years. However, in drier water years, mechanical damage is not likely to have a significant effect at restricting establishing vegetation from reaching detrimental encroachment thresholds. There is likely a relationship between mechanical damage, coarse sediment supply, and magnitude of bedload transport. Theoretically, the amount of coarse sediment augmentation could play a role in preventing detrimental riparian encroachment. No quantitative relationship has been developed, but should be considered by the Program for evaluation.
- *Bank undermining:* older mature vegetation on riparian berms is sometimes susceptible to mass failure when the bank toe is slowly undercut; however, field observations in the 1990s showed this to be a very slow process that did not necessarily lead to widespread riparian berm removal, just local tree removal. Increasing channel complexity is intended to increase this mortality mechanism, but no quantitative predictions have been made.
- *Vortex Scour:* banks containing older mature vegetation (trees) become more prone to erosion because mature vegetation usually has a lower stem density than young vegetation, the mature canopy may suppress understory development, and flow around tree trunks at the channel-bank interface can produce vortices that enhance local bank scour. This process had been observed in few locations before ROD streamflow implementation, and is expected to increase in frequency. In concert with flow obstructions (discussed below), vortex scour is likely to introduce a significant percentage of natural large wood to the channel.
- *Flow obstruction:* existing patches of vegetation or debris can concentrate flow and increase shear stresses elsewhere. For example, high shear can occur adjacent to or between flow obstructions, or flow can be steered toward the opposite bank. This process also had not been observed in many locations before ROD streamflow implementation, but is expected to increase in frequency and (in concert with vortex scour) introduce a significant percentage of natural large wood to the channel.

Success of the rehabilitation sites will depend on the interaction between ROD flow releases, coarse sediment augmentation, and channel rehabilitation design to prevent detrimental riparian encroachment from occurring. Careful assessments of whether detrimental riparian encroachment thresholds are being exceeded should improve our ability to understand and predict encroachment, reducing the risk of potential Program failure in the future.

HYPOTHESES:

The following hypotheses were explicitly derived or inferred from the TRFE restoration strategy:

A. The following water year specific processes are necessary in concert to prevent riparian vegetation seedlings from exceeding detrimental encroachment thresholds:
   - create and maintain patchy, heterogeneous riparian vegetation growing on bars and other complex alluvial features between the 450 cfs and 2,000 cfs inundation zones through scour-induced mortality of riparian hardwoods younger than 3 years old by scouring deeper than $2xD_{84}$s on exposed bars during Extremely Wet water years;
   - create and maintain patchy heterogeneous riparian vegetation growing on bars and other complex alluvial features between the 450 cfs and 2,000 cfs inundation zones through scour-induced mortality of riparian hardwoods younger than 2 years old by scouring deeper than $1xD_{84}$s on exposed bars during Wet water years; and
   - create and maintain patchy heterogeneous riparian vegetation growing on bars and other complex alluvial features between the 450 cfs and 2,000 cfs inundation zones through scour-induced mortality of riparian hardwoods 1 year old or younger by mobilizing the bar surface on exposed bars during Normal and wetter water years.

B. The following fluvial processes are necessary in concert to prevent established and maturing riparian vegetation from exceeding detrimental encroachment thresholds:
   - channel migration during normal and wetter water year classes;
   - burial mortality of any age class of riparian vegetation (deposition);
   - local vertical and lateral scour mortality of riparian vegetation of any age class associated with flow obstructions or bar formation during all water year classes;
   - mechanical damage and mortality to riparian vegetation of any age class; and
   - inundation/desiccation mortality in riparian vegetation of any age class.

C. Riparian hardwood species (specifically narrowleaf willow) are the primary instigators of channel simplification through encroachment and berm formation.

D. Riparian hardwoods >3 years old growing in the 450-2,000 cfs inundation zone exceed the ability of ROD releases to remove them via vertical scour.

E. A riparian plant density and contiguousness threshold exists between 450 cfs and 2,000 cfs that, if avoided, could prevent riparian vegetation from crossing the encroachment threshold and simplifying the channel (i.e., if local scour can create gaps in the dense band of colonizing vegetation and spatially lower densities, encroachment can be prevented and high quality fish habitat maintained).

As discussed in Section 3.1, there is a difference of opinion within the Program on the future risk of detrimental riparian encroachment under the ROD flow regime (see Appendix M for details).

Proposed assessment strategy and rationale

The proposed assessment strategies are intended to assess the sub-hypotheses described above and in Appendix M; therefore, no distinction in assessments between them is required. The assessment strategy for detecting whether riparian vegetation has been prevented from exceeding detrimental encroachment thresholds (Sub-hypothesis A and B) relies on similar methods (band transects) to those used for evaluating sub-objectives in Section 3.5.1. The flows that will promote patchy heterogeneous riparian vegetation on upper bar surfaces and floodplains will be the same flows that prevent riparian vegetation from achieving detrimental encroachment thresholds and maintain high quality fish habitat; therefore, a similar assessment strategy and methodology can be applied for evaluating sub-objectives in both Sections 3.5.1 and 3.5.2.

Field-based mapping at GRTS selected sites should be used to quantify the location and area of colonizing and establishing vegetation, complemented with site-scale cross section-based sampling to verify or expand upon the species, age classes, demographics and abundance of colonizing vegetation. Most importantly, cause-and-effect monitoring and assessment should be conducted at a subset of the GRTS selected sites to: 1) document whether TRFE management targets are being met; 2) evaluate cause-and-effect relationships between flow releases, coarse sediment management, and detrimental riparian encroachment processes in order to inform annual flow management decisions and bank rehabilitation site designs; and 3) investigate other potential riparian mortality sources to improve management options if needed in the future.

System-scale monitoring should use a strategy similar to that proposed in Section 3.5.1, with only the performance measures, analysis and sampling frequency differing. Analysis of system-scale mapping for Objective 3.5.2 should include: increases/decreases in the area of riparian vegetation that has the potential to encroach or has already encroached the channel; the formation and/or decomposition and frequency of berms; and the formation, evolution, and erosion of bar features throughout the study area.

Conducting intensive site-scale mapping and assessment annually will track the planform evolution of potentially encroaching riparian vegetation (trend monitoring) and help inform the Program whether colonizing vegetation is approaching a threshold for detrimental riparian encroachment. Site-scale mapping will occur at sites selected with the GRTS method and will include both rehabilitated and unrehabilitated sites. A subset of GRTS selected sites will consist of naturally-formed bars where detrimental riparian encroachment thresholds have not yet occurred. Naturally formed bars should provide essential information about the fate of alluvial and depositional features that have naturally formed and maintained themselves and the relationship of naturally formed bar creation and maintenance to annual streamflows.

Site-scale mapping should include areas of young establishing riparian vegetation, areas where gaps have been formed by recent streamflows, and locations where riparian vegetation may have already crossed the detrimental encroachment threshold. Mapping defines the extent and general location of colonizing vegetation, broadly illustrating and confirming the conditions documented by cross section-based vegetation transects.

Site-scale cross section monitoring and assessments quantify the cause-and-effect of changes documented on planform maps by evaluating what combination of hydrology, physical processes, and evolution of channel morphology lead to successful prevention of riparian vegetation from reaching encroachment thresholds. Cross section-based assessments should document species composition, frequency and abundance, age class diversity, and density, then relate those variables to site topographic changes (including local and lateral scour), substrate size, bed mobilization and scour, and other conditions that cause riparian mortality.

Proposed performance measures and analyses

Key performance measures

Program success is very dependent on preventing large-scale detrimental riparian encroachment (Objective 5.2) while encouraging riparian establishment on a wide variety of geomorphic surfaces for fish and wildlife habitat (Objective 5.1). Therefore, performance measures must track the success of managed streamflows, bank rehabilitation, and sediment augmentation at preventing detrimental riparian encroachment in the 450-2,000 cfs inundation zone; they should also provide timely information to the adaptive management process about whether riparian vegetation is approaching a threshold beyond the control of ROD management actions, thereby initiating an irreversible decline in habitat quality, quantity, and availability.

Key system-scale performance measures should include:

- ***patch type frequency, abundance, and spatial and size distribution*** within a consistently defined riparian corridor; and
- ***unvegetated cover type frequency, abundance, distribution, and area*** within a consistent definition of riparian corridor.

The key site-scale performance measures should include:

- ***patch type frequency, abundance, and spatial and size distribution*** at GRTS selected sites within a consistently defined riparian corridor;
- ***area, frequency, and abundance*** of colonizing and established riparian patches between 450 cfs and 2,000 cfs;
- ***plants species frequency, abundance, and distribution*** at bank rehabilitation sites within inundation zones;
- ***stem density***;
- ***age class distribution***;
- ***region of river bank above summer baseflows*** *where woody riparian plant species are initiating and establishing; and*
- *zones and abundance of* ***frequently sampled riparian plant species***.

Candidate performance measures

No additional performance measures have been identified for this sub-objective, but others may be determined in subsequent RFPs that specify the details of required assessments.

Integration of performance measures with performance measures in other disciplines

The response of riparian vegetation to management efforts aimed at preventing vegetation from reaching encroachment thresholds must be related to the physical mechanisms that inhibit/facilitate encroachment (e.g., various types of scour, inundation, deposition, etc.). Relating changes in riparian vegetation patterns between the 450 cfs and 2,000 cfs inundation zone to streamflow-induced scour mechanisms requires the following information to be collected:

- channel topography;
- micro-topography along the portion of the cross section accurately depicting the bank locations where future encroachment thresholds may be reached;

- surface substrate characteristics including facies maps and characteristic particle sizes (i.e., the D_{50}, D_{84} and D_{90});
- bed mobility of the surface particles within different inundation zones related to annual spring streamflows;
- channel bed scour and deposition depth within different inundation zones as a function of discharge;
- stage-discharge relationships for monitored cross sections;
- annual high water and low water surveys at monitored sites;
- geomorphic planmaps above wetted channel; and
- estimates of unit stream power or local shear stress within different inundation zones related to annual streamflows.

Expected response

The overall response to prevention of detrimental riparian encroachment and encouragement of beneficial riparian establishment on upper bars and floodplains should be a substantial increase in high quality aquatic habitat between the 450 cfs and 2,000 cfs inundation zone (with smaller increases in quality habitat availability at higher flows).

It is expected that:

- Riparian vegetation should continue to establish in patches, but not establish and mature in dense continuous bands along the summer water's edge such that detrimental riparian encroachment and channel simplification should not occur in the future.
- Established riparian vegetation should be patchy along the low flow water margin, benefiting a wide variety of aquatic species and life history stages because riparian vegetation growing along the water's edge should be frequently disrupted, making it spatially and temporally complex.
- Normal and wetter water year peak releases should induce substantial scour-induced mortality to 1–3 year old riparian seedlings in the 450–2,000 cfs inundation zone.
- Patches of riparian vegetation should establish in the 450–2,000 cfs inundation zone, but not in continuous dense patches that induce irreversible berm building and channel simplification processes.
- Salmonid fry and juvenile rearing habitat quantity, quality, and availability should increase in the 450–2,000 cfs inundation zones.

Analysis

At the site scale, the effect of annual managed streamflows at preventing detrimental riparian vegetation encroachment should ideally be predicted using a model based on empirical data (e.g., TARGETS combined with the RSL bed scour model). Considerable effort has been expended to develop a model that can predict local bed scour as a function of discharge at a site and in a format that TARGETS can use (Alexander 2004; May *et al.* 2004); however, accurate predictions of bed scour remain elusive. In lieu of a model that can provide accurate and cost-effective predictions of channel bed scour depth and location, the recommended approach is relating riparian plant mortality to empirical measurements of bed mobilization and scour at each site.

Changes in density, abundance, and frequency for various plant species age classes within inundation zones should be directly related to whether key physical process thresholds were exceeded in each inundation zone (bed mobility and scour), as well as changes in channel morphology (lateral or vertical scour). Cross section based riparian monitoring is proposed to be conducted in the spring and fall at sites selected using the GRTS sampling design (discussed in Chapter 4). The highest magnitude streamflows within a year (whether winter rainfall-induced floods or managed spring releases) are associated with changes in plant abundance and bank position. Bed mobility and scour resulting from annual winter and spring streamflow peaks will be used in conjunction with riparian monitoring to assess the efficacy of streamflow magnitude at creating the desired riparian response. It is possible that winter flood peaks may cause the disturbance needed to inhibit detrimental encroachment, thereby reducing the need of spring managed streamflows to restrict detrimental encroachment from occurring.

At the system scale, mapping data should be analyzed as described under Sub-objective 3.5.1. Objective-specific analyses include summarizing and plotting as a function of time, physiographic reach, and river mile, the: 1) total and cumulative area of sparsely vegetated gravel bars; and 2) total and cumulative area, frequency and length of encroached channel.

Proposed space and time frames

Site scale

Site-scale monitoring and assessment should be conducted annually at GRTS selected panels at least for the first 3-5 years after a site is rehabilitated. The intensive monitoring period should end when monitoring data indicate that encroachment thresholds have been exceeded or no further changes in riparian vegetation cover and bank position are detected (suggesting that some quasi equilibrium state has been reached). Plant species frequency and abundance should be monitored on the cross sections in the spring to detect effects from winter rainfall-generated tributary floods. Plant frequency and density should be monitored on the cross sections at the end of the growing season to detect effects from spring managed releases. Site-scale mapping should be done annually at the end of the growing season, but before leaf drop and dormancy (September). Riparian vegetation along transects must be sampled along transects during Dry and Critically Dry years, however the associated geomorphic threshold monitoring discussed in Section 3.1 is not required.

System scale

System-scale mapping should occur at the same frequency as the system-scale mapping described under sub-objectives in Section 3.5.1. System-wide mapping should occur every 5 years, or after an Extremely Wet year or flood greater than the 10-yr recurrence interval (measured at the USGS above the North Fork Gage), whichever comes first, to be able to document significant system-wide changes.

Priority issues to address

Technical issues still to be resolved:

Many of the priority issues for Sub-objective 3.5.2 are similar to priority issues identified for Sub-objective 3.5.1. However some priority issues to address are worth repeating and others are unique to Sub-objective 3.5.2. The primary issue to address is the difference of opinion on risk of detrimental riparian encroachment occurring under the ROD flow and sediment regime. Other priority issues to address for Sub-objective 3.5.2 are:

1. How to define the risk of encroachment
2. Exploring whether less intensive measures of plant abundance (e.g., frequency and cover) instead of density can provide the necessary information required to manage riparian vegetation encroachment thresholds.
3. The number of sites to be monitored.

4. Evaluating alternative ways to map patches of vegetation that cannot be detected on aerial photographs (i.e., patches <5 years old) to reduce bias by the mapper.
5. Determining whether it is necessary to have more accurate site-scale assessments of the physical processes responsible for preventing riparian vegetation from reaching encroachment thresholds.
6. The extent, and quantity of mechanical damage that a plant must receive to prevent it (in combination with other plants) from attaining encroachment thresholds.
7. Determining the appropriate frequency of site-scale assessments, recognizing that mapping and transects may occur after different time spans and water years (including the potential management implications of monitoring only in the fall).
8. Improving the ability of the current empirically-based channel evolution model developed by May *et al.* (2004) to predict local bed scour at a site as a function of discharge.

3.5.3 Sub-objective 5.3: Recover riparian vegetation area equal to or greater than that disturbed by physical rehabilitation

Under the terms of the final Programmatic Environmental Impact Report (PEIR), the area of riparian vegetation impacted through channel rehabilitation site construction is required to be replaced at a 1:1 ratio at a minimum (CH2MHill 2000). A hypothesis is unnecessary for evaluating whether riparian vegetation recovery is meeting compliance requirements; vegetation is either meeting or exceeding replacement targets, or it is not. Therefore, monitoring riparian vegetation acreages must occur at all bridge and bank rehabilitation sites. Impacted riparian vegetation at bank rehabilitation sites will be recovered using a combination of artificial revegetation and natural recruitment using ROD flow releases, coarse sediment augmentation, and channel rehabilitation activities.

Proposed assessment strategy and rationale

Patches of riparian vegetation should be mapped at every bank rehabilitation site using the previously described modified plant alliance classification system (Sawyer and Keeler-Wolf 1995; McBain & Trush 2006), and related to Wildlife Habitat Relationship (WHR) cover types used to obtain required environmental permits for construction. Mapped patches should also be associated with additional attributes describing whether mapped vegetation patches consist of undisturbed pre-construction stands (remnant), stands that have regrown after construction attempted to remove them, naturally recruited stands, or artificially planted stands. Mapping should also incorporate exotic plant species to ensure that construction activities are reducing exotics rather than increasing them. Mapping, digitizing, and analysis should be conducted identically to that described for Sub-objective 3.5.1. In contrast with the mapping efforts described for Sub-objectives 3.5.1 and 3.5.2, the baseline location, composition, and structure of riparian vegetation should be characterized at each site at least 1 year before construction. Riparian vegetation mapping should be repeated at each rehabilitation site following construction to quantify impacts to riparian vegetation. Riparian vegetation at each site should be mapped again at 3 and 5 years after construction to document the area of revegetation and natural recruitment.

After each mapping event, the GIS database should be updated and queried with subsequent riparian vegetation mapping to detect changes in the area of different patch types. The area of riparian vegetation 3 years after construction should be used to assess riparian vegetation recovery and quantify mitigation compliance at each site. The likelihood of full mitigation after 5 years should be projected based on the results of mapping after 3 years. Mapping should be repeated at 5 years after construction to assess these recovery predictions, and to determine how much (if any) supplemental revegetation should be required to fully replace riparian vegetation impacted during construction.

Proposed performance measures and analyses

Key performance measures

- Similar to those included under Sub-objectives 3.5.1 and 3.5.2.
- ***Riparian vegetation area at bank rehabilitation sites*** within the environmental study limits established during the permitting process.
- ***Invasive exotic vegetation area at bank rehabilitation sites*** within the environmental study limits established during the permitting process.

Candidate performance measures

No additional performance measures have been identified for this sub-objective, but others may be determined in subsequent RFPs that specify the details of required assessments.

Integration of performance measures with performance measures in other disciplines

- Similar to those included under Sub-objectives 3.5.1 and 3.5.2.

Expected response

At a minimum, riparian vegetation patch area should increase to at least the acreage that occupied the site prior to construction, with increased patch type and structural diversity. Full replacement of impacted riparian vegetation acreage is predicted to occur within 5 years of construction.

Analysis

- Similar to those included under Sub-objectives 3.5.1 and 3.5.2.
- Change in total riparian vegetation area at a construction site within the environmental study limits established during the permitting process.
- Change in total exotic vegetation patch area at a construction site prior to construction and 5 years after construction using the same construction site boundaries.

Proposed space and time frames

Site scale

The pre-construction (i.e., baseline) location, composition, and structure of impacted riparian vegetation should be characterized at all bank rehabilitation sites at least 1 year prior to construction. Riparian vegetation mapping should be repeated at all rehabilitation sites following construction to quantify initial impacts to riparian vegetation, then mapped again at 3 and 5 years after construction to document the area of revegetation and natural recruitment and to verify at least 1:1 replacement.

Priority issues to address

Technical issues still to be resolved:

1. Should revegetation methods be evaluated and potentially modified if revegetation and natural recruitment aren’t meeting compliance requirements on the first few sites after 3 or 5 years?
2. How will the GRTS sampling design be coordinated with the number of sites required under compliance monitoring?

3.6 Objective 6: Rehabilitate and protect wildlife habitats and maintain or enhance wildlife populations following implementation

The increase in aquatic and riparian habitat complexity predicted to result from implementation of localized site rehabilitation efforts, cumulative alluvial effects, and ROD flows are expected to benefit wildlife. Riparian and riverine birds, Foothill Yellow-legged Frogs, and Western Pond Turtles were chosen as target species for monitoring wildlife response to changes in habitat for a number of reasons:

- These species are all good integrators of riparian (RHJV 2004; Burnett *et al.* 2005) and river condition (Lind *et al.* 1996; Reese and Welsh 1998a; Burnett and Lindquist 2005; Mažeika *et al.* 2006), and can respond rapidly (1–2 years) to changes in habitat, while also serving as indicators of long-term (5–20 years) cumulative effects.
- Riverine wildlife have co-adapted with fish in response to a dynamic alluvial river system.
- Observed changes in resident wildlife abundance and productivity are attributable to in-basin conditions, some of which are influenced by management actions.
- Migratory and resident birds respond to local habitat conditions for breeding success and survival and are considered an easy and cost-effective wildlife community for monitoring.
- The Western Pond Turtle and Foothill Yellow-legged Frog (identified as a focal species in the Trinity River ROD (USDOI 2000) and TRFE (USFWS and HVT 1999)) have both responded negatively to changes in channel morphology and flow dynamics since construction of the Trinity and Lewiston Dams (Lind *et al.* 1996; Reese and Welsh 1997, 1998a, 1998b), and are expected to benefit from the addition of warmer water locations resulting from increased channel complexity.

These target species are expected to respond positively following implementation of Program management actions. Estimating historic population levels would be difficult for most species, and impossible for others. Therefore, population estimates from abundance data collected prior to Program implementation will serve as baseline population levels for monitoring post-implementation trends in the target species.

Assessments for wildlife objectives will contribute to AEAM short-term decisions by measuring population changes in response to site rehabilitation implementation, flows, gravel augmentation, habitat development, and other management actions. The assessments will also serve in the longer term evaluation of changes in wildlife abundance and productivity as progress is made towards Program goals, as stated in the ROD and other supporting documents and legislation, to maintain and restore fish and wildlife populations. The assessments will also assist in evaluating success in establishing the amount and characteristics of riparian habitat that meet the needs of wildlife species for successful survival and reproduction.

Roles of wildlife assessments in AEAM

- Provide input to site designs (including recommendations on amount, distribution and diversity of vegetation) through statistical modeling tools developed to predict wildlife response.
- Provide feedback through monitoring on the success of combined restoration designs and flow schedules to create wildlife habitat and achieve predicted wildlife responses.
- Provide input into flow decisions, particularly flow timing.
- Provide input into large woody debris management through assessments of location and functioning of large wood as cover, foraging habitat, and turtle basking sites.

- Test hypotheses by identifying trends in wildlife response to local alterations at rehabilitation sites and long-term cumulative changes to the river system below Lewiston Dam.
- Evaluate the quality of riparian habitat as it develops over time.

Longer term evaluation towards Program goals

- Long term assessments of bird communities, as well as target species of birds, reptiles and amphibians, are essential to evaluating the cumulative effects of Program management actions on wildlife habitats and populations.
- Monitoring trends in wildlife populations and habitat use documents response of species of concern and species that respond to riverine and riparian habitat quality.

3.6.1 Sub-objective 6.1: Maintain Trinity populations and species diversity of birds using the riparian zone in the Program area

6.1.1 Enhance quality and maintain quantity of riparian bird nesting and foraging habitats

Riparian habitat in the Program area will be maintained or established through initiation or revegetation. It is anticipated that a dynamic river system that results in quality riparian habitat equal to the current area of riparian habitat within five years will meet the needs of target wildlife species for successful survival and reproduction. Assessing trends in riparian bird populations and demographics will assist in evaluating the efficacy of this strategy.

HYPOTHESIS:

Program actions will maintain or increase productivity and abundance of target riparian bird species in the Program area by increasing the complexity of riparian habitat from the water's edge to the upland boundary of the floodplain.

Proposed assessment strategy and rationale

We expect the transformation from current extensive riparian-berm habitat to dynamic, species diverse, structurally and spatially complex riparian habitat to benefit the riparian bird community in the long-term. A set of "target" riparian bird species were selected for monitoring because: (1) they are strongly associated with riparian habitat; (2) they are present in sufficient numbers to detect changes in abundance; or (3) their population status in California is of special concern. We will predict bird response to anticipated habitat changes and monitor population measures of abundance, productivity, species diversity, and health of individuals over time. We will use two methods to estimate baseline population size for five target riparian bird species using data collected from 2002 through 2006. One method uses observed bird densities in generalized riparian habitat to extrapolate to a population size across all riparian habitat mapped in 2002 through 2004. The second method uses statistical models developed from baseline bird and riparian habitat data to predict abundance by specific riparian habitat classes in the Program area. Once population size is estimated, we will select meaningful changes in the population to serve as targets for testing hypotheses and assessing success in reaching Program goals. Analyses of the power to detect target species population changes over 3-15 years will be used to estimate sample sizes needed to determine when or if target population levels are achieved. Abundances of target species are expected to fluctuate as rehabilitation projects are implemented, and as riparian habitat is planted, initiates naturally, and develops over time. Species diversity/richness is associated with habitat complexity and these relationships should become evident at the Program area scale as rehabilitation actions generate an array of riparian habitat patches of diverse age, size, plant species, and structure across complex geomorphic surfaces. Measures of bird health across the seasons will allow us to relate observed changes in the bird community to potential causes. For instance, if abundance or diversity is high, but productivity is low, the habitat may not be providing sufficient forage for nestling survival. We will analyze trends in the bird community in relationship to changes in aquatic, riparian and geomorphic changes.

Bird surveys will be undertaken employing standardized census and capture methods (Ralph *et al.* 1993) appropriate to each season. Measures of habitat quantity and quality collected at bird survey locations and from other disciplines will be incorporated into assessments of bird population trends. We will analyze the relationships between any observed trends in bird abundance or productivity (as estimated from the ratio of juveniles to adults present in the different seasons), and the changes in riparian habitat abundance, structural and vegetative characteristics, spatial arrangement, and plant species composition. Predictive models developed from pre-implementation bird surveys will be tested with post-implementation abundances, productivity, and habitat conditions.

Proposed performance measures and analyses

Key performance measures

- ***Abundance*** of target riparian bird species in the breeding, post-breeding, and migration seasons of the birds' life histories.
- ***Productivity*** of target riparian bird species.
- ***Trends in abundance*** and ***productivity.***

Candidate performance measures

- ***Species diversity*** (richness, composition).
- ***Bird health.***

Integration of performance measures with performance measures in other disciplines

Development and application of predictive models will integrate performance measures from riparian, physical, and habitat disciplines. Current abundance levels for target riparian bird species are being used to develop statistical models that predict bird abundance as conditions in the Program area are altered to achieve Program goals. Predictive models to test hypotheses of reproductive success will be developed as construction and monitoring of rehabilitation sites progresses.

Expected response

- *Abundance* – In the first few years after removal of riparian berms at bank rehabilitation sites, abundance of riparian birds is expected to decline at the site scale. However, revegetation and natural initiation on the new complex of geomorphic surfaces is expected to result in diverse riparian habitat. Establishment of riparian habitat with complex age, structural, and spatial characteristics and diverse plant communities associated with establishment of a dynamic alluvial system should result in an increase in bird abundance in the Program area 10-20 years after implementation.
- *Productivity* – Restoration at bank rehabilitation sites could significantly decrease the reproductive success (measured by productivity) of riparian birds immediately following implementation. As complex riparian habitat establishes on floodplains, productivity should increase for some species to levels equal to or exceeding pre-implementation.
- *Species Diversity* – Species diversity in bird communities generally increases with habitat complexity (Jaramillo and Hudson 2001; Burnett *et al.* 2005). Although removal of riparian berm

vegetation may initially cause a decrease in species richness, birds should respond positively to increased complexity as habitat becomes more dynamic across the Program area.

Analysis

Changes in abundance and species diversity of breeding, migrating, and over-wintering riparian birds will be assessed using methods that monitor annual and seasonal abundance (Ralph *et al.* 1993) at rehabilitation sites, reference and control areas, and throughout the Program area. We will estimate abundance of target riparian birds by species, general abundance of all birds, and diversity and composition of bird species from point counts and other census methods. Target species for monitoring were selected for several reasons: 1) they have protected or legal status (Endangered Species Act 1973, Migratory Bird Treaty Act 1918); 2) they are identified as riparian species of concern (USFS 1998; CDFG 2004; RHJV 2004); 3) they respond to changes in riparian habitat quality (Burnett *et al.* 2005); and 4) abundance levels in the Program area are high enough to detect changes. Monitoring will document impacts or enhancements to species of concern and test the validity of the current riparian replacement strategy for habitat mitigation. The amount of riparian habitat will be tracked through periodic vegetation mapping (from remote sensing and vegetation plots), and we will measure plant species diversity and spatial and structural complexity of riparian habitat from vegetation mapping, vegetation measurements (plots and transects), and LIDAR data when available at bird survey and capture locations.

We will measure productivity of riparian breeding birds, from the ratio of juveniles to adults captured at mist-net stations and from measures of reproductive indices. Productivity related to localized habitat conditions can be estimated by age ratios (ratio of the numbers of adults and juveniles captured at demographic stations) and measures of the birds' condition at the onset of and throughout the breeding season. Monitoring annual and seasonal age ratios for target riparian bird species at reference locations related to rehabilitation sites and throughout the Program area will allow us to assess changes in numbers of breeding birds and young fledged. Additional data collected on the health and breeding status of captured birds will provide insights into the physiological status of the birds and possible causes for any observed changes.

Changes in habitat quality and quantity will be tracked as predictors of riparian bird abundance and productivity to validate predictive models we are developing from data collected from 2002 to 2006. We will estimate trends in these bird population parameters by species, and analyze relationships between trends and changes in riparian habitat quantity and characteristics.

Proposed space and time frame

There are three spatial scales: 1) individual rehabilitation sites; 2) the associated river reference reach, often encompassing a treatment suite of sites, or implementation "Phase", that are producing cumulative changes within the reach through improved alluvial processes; and 3) the Program area. The temporal scale of bird response will differ for the various spatial scales.

Site scale

Birds nesting in the riparian habitat at the site will respond rapidly to vegetation removal. Following an initial decrease in the amount of riparian habitat at some rehabilitation sites, the abundance of breeding and migrating bird species will likely decline for 1 to 5 years. The expected time to detect an initial response to vegetation removal and construction may vary from 1 to 2 years. A reduction in nesting substrate and food abundance could affect many aspects of life history for these birds (TRRP 2005), resulting in changes in abundance, species diversity, and reproductive success. Post-construction bird surveys during the first Phases of rehabilitation are a high priority as they provide valuable information for future planning and adaptive management.

Reach scale

As the riparian habitat progresses through development in each construction phase, the complexity of plant species composition and vegetative structure are expected to increase and provide nesting and foraging habitat for breeding and migrating birds. As cumulative effects of the rehabilitation actions begin to reestablish natural alluvial processes in the Program area, natural riparian habitat initiation and succession will create a dynamic riparian system with a variety of habitat conditions suitable for a diverse suite of riparian bird species.

Measuring bird abundance throughout the Program area each year during pre- and post-construction periods will provide comparisons of annual abundance for assessing change at the reach scale. During Phase I of implementation, all 360 available point count stations along the river or a subset of four randomly selected reaches (these reaches were selected prior to the Program's proposed reference reaches) should be surveyed annually as they provide population data for trend analyses. A population response time of 5 to 10 years is expected at selected reaches.

System scale

As natural alluvial processes are reestablished and riparian initiation and development proceed, we expect abundance and productivity of riparian birds in the Program area to increase to current or enhanced levels over the next 20 years. Annual surveys at the system scale in the first 10 years are important for evaluating the power of the sampling to estimate population trends. Once population estimates and early trends have been identified, less frequent surveys could be conducted.

Priority issues to address

Technical issues still to be resolved:

1. Power analyses on current and 1990s point count data have been completed to determine the duration and intensity of monitoring needed to detect varied levels of change in target riparian species abundance with expected levels of confidence. Similar power analyses are now needed for monitoring productivity through demographic data collected at banding stations.
2. Population size for target species needs to be estimated to help establish target population levels for up to 15 years after initial implementation.

3.6.2 Sub-objective 6.2: Maintain Trinity River riverine bird populations and species diversity in the Program area

6.2.1 Enhance quality and maintain quantity of riverine bird nesting and foraging habitats

Riverine birds depend on the aquatic and riparian habitats in the Program area for foraging and breeding. Some species are resident year-round on the Trinity River, while a few disperse from breeding territories or migrate to warmer climates during winter months. Life histories of this group of birds encompass a variety of aquatic habitats, including those used by salmonid fish. Riverine bird abundance and productivity are good indicators of the health of a river ecosystem (Tyler and Ormerod 1994) and monitoring trends in these species on the Trinity River will help to assess Program success.

HYPOTHESIS:

An increase in river channel complexity and the amount of juvenile fish habitat resulting from rehabilitation and reestablished natural alluvial processes will increase the abundance and productivity of target riverine birds that share prey and foraging habitats with fish and other wildlife in the Program area.

Proposed assessment strategy and rationale

We will monitor changes in riverine bird abundance and productivity (as measured by the ratio of juveniles to adults observed during surveys) to assess response to an increase in the amount of juvenile salmonid habitat (also foraging habitat for riverine bird species) in the Program area. Several species have been selected as target species for monitoring because of their associations with riverine habitats or special status as species of concern for state and federal agencies or conservation groups. For inclusion as target species, consideration was also given to species addressed in prior work in the study area (Wilson *et al.* 1991; Burnett *et al.* 2005), species listed as threatened or endangered by the U.S. Fish and Wildlife Service or California Department of Fish and Game (CDFG 2005), the Partners in Flight Avian Conservation and Riparian Conservation Plans (RHJV 2004), and the U.S. Forest Service lists for sensitive animal species (USDA Forest Service 1998) and National Forest management indicator species lists.

We will estimate baseline population size for target riverine bird species using species densities from data collected from 2002 through 2008. Once population size is estimated, we will select meaningful changes in the population to serve as targets for testing hypotheses and assessing success in reaching Program goals. Analyses of the power to detect target species population changes are underway and when completed will be used to estimate sample sizes needed to determine when or if target population levels are achieved.

Proposed performance measures and analyses

Key performance measures

- ***Abundance*** of riverine bird species.
- ***Diversity*** of riverine bird species.
- ***Productivity*** of riverine bird species.

Candidate performance measures

No additional performance measures have been identified for this sub-objective, but others may be determined in subsequent RFPs that specify the details of required assessments.

Integration of performance measures with performance measures in other disciplines

The relationships between riverine bird species abundance and channel complexity, amount and location of juvenile fish habitat, and fish and macroinvertebrate prey abundance will be integrated with other Program objectives (fish, physical, habitat, hatchery release management) as data become available. Changes in habitat quality and quantity will be tracked through the integrated assessments and evaluated as predictors of riverine bird abundance, diversity and productivity.

Expected response

- *Abundance and diversity* – We anticipate an increase in abundance of riverine birds with increased geomorphic, hydrologic, and riverine habitat complexity. The addition of side-channels, alluvial river bars, and woody debris into the system should increase prey abundance and foraging substrates. Retention of some riparian plants at the water's edge and additional riparian habitat in side-channels will provide cover from predators and nesting substrate for riverine birds. The diversity of habitats should increase the number of species using the river across seasons.
- *Productivity* – Increased habitat quality and availability of prey species (fish and macroinvertebrates) combined with retention and increases in protective cover for young and adults will likely result in higher survival of juvenile birds and increased productivity, which are measures of reproductive success.

Analysis

We will monitor changes throughout the Program area in annual and seasonal abundance of target species of breeding and fall migrating riverine birds that rely on the river and riparian habitats for foraging and reproduction. This monitoring will assist in measuring the success of flow changes and site rehabilitation implementation to create a dynamic, functioning river ecosystem. Riverine birds respond positively to improved aquatic habitat quality (Mažeika *et al.* 2006). We will test the ability of statistical models to predict the direction and magnitude of changes in abundance and species diversity from changes in river and riparian conditions. Monitoring trends in riverine bird abundance following implementation will assist the Program in assessing the response of these birds, which rely on aquatic resources and interact with fish in positive and negative ways, to the development of a complex, alluvial river channel.

Changes in the annual productivity of some riverine birds can be monitored by estimating the ratio of juveniles to adults from riverine bird surveys throughout the Program area as ROD flow schedules and site rehabilitations are implemented. Age is determined from plumage observations recorded during surveys conducted from boats on the river. For some species, with current low densities and uncertainties in age determination, there is a need to assess whether there is sufficient statistical power to evaluate trends in age ratios.

A model of riverine bird abundance and river and riparian habitat conditions will be developed from the geomorphic and fish habitat maps in conjunction with the monitored distribution and abundance of fish. If strong associations are found, then riverine bird abundance could be predicted from the anticipated amount of habitat present when the Program's minimum goal of 400% increase in fish habitat is reached. This could be the target riverine bird abundance. An alternative approach would be to monitor trends from pre-implementation to help assess the birds' response to development of a complex, alluvial river channel with increased amounts of fish rearing habitat and prey.

Proposed space and time frame

System scale

As indicated above, the spatial horizon for riverine birds is the Program area. Abundance and productivity of riverine birds are expected to increase as river channel complexity increases in the Program area. Riverine birds on the Trinity River have life histories that vary both spatially and temporally. Nesting substrates, territory size, foraging behaviors, and productivity levels differ among the species and some species will respond more rapidly than others. Within 5 to 10 years of measurable changes in habitat quantity and quality, we expect to detect a measurable response in abundance of riverine birds in the Program area.

Priority issues to address

Technical issues still to be resolved:

1. Power analyses on current and historical riverine bird data are necessary to determine the duration and intensity of monitoring needed to detect varied levels of change with expected levels of confidence.
2. Protocols used to monitor annual productivity of riverine birds need to be evaluated to determine if current methods allow determination of age with sufficient certainty and sample sizes to detect changes in age ratios for these species.
3. Population size for target species need to be estimated to help establish target population levels for up to 15 years after initial implementation.

3.6.3 Sub-objective 6.3: Minimize impacts of riverine bird predation on fry and smolts

6.3.1 Adapt timing of hatchery release to alter distribution of avian predators and minimize predation on natural fry and smolts

Smolts and fry of various fish species comprise a large portion of the diets of some riverine birds. Common Mergansers, in particular, can consume large numbers of salmonid prey during the year (Stephenson and Fast 2005). If Common Mergansers concentrate near the Lewiston Hatchery during scheduled releases, the survival of hatchery and natural smolts and fry and, ultimately, escapement could be decreased. Observation of the distribution and abundance of Common Mergansers and other piscivorous birds in important spawning and juvenile habitats will provide insight into the scope of potential impacts on the salmonid populations.

HYPOTHESIS:

Predation by riverine birds on natural fry and smolts is significant and could be minimized by adapting the timing of hatchery releases to avoid concentrating these birds in the active spawning area near Lewiston Dam.

Proposed assessment strategy and rationale

We will monitor abundance, distribution, and foraging behavior of riverine birds before, during, and after the release of hatchery fish into the river. By comparing changes in the birds' distribution and foraging behavior to migration of the released fish, we could begin to assess the potential importance of impacts to the salmonid populations.

Proposed performance measures and analyses

Key performance measures

- ***Abundance*** of piscivorous riverine bird species.
- ***Distribution*** of piscivorous riverine bird species.

Candidate performance measures

- ***Foraging behavior*** of piscivorous riverine bird species.

Additional performance measures may be identified for this sub-objective in subsequent RFPs that specify the details of required assessments.

Integration of performance measures with performance measures in other disciplines

Information about riverine bird abundance and foraging behaviors will be integrated with data for number and size of fish released from the hatchery. Data including release dates, natural spawning activity, post-release movements, and emergence of fry in the river reach will also be incorporated into analyses.

Expected response

Although some behavioral responses of riverine birds would be expected (e.g., change in distribution and foraging behavior in response to hatchery releases), the broader population responses cannot be anticipated at this time. Preliminary data and analysis would be needed to determine the scope of any relationship or impacts.

Analysis

Analysis incorporating changes in spatial distribution of the birds and fish before and after hatchery releases would be conducted following data collection. Bird foraging activity and success rates during these time periods could be analyzed.

Proposed space and time frame

Reach scale

Distribution, abundance and behavior of piscivorous riverine bird species will be monitored from the Lewiston Dam to Old Lewiston Bridge. Monitoring periodically over a one year period will likely provide insights into the potential impacts and need for further monitoring and analysis.

System scale

Monitoring and analyses will take place at the reach scale, but impacts could have system scale consequences.

Priority issues to address

No priority issues relating to this sub-objective have yet been identified, beyond what is currently described for the proposed assessment strategy.

3.6.4 Sub-objective 6.4: Increase population size, survival, distribution, and recruitment success of Foothill Yellow-legged Frogs (FYLF)

6.4.1 Increase population size, survival, distribution, and recruitment success of Foothill Yellow-legged Frogs

6.4.2 Increase quality and quantity of breeding and rearing habitat for Foothill Yellow-legged Frogs

The Foothill Yellow-legged Frog (FYLF) is a State Species of Special Concern (Jennings and Hayes 1994), with habitat alteration being the primary threat. Northern California is a stronghold for remaining populations, but populations are still threatened by dam operations, even in remote regions. In the Program area, FYLF have been negatively impacted by dam operations (Lind *et al.* 1996). Alteration of the hydrograph since damming has allowed encroachment of vegetation on breeding sites (Evans 1980; Wilson *et al.* 1991), reducing habitat quality for these river-breeding frogs; over the decades since dam construction, populations in the Program area have been drastically reduced. Unnatural timing, magnitude, and duration of flows (hydrograph shape) have disrupted the reproductive effort of this species in most years since damming (Lind *et al.* 1996). Source populations to seed recovery still exist in major tributaries and Foothill Yellow-legged Frog populations are expected to recover following implementation of mechanical site manipulations, coupled with naturalization of the hydrograph (i.e., timing, magnitude, and duration of managed flows mimicking natural conditions). This species is likely to benefit by establishment of a sinuous alluvial channel with dynamic point bar features available for use during breeding season (late spring) if physical rehabilitation is coupled with naturalization of the hydrograph.

HYPOTHESIS:

Program actions will: 1) enhance quantity and quality of habitat, and 2) increase population size, distribution, and recruitment for FYLF.

Proposed assessment strategy and rationale

Habitat for FYLF will be quantified by habitat mapping. FYLF population size will be assessed by seasonal surveys, or monitoring, of multiple life stages at treatment and control sites for evaluation both of localized, short-term response and of long-term response throughout the Program area. Treatment and control sites will be compared to evaluated FYLF reproductive output and/or reproductive success (recruitment) at site scales.

Proposed performance measures and analyses

Key performance measures

- ***Breeding habitat*** of FYLF.
- ***Adult population size*** of FYLF.
- ***Reproductive output*** and/or ***reproductive success (recruitment)*** of FYLF.
- ***Temporal and spatial temperature heterogeneity.***

Candidate performance measures

- ***Breeding phenology*** of FYLF.
- ***Time and size of metamorphosis*** of FYLF.

Integration of performance measures with performance measures in other disciplines

Analyses will integrate FYLF measures with flow timing, release hydrographs, the amount and location of breeding habitat, water temperature, prey and predator abundance (if available). These performance measures will utilize measurements from the physical and riparian disciplines to assess changes in FYLF habitat and populations relative to rehabilitation efforts.

Expected response

At the rehabilitation site scale, an immediate increase in FYLF habitat quantity is expected where riparian berms are mechanically removed and graded, and habitat quality is expected to improve system-wide with subsequent high flow events. At the system scale, habitat quantity and quality are expected to continue to increase over time as Program management actions revive the river’s dynamic alluvial nature. At least a 10-fold increase in reproductive output is expected. This would bring the mainstem FYLF reproductive output to within an order of magnitude of that seen on adjacent unregulated tributaries.

Analysis

Habitat for FYLF during the breeding and rearing season will be assessed by measures of relative change in habitat area and spatial arrangement using detailed habitat mapping relative to the flow schedule (hydrograph, including timing, duration, and magnitude).

Seasonal (spring and/or summer) monitoring of FYLF egg masses, tadpoles and adults at rehabilitation and control sites, and throughout the Program area will be used to monitor changes in abundance and recruitment using a "Before-after Control-impact" (BACI) design (Stewart-Oaten *et al.* 1986).

Proposed space and time frame

Population response time to habitat recovery is contingent upon proximity to FYLF source populations, water-year type, and timing, magnitude, and duration of the spring hydrograph.

Site scale

At the rehabilitation site scale, an immediate increase in habitat quantity is expected where riparian berms are mechanically removed and graded. Habitat quality is expected to improve following the first high flow event at the site. Habitat quantity and quality are expected to continue to increase over time as rehabilitation actions revive the river's dynamic alluvial nature. A rapid response, which may vary from 1 to 5 years, is expected at habitat created near tributaries with a current population of frogs. The response may be delayed at sites more distant from source populations, such as upstream of Indian Creek where source populations are scarce.

System scale

We expect the time for a detectable response by FYLF populations over the Program area to be 5 to 10 years.

Priority issues to address

Technical issues still to be resolved:

1. Power analyses on current and historical herpetofauna data are necessary to determine the duration and intensity of monitoring needed to detect varied levels of change in populations with expected levels of confidence.
2. Determining whether dam releases could be synchronized with FYLF breeding chronology to improve reproductive success.

3.6.5 Sub-objective 6.5: Increase population size, survival, distribution, and recruitment success of Western Pond Turtle (WPT)

- 6.5.1 Increase population size, survival, distribution, and recruitment success of Western Pond Turtles
- 6.5.2 Increase structural and thermal diversity of aquatic habitats used by various age classes of Western Pond Turtles
- 6.5.3 Increase recruitment of younger age classes of Western Pond Turtles

The Western Pond Turtle (WPT) is a State Species of Special Concern (Jennings and Hayes 1994), with habitat alteration being the primary threat. While the species does occupy a wide variety of habitats across its range, it has suffered declines in many regions. These are long-lived, resident animals (not migratory or anadromous); for them to persist in an area, the specific habitat features used by each life stage must be present (Reese and Welsh 1997, 1998b). There has been a reduction in area of suitable rearing habitat in the Program area since damming, resulting in an adult-skewed demographic in WPT populations (Reese and Welsh 1998a). By increasing the diversity of aquatic habitats available to various life stages (including thermal diversity), fisheries recovery efforts may improve conditions for WPT populations, followed by a system-wide response (increased recruitment and survival). Thermal impacts from hypolimnetic reservoir releases may also have long-term population impacts on WPT populations. Insights gained in this investigation of thermal effects can inform fisheries sciences and may help guide future management actions.

HYPOTHESES:

A. Increasing aquatic and terrestrial habitat diversity (including thermal diversity resulting from increased channel complexity) will increase turtle survivorship.
B. Increased diversity of aquatic and terrestrial habitats will increase recruitment of turtles.

Proposed assessment strategy and rationale

Structural and thermal complexity of WPT habitat pre- and post-implementation will be assessed from habitat mapping and in-stream temperature monitors, and compared to relative abundance of WPT at the site scale. We will assess population demographic structure and survivorship through trends measured from turtle surveys that include capture/mark-recapture and population estimation. These estimates will be used to formulate a goal for population size for WPT on the mainstem.

Proposed performance measures and analyses

Key performance measures

- ***Habitat diversity and complexity***
- ***WPT demographic structure***
- ***WPT survivorship***
- ***Temporal and spatial temperature heterogeneity***

Candidate performance measures

- ***Growth rate and fecundity***

Other performance measures may be determined in subsequent RFPs that specify the details of required assessments.

Integration of performance measures with performance measures in other disciplines

Turtle demographic structure and survivorship will be integrated for analyses with aquatic habitat mapping, and measures of soil conditions and floodplain vegetation in terrestrial habitats. Habitat measures will be obtained from geomorphic, riparian, and fish habitat maps; temperature loggers, and site visits. Temperature measurements can be integrated with the work on temperature heterogeneity described in Section 3.2.2.

Expected response

Structural and thermal habitat complexity is expected to increase as rehabilitation actions are implemented. We also expect the proportion of younger turtles within the population to increase with increased channel complexity (including side channels), which provides cover from predators, increased access to prey, and increased diversity of water temperatures. Survivorship of adults and younger age turtles should increase with increasing spatial and temporal habitat complexity.

Analysis

Relative changes in aquatic habitat diversity (structural and thermal) for WPTs will be assessed through aquatic habitat mapping for comparison to habitat conditions existing prior to implementation of Program actions. Terrestrial nesting and over-wintering habitat at rehabilitation sites will be assessed through mapping of slope and soil conditions and floodplain vegetation, and may be used to guide and evaluate potential site designs.

Biotic response to habitat changes will be assessed. Changes in habitat characteristics related to structural and temporal diversity will be analyzed in relation to turtle performance measures.

The abundance, distribution, and age ratio of WPTs, monitored within selected reaches, will be used to assess demographic changes related to Program management actions. Comparison with these population parameters on an unregulated tributary (BACI design) will provide insights into understanding the causes of observed changes and how they may relate to management actions.

Proposed space and time frame

Habitat and population responses will initially occur at the site scale, with more critical responses ultimately occurring at reach and system levels. Turtles are long-lived animals which rely on knowledge of their home area for survival. Major habitat modifications may result in lower survival following construction until the turtle become familiar with the new habitat arrangement. There is also danger of direct mortality during site modification activities.

Site scale

Habitat diversity is expected to increase immediately following mechanical rehabilitation of treatment sites. Monitoring during the early phases of implementation is key to understanding the immediate response of turtles to habitat changes and for testing hypotheses for adaptive management input, but long-term monitoring is needed to assess a population level response for these long-lived residents.

Reach scale

Initially, at the reach scale, habitat diversity is expected to increase following mechanical rehabilitation at treatment sites. Subsequent ROD flows are expected to continue to increase habitat diversity system wide over the decades. After an initial acclimation period following construction, we expect localized increases in turtle survivorship in response to increased habitat diversity and complexity, with trends being detectable following a period of several years to decades after implementation.

Changes in the age ratio of juveniles to adult WPTs, which may represent increased recruitment, are expected to be detectable within 10 years at selected treatment reaches, and eventually over the entire Program area, as natural river processes return.

System scale

ROD flows are expected to continue to increase and maintain habitat diversity system wide, as natural river processes return. Because WPTs are currently affected by a suite of post-dam impacts, increased survivorship of turtles in response to physical rehabilitation may not be immediate. The expected time to detect a response within identified reaches or at the Program area scale could exceed 10 years.

In the long-term, at the system scale, we expect population density and demographic structure to approach that of control populations on the South Fork Trinity River.

Priority issues to address

Technical issues still to be resolved:

1. Power analyses on current and historical herpetofauna data are necessary to determine duration and intensity of monitoring needed to detect varied levels of change with expected levels of confidence.
2. Identifying the cause of reduced body size of post-dam WPTs would assist with adaptive management recommendations for this and other species (is it related to a lack of thermal diversity, timing of hydrograph, prey availability, other?).

3.6.6 Sub-objective 6.6: Minimize adverse impacts to additional native riparian or aquatic associated wildlife from Program activities. Focus on wildlife species associated with a healthy river ecosystem, not necessarily all species

6.6.1 Discourage invasive species

Many species use the riparian and aquatic habitats in the Program area. Several target species or species groups have been selected for monitoring (see above for selection rationale). However, as implementation progresses, additional wildlife species, including non-natives, may emerge as suitable or essential for measuring Program success or addressing evolving compliance issues. Data are currently being collected on some non-target wildlife species observed during target species surveys. To accommodate later additions to the wildlife monitoring strategy, this sub-objective was purposely left open-ended. New species can be added into the IAP as we learn more about the functioning of the system and the array of potential wildlife responses to rehabilitation.

HYPOTHESIS:

Program actions create or increase aquatic or terrestrial habitats that *can* promote invasion or expansion of invasive wildlife species that are potentially detrimental to fish, riverine or riparian associates.

Proposed assessment strategy and rationale

Habitat and population response of current (e.g., Bullfrog) and future (e.g., New Zealand Mudsnail) invasive or yet to be identified target wildlife species of concern to the Program should be measured. As an example, relative changes in aquatic habitat suitability for and utilization by Bullfrogs could be assessed through habitat mapping and population monitoring. If additional invasive species become a concern, appropriate monitoring protocols could be initiated.

Proposed performance measures and analyses

Key performance measures

- ***Relative changes in aquatic habitat suitability for and utilization by Bullfrogs*** (as an example)

Candidate performance measures

No additional performance measures have been identified for this sub-objective, but would be developed as deemed necessary by Program partners.

Integration of performance measures with performance measures in other disciplines

Some of the wildlife assessments benefit from integration with other subsystems to obtain riverine and riparian habitat measures for identifying changes in instream and riparian habitat distribution, quantity, diversity, and structure. This interdependence with other disciplines for baseline and trend information requires integration of sampling scale (temporal and spatial frames) for geomorphology, vegetation, fish rearing habitat, and other data.

Ideally, the design for site level fish habitat and juvenile fish density sampling would integrate (overlap) with wildlife density sampling locations. Once fish sampling sites are selected, wildlife sampling locations could be adjusted or established to maximize the value of collected data.

Expected response

The response of Bullfrogs to rehabilitation sites will depend on resulting habitat configuration. Sites with an increase in permanent still water with aquatic vegetation could expect an increase in this detrimental invasive. Sites where permanent still water is converted to seasonal wetlands are expected to experience a decline in Bullfrogs. A population level response may take 2 to 5 years to be detectable. Additional responses cannot be anticipated at this point, as no additional target wildlife species or invasive species of concern have yet been identified by Program partners for assessments.

Analysis

The approach of using predictive modeling tools for assessing wildlife species of current Program concern could be adapted to link the amount and configuration of habitat with population parameters for other species.

Proposed space and time frame

Identifying species and objectives for assessing non-target, native wildlife species could be defined within the first 2 years of implementation. Once objectives are determined, selecting or developing and testing methods could take 2 to 5 years. The space or time frame for response will depend on the species and sampling protocols selected.

Site scale

Some potential future assessments could be undertaken at the site scale, but currently this is unknown.

Reach scale

Some potential future assessments could be undertaken at the reach scale, but currently this is unknown.

System scale

Some potential future assessments could be undertaken at the system scale, but currently this is unknown.

Priority issues to address

Technical issues still to be resolved:

1. The mechanisms by which invasive wildlife species might impact native biota need to be identified.

Policy issues still to be resolved:

1. Objectives related to non-target, native wildlife and invasive species need to be defined.

4. Sampling framework for the program area

4.1 Introduction

4.1.1 Purpose of Chapter 4

The purpose of Chapter 4 is twofold. First, it provides a foundational and integrated sampling design for IAP assessments and future RFPs. Second, it synthesizes key sampling design concepts from past TRRP documents, including the IMEP (TRRP, ESSA, NSR 2006), SAB reviews (SAB 2006a, 2006b) and notes from various workshops (including the December 2004 meeting in Turtle Bay on fish monitoring, and the three IAP workshops held in 2008[18]). To evaluate sampling design alternatives we reviewed assessment methods in detail (see Appendix L), creating some overlap in the priority issues identified in Chapter 3 and Chapter 4. Priorities identified in Appendix L and Chapter 4 are, however, intended to be more specific to actual on-the-ground monitoring efforts.

Within the context of this chapter, the terms, "foundational and integrated" and "sampling design" have the following meanings:

a. *Foundational and integrated:* The Chapter 4 sampling design must provide a foundation for the *major* assessments that are required at site, reach and system scales to fulfill the two purposes of the IAP (i.e., feedback to revise management actions, judging progress towards TRRP goals and subsystem objectives). As RFPs and proposals are developed for particular component assessments, they all need to build upon the sampling design foundation established in Chapter 4. The sampling design also needs to support the integration of assessments, as described in Sections 2.0 and 3.0 of the IAP, and more specifically in the Looking Outward Matrix[19] developed at Workshop 1. That is, data required at a specific spatial/temporal scale for Assessment A can be provided by Assessment B (e.g., co-locating sites, both generating reach- or system-scale estimates that can be matched up, reliably extracting information from a larger scale map that is pertinent to a smaller scale).

b. *Sampling design:* where and when sampling should occur. This needs to be driven by the *evaluation design* (i.e., how data will be analyzed) for assessments at site, reach and system scales. The *sampling* and *evaluation designs* will ultimately need to be linked to the *response design* (monitoring protocols at specific locations and times).

    i. The *evaluation design* has not been described in detail for most assessments, though various possible methods have been outlined in Chapter 3 of the IAP (Assessment Strategy and Analysis sections), as well as in the IMEP (TRRP, ESSA, NSR 2006), and other creative ideas may emerge in response to RFPs. Therefore, the sampling design in Chapter 4 should be robust enough to support the types of analyses/assessments we know about or can imagine now, and trust that this will be sufficient to support other types of analyses/assessments that we can't imagine now but could build on the collected data.

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[18] Fish to Habitat (Jan. 15-18, 2008); Habitat to Physical (April 1-4, 2008); Sampling Design and Monitoring Assessments (July 22-23).

[19] The Looking Outward Matrix describes the inputs required from each domain to complete assessments in other domains (see Appendix F).

ii. In some cases the *response design* has been largely but not completely determined (e.g., at Workshop 2 the group selected the Suitability Based Habitat Mapping protocol to assess the area of habitat for juvenile salmonids, but still need to figure out exactly how that can be coupled to 2-D modeling for other flows and other species' habitat suitability criteria). In other cases, the response design can be developed in response to RFPs (e.g., whether fry abundance should be monitored by fyke nets, electroshocking, snorkeling, or some other method).

4.1.2 Study design principles

There are many possible ways in which to approach an environmental field study (see Eberhardt and Thomas 1991 for an overview). Choosing the right approach requires careful consideration of: the study objectives, the degree of control required, the desired level of inference, the effect size of interest, and the tradeoffs surrounding issues of cost and feasibility of the various approaches. Cochran (1977) describes two broad types of survey: *descriptive* and *analytical*. The objective of *descriptive* surveys is to obtain information about general categories of objects; whereas, analytical surveys are used to make comparisons among groups within the target population in order to test hypotheses. Hurlbert (1984) categorizes studies as either: *manipulative experiments* or *mensurative experiments*, where *manipulative* studies are those where the investigator has control over the factors in the study and *mensurative* studies are those where only passive observation is used. Eberhardt and Thomas (1991) include replication as a key requirement for improving the strength of inference and describe eight categories of environmental studies that range from the preferred approach of a controlled experiment with replication to a simple descriptive sampling approach. Schwarz (2007: Chapter 3) provides an excellent summary of the tradeoffs between different study approaches ranging from descriptive surveys to designed experiments; an excerpt from this document is included here as Appendix K. In summary, the degree of control the investigator has on a study affects the ability to show causation, while the ability to make inference to other sampling units depends on random selection of samples or assignment of treatments.[20]

The monitoring design must generate sufficiently precise estimates to detect effects of interest. However, exceeding the necessary level of precision is a waste of resources, as is failing to achieve it. Increased precision can be achieved by minimizing sources of error including: measurement error[21], model error[22], and sampling error[23]. Even if all of these sources of error are removed, natural stochastic variability will remain. For example, even if we knew with absolute certainty how many smolts emigrate annually from the Trinity River, the number would still vary year to year. The larger the natural variability the more time it will take to detect a trend. Understanding the sources of total study error for each assessment will be important in helping to focus the study design efforts (e.g., should more effort be put into minimizing sampling error or measurement error?). Typically as sampling error is minimized, the measurement error increases and vice versa (if we take more samples we can't afford to measure them as closely). Completing a census is often very expensive and time consuming and may not improve the estimates substantially beyond a well designed sample. "It is usually much better to take a high-quality sample and allocate resources elsewhere, for instance, by being more careful in collecting or recording data, doing

[20] This introductory review of study approaches was adapted from Weickowski *et al.* (2008).
[21] ***Measurement error*** is influenced by the imperfections in the measurement and analysis system. Random and systematic error are introduced in the measurement process during physical sample collection, sample handling, sample preparation, sample analysis, data reduction, transmission and storage (EPA 2000).
[22] ***Model error***, occurs any time we make assumptions about the relationship between variables (e.g., if we assume that each redd observed represents one female spawner).
[23] ***Sampling error*** is simply the error resulting from only examining a portion of the total population (Cochran 1977; Lohr 1999; Thompson 2002), if a census of the population is taken then there is no sampling error.

follow-up studies, or measuring more variables" (Lohr 1999). The frequency of sampling affects both precision and cost. When the natural variability in the measured attribute is high, it is important to sample more frequently (e.g., smolt emigration), otherwise year effects will be confounded with the response. For example, if year 1 is a dry year and year 5 is a wet year, would an observed increase in the attribute be the result of an increasing trend over time in response to the management actions, or could it simply be due to the contrast between dry and wet years? Likewise if the attribute changes slowly over time and doesn't have high year-to-year variability (e.g., bank length), then it may be more cost effective to reduce the frequency of sampling. It should also be recognized that, in terms of budgeting and maintaining trained field technicians, there are some obvious advantages to having consistent annual monitoring. The level of required precision is that which gives decision makers data that provide an acceptable level of confidence in making decisions. Determining the required level of precision requires specifying a decision rule (e.g., if…then… statement) and tolerable limits on decision errors (performance criteria). There is then some iteration required between managers, scientists and statisticians to converge on designs which have sufficient precision to meet the performance criteria for decisions at acceptable cost. The USEPA provides substantial guidance for determining the required level of precision for a study as part of their Data Quality Objectives (DQO) process (USEPA 2000). A brief summary of this material is provided here in Appendix J.

TRRP assessments may provide feedback to management actions and/or evaluate progress towards goals (Figure 1.4, Table 4.2). Depending on the scale of the assessment, manipulative experiments may be possible (e.g., evaluating the change in distribution or behavior of riverine birds under different hatchery release strategies). However, in many cases it will not be possible to control all the factors of interest (e.g., water year, river mile, radius of curvature, tributary influence, etc.). The optimal method to deal with this limitation is to rely on replication of treatments which cannot be controlled in an analytical survey framework (see Appendix K).

Any study (descriptive or manipulative) needs to develop a strategy for collecting the data. The sampling design addresses 'where' and 'when' samples will be taken. The first step in selecting a sample is identifying the target population which corresponds to the study objective. The target population refers to the complete set of individuals or units about which we want to make inferences (Lohr 1999; Elzinga *et al.* 2001). In order to make inferences about the entire target population, all individuals within the target population must have some chance of being selected in the sample. The sampled population is the collection of all possible observation units that might have been chosen in a sample (Lohr 1999). Probabilistic sampling refers to designs in which each sampling unit within the sampling frame has a known and non-zero probability of being selected (see Table 4.1**Table 4.1**).

Table 4.1. Definitions required to make the notion of a good sample more precise.

Term	Definition
Observation unit	An object on which a measurement is taken. **Example**: The observation unit of interest is natural juvenile Chinook salmon.
Sampling unit	The unit we actually sample. Sampling units provide the basis for analysis. **Example**: Our observation unit is natural juvenile Chinook salmon, but we do not have a list of all individual fish in the target population. Instead, stream reaches serve as the sampling units.
Target population	The complete set of individuals or units about which we want to calculate an estimate and make inferences. **Example**: The target population we are interested in is natural juvenile Chinook salmon reared exclusively in the mainstem.
Sample frame	The list of sampling units that are potential members of the sample. Sample frames are almost always not exact representations of the target population. Sample frames may not include some target population elements or they may include some non-target population elements resulting in under and over coverage, respectively. **Example**: The sample frame consists of a list of all the stream reaches in the Trinity River Program Area. Because hatchery juvenile Chinook salmon and natural juvenile Chinook salmon reared in tributaries are found in the Trinity River Program Area, there are some non-target population elements in the sample frame. If they are not identified as being non-target population elements, their inclusion as observation units within a sample unit could lead to overcoverage.
Sample	A subset of the sample frame, the sampling units selected to form the sample. **Example:** The sample consists of the stream reaches randomly selected from the sample frame
Sampled population	The collection of all possible observation units that might have been chosen in a sample. It excludes portions of the target population within the sample frame that could not be sampled due to access problems, lost samples, or other reasons a sample could not be sampled. **Example**: Let's say the Trinity Program Area is divided into 50 reaches, of which 5 cannot be accessed for various reasons. The sampled population therefore only consists of the fish found in the 45 reaches that could be sampled.

A simple random sample (SRS) is the most basic probabilistic sampling strategy, where all sampling units have an equal chance of being selected (Cochran 1977). A SRS is always valid but may not always be very efficient. Extensive research has been done in sampling design to determine how we can improve our efficiency by taking advantage of additional information that may exist about the target population. This research has resulted in the development of many sampling strategies including: systematic random sampling (SysRS), stratification, adaptive sampling, generalized random tessellation stratified (GRTS), cluster sampling, and multi-stage sampling. Stratification is a tool which can be applied to any of these approaches to select sampling units. Stratification may result in a more efficient design when there is less variability within strata than between strata (Cochran 1977; Lohr 1999). Stratification may also be useful if estimates for individual strata are desired as well as for the entire target population. Literature on statistical methods is extensive and is available to assist in the development of a sampling design including several excellent texts on the subject: Cochran 1977, Lohr 1999, and Thompson 2002.

Judgment samples are selected subjectively, making it impossible to enumerate the probability of any given sampling unit being included in the sample. Sites may be chosen according to some prior belief about where individuals should be found, they may be chosen arbitrarily to be representative of the target population, or they may be chosen just for convenience. So called 'representative reaches' in stream surveys are an example of a judgment sample; without a census of the target population (e.g., the entire stream), it is impossible to be sure that you have chosen a representative sample reach. Making inference from judgment samples can result in extremely biased estimates. For example, there have been some famous miscalculations in predicting election results using judgment based samples (Edwards 1998).[24]

[24] This review of judgement based samples was adapted from Province of British Columbia (2008).

Sampling designs spanning multiple years may monitor the same set of sites each year or they may re-randomize the site selection each year. There are advantages and disadvantages to each approach and there are conflicting opinions about the best approach. McDonald (2003) provides a summary of the different strategies and the rotating panel designs which have evolved as a compromise. Multiple variations of rotating panel designs exist. Differences between designs include the number of sites visited each year and the pattern by which sites are re-visited (McDonald 2003).

In Appendix G, we list and describe the information we believe is necessary to develop a sampling design for the TRRP assessments. Other summaries of the steps involved in study design can be found in: Cochran 1977, Elzinga *et al.* 2001, Yoccoz 2001, and Vesely *et al.* 2006. The number and organization of these steps varies depending on the source, but generally they are similar and should all provide a reasonable strategy for tackling a study design.

4.2 Sampling framework

In this section we present an overarching sampling framework (see Figure 4.1) that will act as the foundation for integrating assessments across the 40 mile study area of the Trinity River. This sampling framework should allow for comparable system-wide estimates generated using alternative approaches (e.g., census or sample) so long as the critical principles for sample design described in Section 4.1.2 are followed. Within this framework, ongoing assessments with established protocols will be maintained so long as they provide information at the right scale and the design is sound. Where appropriate, new assessments should use the proposed (GRTS panel) sample design described in Section 4.4. This general design for the Trinity River study area should be compatible with the majority of sampling needs for the key assessments identified to date. However, we are cognizant that one sampling design will not fit all needs, and that some assessments (e.g., some processed based studies, or egg mass survival where the location of egg masses drives the sampling design) will require a unique sampling design. Consequently, the sampling framework allows assessments to fall into one of five different categories: 1) established valid[25] protocols (census, sample, and model based); 2) census; 3) GRTS panel design (Section 4.4); 4) alternative sampling design (i.e., question requires a unique design); and 5) experiment or process based study. The intention behind creating this sampling framework and a recommended sampling design is to provide an accepted base structure around which RFPs can be developed and coordinated, and through which data can be combined across disciplines to elucidate cause-effect relations at a system scale.

[25] Within the context of this chapter, the term "valid" refers to whether an established protocol produces statistically defensible estimates at the scale required by all assessments, including itself. It is important to note that at this point in time the definition of valid/adequate does not include precision because this has not yet been defined in many cases.

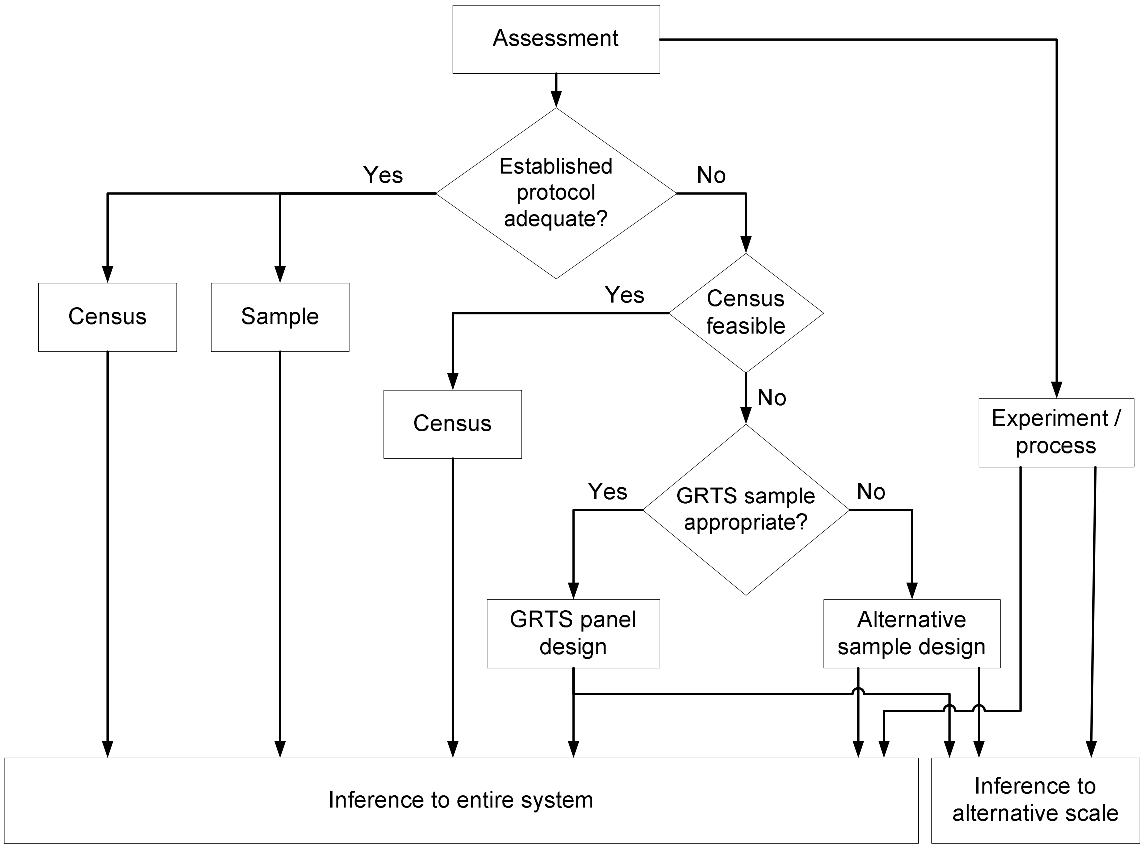

Figure 4.1. Flow chart of the sampling framework. This illustrates alternative methods/pathways of arriving at a system-wide estimate as well as for alternative scales.

Assessments with existing sampling designs and accepted protocols are documented in Appendix L and Section 4.5. As previously stated, the intention is to continue using these established approaches to provide data continuity. However, minor modifications to designs or associated protocols may be recommended where it is felt that existing assessments could be strengthened to improve inference or efficiency, and as a result better inform management questions and progress towards the goals of the Program.

Where practical, we propose the use of a rotating panel, spatially balanced sampling design as a sophisticated and flexible approach that can simultaneously address many assessments from various disciplines (described in Section 4.4). The proposed sampling design has three strengths. First, it enables monitoring of both system-wide status estimates and trends through time for different performance measures throughout the river, as well as the ability to assess site-scale evolution. The design will allow the Program to determine how the system as a whole responds to management actions and rehabilitation efforts over time. It will be possible to conclude for example, whether the Program goal of increased numbers of juvenile Chinook salmon in the 40 mile stretch is being achieved as opposed to only knowing whether there are more juvenile Chinook salmon at specific sampled sites. Additionally, information collected at the site scale can be used to inform site level analyses and/or provide data required for SALMOD. Second, the proposed sampling design will capture spatial contrasts between sites (e.g., information on upstream/downstream, different strata, etc.). Last, the sampling design, by virtue of the fact that assessments will be carried out at co-located sites, will facilitate evaluation of specific cause-effect relationships across disciplines (i.e., how multiple variables relate to each other under different conditions).

The series of questions described in Appendix G was used to solicit the information required to determine sampling needs for different assessments (e.g., census approach or sampling), which is summarized in Appendix L. Working through the responses to the different questions allowed identification of commonalities between assessments and refinement of the general sampling design. Additionally, the information collected through these questions provides the details necessary to develop protocols within the overarching sampling framework. For proposed assessments with no existing design, we recommend reviewing the 'information needed to develop a sampling design' (Appendix G) to determine whether the proposed rotating panel approach is feasible. Similarly, we recommend that any remaining assessments not yet discussed at length in Section 4.5 use this list of questions to identify a preferred sampling approach.

4.3 Methods

The recommended sampling design proposed in Section 4.4, emerged after considerable consultation with IAP participants and outside experts; the results of these conversations are contained in Appendix L. We engaged in conversations with IAP writing team leads, TRRP staff and Program partners, and statistical experts in GRTS and rotating panel designs (i.e., Phil Larsen, Pacific States Marine Fisheries Commission). Additionally, we reviewed GRTS and rotating panel design methodologies. We also reviewed various Program documents including: Chapter 3 of this document; outlines developed to address the questions in Appendix G; IMEP (TRRP, ESSA, NSR 2006); SAB comments (SAB 2006a, 2006b); protocol descriptions; and reports from California Department of Fish and Game (CDFG), Hoopa Valley Tribe (HVT), Yurok Tribe (YT), and U.S. Fish and Wildlife Service (USFWS).

Based on our review of the documents listed above we created a table containing all the identified assessments (see Appendix H), as well as our initial assessment of their relative level of priority (a process that will continue iteratively with Program partners). To the extent possible given the short time frame, we first summarized the status quo monitoring methods for each assessment, the uncertainties in these methods, and the remaining issues to be resolved (Appendix L). The highest priority assessments were then used to inform the creation of a sampling design that we considered capable of integrating the majority of these assessments. As part of this process we compared various options for a sampling design that could be used by multiple assessments. In particular we explored the possibilities of using a combination of stratification with simple random sample (SRS), a systematic random sample (SysRS), or a generalized random tessellation stratified (GRTS) approach. A comparison of these three methods is available in Appendix I. Last, we considered how sites should be selected over time (permanent versus re-randomizing every year). For reasons described in Section 4.4, we ultimately chose to put forward a GRTS rotating panel based approach as our recommended sampling design for IAP assessments.

4.4 Recommended sampling design

The TRRP is interested in evaluating trends at both the system-wide scale and the site scale. The Program strategy is to restore and maintain fish and wildlife resources by restoring the processes that produce a healthy alluvial river ecosystem. Achieving this strategy will require testing or assessment of hypotheses around management actions (e.g., flow, gravel, and mechanical manipulations) to see if they contribute to the formation of a healthy alluvial river. Testing these hypotheses will require system-wide estimates over time. Additionally, there is a need to understand how individual sites evolve over time; consequently, it is also important to re-visit sites periodically to see how specific sites change (re-visit frequency will depend on the question being asked). We recommend a rotating panel approach as the best strategy for obtaining system-wide estimates of trend while still allowing for assessment of site-scale evolution (see Section 4.1.2). A rotating panel approach eventually provides greater power to detect trends at the system-wide scale as many more sites will be monitored over the course of the program (i.e., the sample size is greater) than if a fixed set of permanent sites was monitored. Depending on the relative importance of the two scales of hypotheses, we can allocate more or less of the sample each year to the re-visit sites. This approach is being used by Oregon Department of Fish and Wildlife (ODFW) to assess coho salmon populations in the lower Columbia (Stevens 2002); for bull trout monitoring in the Lewis, WA and the John-Day (OR) sub-basins (USFWS 2008); and for both habitat and biological performance measures across the U.S. as part of the EMAP program (Kaufmann *et al.* 1999); other examples are given in Urquhart and Kincaid (1999).

The *panel* in a rotating panel design is the ‘group of sampling units that are always sampled during the same sampling occasion or time period’ and the allocation of units to a panel is called the *membership design* (McDonald 2003). The membership design can be determined using any traditional method of selecting units from a target population such as: SRS, SysRS, stratified sampling etc. A SRS has generally been found to be less efficient for environmental data than a spatially balanced sample such as a SysRS or GRTS (Stevens and Olsen 2004; Stevens and Jensen 2007). This is intuitive if sites close to each other are more similar than sites far apart; consequently, sampling sites that are close together is ‘wasted effort’. SysRS have traditionally been used to address this problem and are a valid approach, but have their own set of limitations (e.g., variance estimates are impossible to make without strong assumptions or repeated sampling effort; if the resource is distributed regularly there is a risk of a biased estimate). An additional limitation of SysRS which is critical in the case of the Program is that it is difficult to change the sampling intensity within a systematic design. Adding or dropping sites results in a sample that is no longer evenly spread across the target population. Therefore, within a SysRS design it would be difficult to maintain the flexibility required to allow for different assessments to be completed at different intensities, as well as to allow adjustments in the sample size over time in response to learning. A GRTS design generates sampling units that are spatially balanced while accommodating variable inclusion probabilities and the ability to adjust sample sizes (Stevens and Olsen 2004). A more detailed comparison of SRS, SysRS, and GRTS is provided in Appendix I. Using the GRTS approach it is possible to generate a list of sampling units which can be used for multiple assessments so that each assessment is nested within the next. For example, if there were three assessments (1, 2, and 3) which the Program would like to be able to compare at co-located sites but can only afford 50, 25, and 15 samples for each assessment, respectively, then assessment 1 could be completed at all 50 GRTS points. At the first 25 points, assessments 1 and 2 would be completed, and at the first 15 points assessments 1, 2, and 3 (Figure 4.2). The first 15 points would provide information on all three assessments, facilitating the ability to directly link between disciplines and evaluate x-y relationships. The sampled sites for each assessment are spatially balanced across the system (i.e., the first 15 are spatially balanced, as are the first 25, and all 50 points). Co-located assessment protocols carried out at a given site may vary in terms of their actual spatial extent or configuration, however each assessment utilizes the GRTS selected point for that site as a centering location around which to frame their respective sampling protocols (see Figure 4.3).

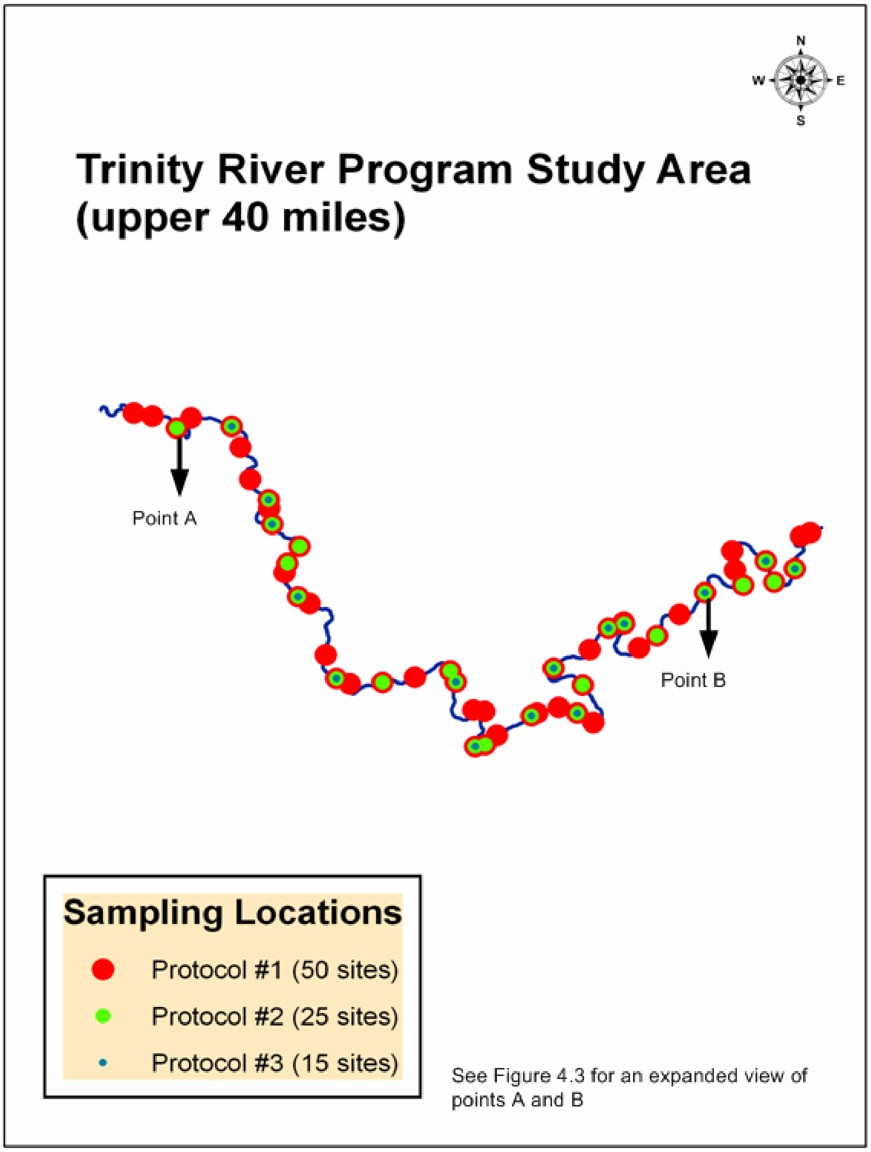

Figure 4.2. Nested set of hypothetical GRTS sample points integrated across three alternative assessment protocols. All three of the protocols are undertaken at 15 sites, two protocols are undertaken at another 10 sites (total of 25 sites), while only one protocol is undertaken at an additional 25 sites (total of 50 sites). All sites selected are part of spatially balanced designs used for each protocol.

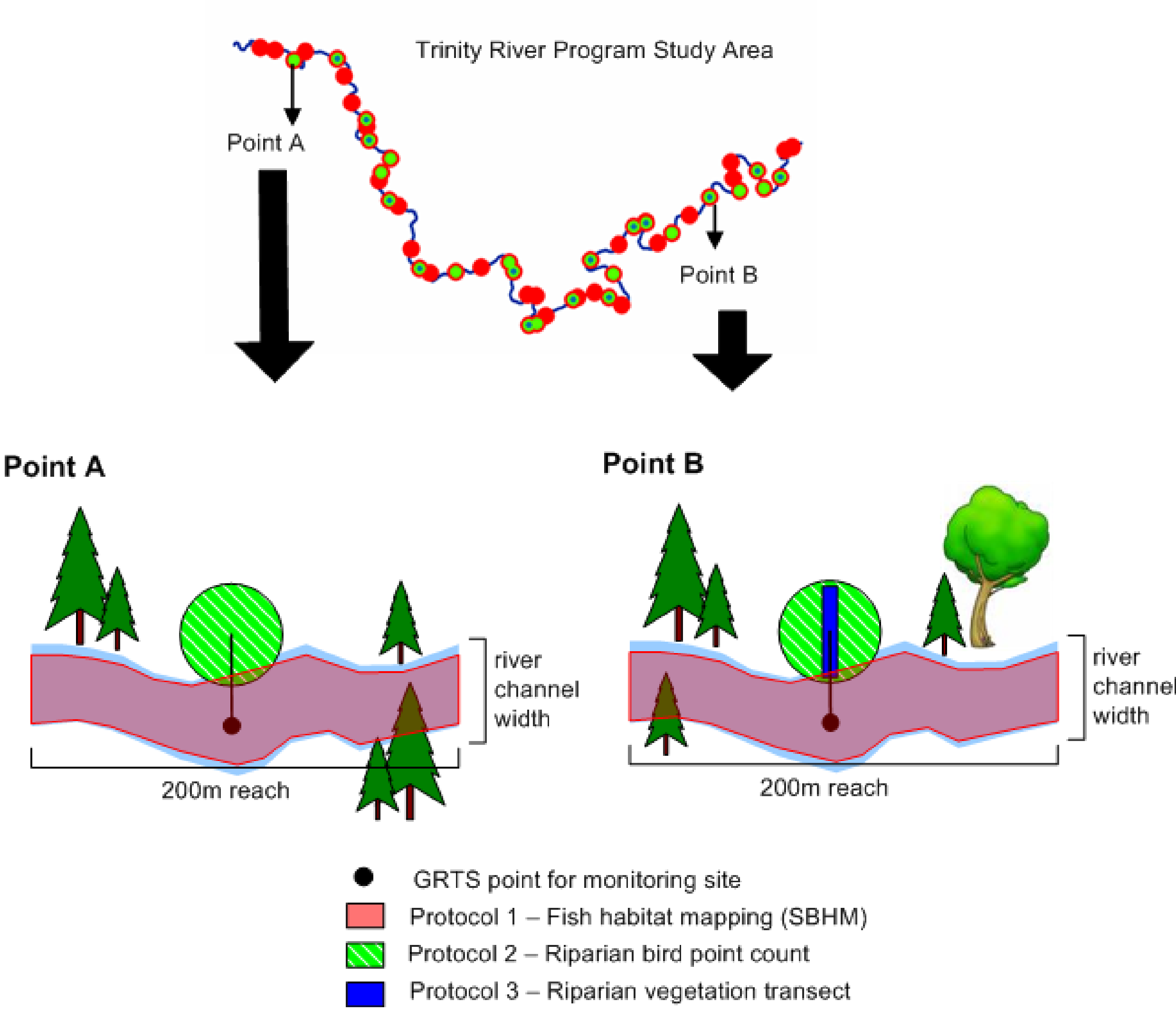

Figure 4.3. A hypothetical example of multiple assessments undertaken at integrated monitoring sites that have been selected through GRTS procedures (two assessments at Point A and three assessments at Point B). The spatial extent and configurations of individual assessments undertaken at a site will vary depending on the nature of the protocols employed; however a GRTS point located in the center of the stream channel can act as a centering point for all protocols. Each protocol would be executed in a standardized way at all sites where it is undertaken. For example, if Protocol 1 requires mapping of a total of 200m of stream channel, habitat sampling could be undertaken for 100m both upstream and downstream of the GRTS point. Protocol 2 could be a point count for riparian birds, where the count area is a 50m radius circle centered 40m upslope from the edge of the closest defined bank located perpendicular to the GRTS point. Protocol 3 could be a 50m riparian vegetation transect that begins at the point of defined stream bank perpendicular to the GRTS point.

Stratification is an additional sampling tool which can be incorporated within the GRTS design if necessary. As described in Section 4.1.2, stratification can result in improved sampling efficiency if the variability within strata is less than between strata. There are many possible stratification variables in the Trinity River (e.g., meso-habitat units; geomorphic units; radius of curvature; 6 geomorphic reaches (TRRP, ESSA, NSR 2006: Figure 3.4;); confined vs. unconfined; complex vs. simple; alluvial potential; upstream vs. downstream; rehabilitation site vs. non-rehabilitation site). Different stratification variables will be optimal for different assessments. Using a spatially balanced sampling design is another way to account for gradients in space (i.e., upstream versus downstream sites). Rather than trying to identify the optimal stratification variables for each assessment, we recommend starting with a very simple set of strata that we expect to be important for all assessments. These stratification variables can always be revised if the data suggest there is a need to do so. An advantage of the GRTS design is that it ensures that the full system is represented (i.e., spatially balanced within all strata). We are expecting to see changes as a result of the rehabilitation actions (flow, gravel, mechanical) in all assessments, and certain reaches are expected to change more than others as a result of these actions. In general, it may be more efficient to expend higher levels of effort in those reaches where there is greater potential for change (e.g., areas with greater alluvial potential (TRFE, USFWS and HVT 1999:230)).

The optimal allocation of sites to panels and pattern of re-visits is dependent on the assessment, the desired precision, and the variability in the data. The GRTS panel design will not be suitable for all assessments, but we believe it will be suitable for many of the assessments identified in the IAP (Appendix H) and will provide an effective and efficient sampling design. In Section 4.5 we describe the priority assessments. For each assessment we state whether a census is feasible, and if sampling is necessary we determine whether it can be addressed with this design or not.

4.5 Assessments

The following sections discuss the key assessments from each of the five domains (physical, riparian, adult and juvenile fish, fish habitat, and wildlife) in relation to the performance measure(s) and the protocol used to collection information for the assessment. The performance measure(s) and protocol(s) for a particular assessment are discussed individually.[26] Additionally, each assessment is grouped into one of five categories (Figure 4.1): 1) established protocol (census and sample); 2) census; 3) GRTS panel design; 4) alternative sampling design; and 5) experiment/process. [27] Protocols required for carrying out a specific assessment (i.e., informing a performance measure) are described as being either field-based (i.e., on-the-ground) or remotely sensed-based.

All assessments, including those not discussed but listed in Appendix H, serve one of two functions (sometimes both) with respect to the Program. Assessments are intended to provide either AEAM feedback or help to evaluate program goals or both (the purpose of each assessment is given in Appendix H). A summary of all the assessments with respect to their Program function, scale, type of design, and required frequency of assessment is given in Table 4.2. The most convenient way to get an overview of the Program's potential assessments is to examine Table 4.2 and Appendix H concurrently, cross-referencing the assessment codes (e.g., 4J = smolt outmigration monitoring).

[26] A short summary of each assessment can be found in Appendix H
[27] Appendix L identifies the assigned category from the sampling framework for each assessment.

Table 4.2. Summary of major assessments by spatial scale and required frequency of assessment. Assessment letter codes: A = adult fish; H = habitat; J = juvenile fish; P = physical; R = riparian; and W = wildlife. Highest priority assessments are in underlined bold type; medium priority assessments in simple bold type, lower priority assessments italicized. Required frequency of assessment is indicated by color coding: blue = information needed on a daily and/or seasonal basis, purple = information needed on an annual basis, red = information needed regularly but infrequently (approximately every 3-5 years), black = information needed in a year subsequent to one or more major channel changing flows or events. Assessments are described (with codes shown) in Appendix H.

Type of Assessment	IAP Component	System Wide			Reach		Site		
		Census	Sample	Model*	Census	Sample	Census	Sample	Non-Rep* or model†
Assessments Needed to Revise Specific Actions (e.g. flow, gravel, rehab sites)	Adult Fish:		*5A*, **8A**, **10A**						
	Juvenile Fish		*5J*					**1J**, *6J*	
	Wildlife:			*7W*				**1W**, *2W*, **10W**, **12W**, *15W*	*3W*
	Fish Habitat:		**2H**	**7H**, *12H*,		*11H*		**8H**, *10H*	**1H**, **3H**
	Riparian:		**3R**					**1R**	**4R**, **5R**
	Physical:		**2P**, **3P**, **4P** **6P**, **9P**, **11P**,	**5P**, **7P**, **8P**, **10P**, **11P**, **14P**			**9P**	**12P**	**12P**
Assessments Needed to Judge Progress Towards Goals	Adult Fish:	**1A**, *2A*, **3A**, **13A**, *14A*, *15A*	*4A*, ***9A***, **16A**, **17A**, **18A**, **19A**, *20A*, *21A*	**22A**, **23A**					
	Juvenile Fish	**4J**, **9J**	**2J**, **3J**, *7J*, *8J*, *10J*						
	Wildlife:	**6W**, **9W**, **13W**	**4W**, *5W*, **11W**, *14W*		*8W*, **13W**	**4W**, *5W*, *14W*			
	Fish Habitat:		**2H**, **4H**, **6H**	**2H**, *13H*	*5H*	*9H*		*10H*	**1H**
	Riparian:	**2R**							
	Physical:	**1P**	**15P**		**13P**			**16P**, **17P**	

* Non-rep = sites that are used to study cause-effect processes, but are not necessarily representative of larger spatial scales.
† Model = informing an existing predictive model (based on information from non-representative sites), or used to develop a new model (relying on information from other IAP assessments collected from census, sampling or non-representative sites).

4.5.1 Objective 1: Create and maintain spatially complex channel morphology

Physical habitat diversity and availability

Remotely sensed data, aerial photos and LIDAR in particular, are capable of generating many useful performance measures as described in Section 3.1.1. In addition to the collection of remotely sensed data, field monitoring needs to occur at a sample of sites to validate the remotely sensed performance measures. Transects from the entire Program Area may also be sampled to assess the variability in channel geometry and hydraulic parameters. Additional transects may be needed at a reduced set of sites to address specific process questions linking geomorphologic activity to flow, sediment inputs or riparian conditions. Performance measures to capture include topographic and planimetric variability at all spatial scales (bars, pools, alcoves, side channels, bank crenulations, etc.), variations in materials (substrates, debris, etc.), and variability in the composition and structure of near-channel vegetation. A number of performance measures are available to assess channel complexity. The most suitable choice of measures depends to a large degree on which aspects of the riverine landscape relate most directly to the habitat characteristics the Program intends to create.

Possible performance measures for key assessments related to **Sub-objective 1.1** (increase physical habitat diversity and availability) include:

- bank length, sinuosity (*Assessment 1P and 15P*);
- meander, thalweg crossings, radius of curvature, etc. (*Assessment 1P and 15P*);
- frequency of geomorphic units (*Assessment 1P and 15P*);
- frequency of hydraulic units (*Assessment 1P and 15P*); and
- longitudinal profile of the bed surface (*Assessments 2P and 4P*).

As described in Appendix L, some of the key issues to be resolved include: an examination of the most appropriate remotely sensed data for different purposes (i.e., aerial photographs vs. LIDAR) and the most cost-effective sampling frequency and timing of data collection; the potential for selecting transects for channel and hydraulic measurements using a GRTS panel design (studies of potential strata, appropriate sample sizes, and other details could be initiated in 2009); determining the best approach to incorporate both rehabilitation and non-rehabilitation sites into the overall sampling design; and developing a structured experimental approach to address the process of berm formation (i.e., identifying the target population of interest, rigorously selecting a sub-sample of these to study).

Coarse sediment transport and channel dynamics

Sediment mobility and transport rates require on-the-ground collection of samples followed by lab analyses at a sample of sites. Estimates of bed-surface grain size must be obtained via on-the-ground monitoring; however, using visual estimation techniques may be an option for covering a large area quickly.

Performance measures for key assessments related to **Sub-objective 1.2** (increase coarse sediment transport and channel dynamics):

- bedload transport measurements and computed coarse sediment loads (*Assessments 5P and 7P*);
- measures of bed mobility at specific locations (*Assessment 6P*);
- changes in the reach-averaged bed-surface grain sizes in the mainstem Trinity River (*Assessment 13p and 16P*); and;
- bed scour (*Assessment 6P*).

As described in Appendix L, some of the key issues to be resolved include: an examination of the most cost effective frequency of bedload transport studies (e.g., annually as done currently vs. every 5 years, or after major sediment augmentation); close review of various aspects of bed-surface grain assessments (i.e. sharper definition of hypotheses and the critical locations to test them, potential for using a double sampling approach with visual estimates completed first followed by more intensive sampling); and a critical review of scour core and bed mobility studies (i.e., improving site selection from historic non-random sites to a random sample from a clearly identified target population co-located with riparian studies, obtaining more data at higher flows).

Coarse sediment storage

Performance measures for key assessments related to **Sub-objective 1.3** (increase and maintain coarse sediment storage):

- Coarse sediment inputs from tributaries (*Assessment 8P)*

Coarse sediment inputs from major tributaries (the target population) have been quantified in the past through delta surveys and bedload sediment sampling in the tributaries as described in Section 3.1.3. Both of these approaches require on-the-ground monitoring with multiple visits within the year, and both approaches have weaknesses. The SAB (Scientific Advisory Board 2006a:7) suggested that it was not necessary to measure tributary inputs of coarse sediment with a sufficient level of precision and accuracy to perform coarse sediment storage calculations. Rather, they felt it was sufficient to obtain a general understanding of the magnitude of tributary inputs to assist the gravel augmentation program.

Fine sediment storage

Performance measures for key assessments as related to **Sub-objective 1.4** (reduce fine sediment storage in the mainstem Trinity River):

- fine sediment inputs from tributaries (*Assessment 11P and 17P);*
- quantity of fine sediment in the mainstem (*Assessments 9P, 10P, 16P, and 17P*):
  - subsurface bulk sampling;
  - substrate permeability; and
  - substrate productivity.

Fine sediment inputs from tributaries can be obtained by sampling tributaries, similar to the sampling described for coarse sediment inputs or as a residual term in the fine sediment budget as described in Section 3.1.4. The quantity of fine sediment in the mainstem requires field monitoring and can be completed as part of the bed-surface grain size monitoring. More detailed field performance measures would require an efficient sampling design. Depending on the target population and the specific question the GRTS panel design might be a suitable approach. Remaining issues to be resolved include: defining the size fractions of biological interest; determining the methods and required sample sizes for quantifying fine sediment stored on the bed surface and subsurface; and evaluating alternative strategies for obtaining useful estimates of fine sediment inputs from tributaries.

4.5.2 Objective 2: Increase/improve habitats for freshwater life stages of anadromous fish to the extent necessary to meet or exceed production goals

Field methods are used to assess the area of suitable habitat for different species and life stages. Suitable habitat for different species varies with flow and some form of modeling is necessary to assess the available habitat at different flows for different species. A census is not feasible to assess the available habitat, at least not for all of the different species and flows. The sample size for different species and flows will vary depending on precision requirements, priorities, and budget. The GRTS panel design would be an appropriate strategy to select these sites. Remotely-sensed data could provide substantial information for habitat assessments. Exploration of the relationships between remotely-sensed candidate performance measures and those collected in the field is required to determine whether remote-sensed performance measures are good indicators of habitat quantity and quality. Remotely-sensed data, including aerial photographs and LIDAR, may be used to inform performance measures such as bank length and the frequency of: meso-habitat units, geomorphic and/or hydraulic units. The remotely-sensed data provide a spatial census of each metric.

The temperature profile is assessed using existing protocols and models (RMA-11, Mike Deas, pers. comm.) to model temperature between probes located throughout the Program Area. The macroinvertebrate assessments have not been completed historically. The field protocol is very time consuming and this objective/assessment is considered to be lower priority (Table 2.1, Appendix E). However, if in the future their relative priority increases, the GRTS panel sampling design could be used to select sampling sites.

Performance measures for key assessments for **Sub-objectives 2.1** (increase and maintain Salmonid habitat availability for all freshwater life stages) and **2.2** (manage habitat and river migration corridor temperatures for growth and survival of natural anadromous salmonids):

- area of suitable habitat (by species and life-stage) (*Assessments 1H, 2H, 3H, 4H, 5H, and 6H*);
- habitat x flow curve (by species and life-stage) (*Assessments 1H, 2H, 3H, 4H, 5H, and 6H*);
- potential habitat capacity (*Assessment 13H*);
- temperature profile (spatially and temporally) (*Assessments 7H and 8H*);
- number of riffles (*Assessments 11H*);
- abundance of macroinvertebrate prey (*Assessment 9H*); and
- standing crop and production rates of macroinvertebrate populations (*Assessments 10H*).

As described in Appendix L, some of the key issues to be resolved include: the development of a fish habitat sampling design capable of generating system wide estimates; development and validation of the hybrid protocol; consideration of how to allow sites to change from non-rehab to rehab strata within the sampling design; compilation of existing data so that before/after comparisons or trend analyses can be done (includes updating records to reference the ‘standardized river mile’); and if food availability is an issue, identification of performance measures, metrics, and protocols for macroinvertebrate assessment.

4.5.3 Objective 3: Restore and maintain natural production of anadromous fish populations

Spawning related assessments

The assessment of spawning, incubation, and emergence success are conducted as part of the total census of carcasses and redds in the Program Area (CDFG 2005).

Performance measures for key assessments related to **Sub-objective 3.1** (increase spawning, incubation, and emergence success of anadromous spawners):

- density of redds (per longitudinal river segment, reach, or tributary) (*Assessment 1A*);
- number of redds/spawning habitat (in association with reach or river segment) (*Assessment 1A*);
- redd superimposition (*Assessment 2A*);
- number (proportion) of un-spawned or partially spawned females (*Assessment 3A*); and
- in-vivo egg viability (*Assessment 4A and 12A).*

As described in Appendix L, some of the key issues to be resolved include: development of a method for quantifying the extent of superimposition; exploration of alternative methods for calculating spawner abundance; and exploration of how to manage flows to encourage and/or discourage spawning in certain areas.

Juvenile fish related assessments

The juvenile fish assessments listed in Appendix H fall into 2 categories; those that can be sampled using a GRTS Panel design and those that have specific spatial methodologies (i.e., require an alternative design). Assessments of density, survival, size, growth, condition and overall health of natural fry and juvenile salmonids could be co-located at sites where geomorphic and habitat assessments are carried out. Using a GRTS design for the assessment of certain habitat, physical, and juvenile fish performance measures would allow cause-effect relationships to be elucidated. Assessments that require different spatial scales or a census include: outmigration timing (see USFWS 2004), fish disease prevalence (YTFP 2005; Naman 2006), fry stranding mortality and distribution, mortality from predation, and egg to fry survival. Estimates obtained at the system scale can still be used to explore interdisciplinary linkages. For example, a system-wide estimate of juvenile fish habitat could be an independent variable in a regression analysis where the annual system-wide estimate of smolt abundance is the response variable.

Performance measures for key assessments related to **Sub-objective 3.2** (freshwater production of anadromous fish):

- fry density and abundance (*Assessment 1J and 2J*);
- presmolt and smolt condition or overall health (*Assessment 4J*);
- fry and juvenile size distribution (*Assessments 3J and 4J*);
- fry and juvenile growth rate (*Assessments 3J and 4J*);
- salmonid presmolt and smolt abundance and survival;
- outmigration timing (*Assessment 4J*);
- outmigration duration (*Assessment 4J*);
- incidence and severity of infection of Ceratomyxa shasta (*Assessment 4J*);
- incidence and severity of infection of Parvicapsula minibicornis (*Assessment 4J*);

- predation rate on fry and smolts (*Assessments 6J, 7J, and 8J*); and
- fry and juvenile rearing habitat quality and availability (*Assessment 1H*).

As described in Appendix L, some of the key issues to be resolved include: development of a GRTS panel sampling design to co-locate fry counts with habitat mapping as well as to provide estimates of density associated with specific habitat types; exploration of alternative methods for computing population estimates from RST; identifying a method to quickly mark fish in large quantities to allow monitoring of growth rates; identifying effective methods for documenting outmigration for species other than Chinook salmon; identification of a method to separate fall from spring Chinook salmon fry; and more accurately distinguishing natural from hatchery fry with respect to all the above performance measures.

Hatchery related assessments

Detailed assessments such as extent of hybridization and reduced spawning success due to hatchery fish in natural areas will need their own experimental designs. Other assessments including predation rate, proportion of natural to hatchery fish (adults and juveniles) can be carried out using a sampling approach.

Performance measures for key assessments related to **Sub-objective 3.3** (hatchery-wild interactions):

- predation rate (by hatchery reared fish on natural salmon and steelhead fry) (*Assessment 8J*);
- proportion of hatchery to natural juveniles (*Assessment 9J*);
- proportion of hatchery to natural spawners in natural areas;
- degree of overlap of spawning habitat niches (between hatchery and natural adult salmon and steelhead) (*Assessment 5A);*
- degree of overlap of rearing habitat niches (between hatchery and natural juvenile salmon and steelhead) (*Assessment 10J*);
- fecundity of hatchery and natural fish spawning in natural habitat (*Assessment 6A*);
- spawning success of hatchery and natural fish spawning in natural habitat (*Assessment 7A*);
- emergence success for hatchery and natural fish in natural habitat (*Assessment 12A*); and
- maturation timing of adult fall and spring Chinook salmon (*Assessment 8A).*

4.5.4 Objective 4: Restore numbers of naturally produced salmon and steelhead to pre-TRD population levels in the Trinity River in order to facilitate dependent tribal, commercial, and sport fisheries full participation in the benefits of restoration via enhanced harvest opportunities

The assessment of adult in-river run size and escapement relies on weir sample data. This assessment generates a total escapement or run size estimate for the return migration of ocean going salmonids. A census at key points appears to be sufficient for this assessment. Harvest data are sampled at several locations within specific reaches of the Klamath and Trinity Rivers (see Yurok Tribal Harvest Report; CDFG Annual Report and HVT Creel Census Report, megatable for fall Chinook salmon).

Performance measures for key assessments related to **Sub-objectives 4.1 to 4.6** (escapement of anadromous fish):

- escapement of naturally produced anadromous fish (*Assessments 13A to 15A*);
- contribution of Trinity River naturally produced anadromous fish to dependent sport, tribal, and commercial fisheries and recruitment (*Assessments 16A to 21A*);

- cohort performance or year class strength (*Assessments 22A and 23A*); and
- number of age 3 ocean recruits of fall-run Chinook salmon (*Assessment 22A*).

As detailed in Appendix L, key uncertainties in these PMs and assessments include differentiating Klamath from Trinity fish; distinguishing Trinity hatchery fish from naturally spawning fish (due to incomplete marking); and limitations in the spatial extent or temporal duration of sampling (requiring either assumptions about unsampled locations or times, or redefining the target population to exclude the unsampled portions). Remaining issues to be resolved include improving harvest estimates and cohort reconstructions.

4.5.5 Objective 5: Establish and maintain riparian vegetation that supports fish and wildlife

Aerial photographs of the Program Area can be used to map patch area, type, and location in the field. Field mapping at a sample of sites is required for accurate interpretation of the aerial photographs and detailed vegetation metrics such as age class, diversity, seedling initiation location, and density. Float surveys are a feasible option to obtain coarse census information on riparian vegetation and encroachment. Compliance monitoring must be conducted at all bank rehabilitation sites.

Performance measures for key assessments with respect to **Sub-objectives 5.1** (encourage and maintain diverse riparian communities on different geomorphic surfaces via natural colonization processes and plantings), **5.2** (inhibit riparian vegetation that impairs fluvial processes, simplifies channel morphology, and degrades aquatic habitat quality), and **5.3** (recover riparian vegetation area equal to or greater than that disturbed by physical rehabilitation):

- patch area (Assessment 1R);
- patch type (Assessment 1R);
- patch location (Assessment 2R);
- initiation success of riparian vegetation (Assessments 3R and 5R);
- age class distribution of plants within patches (Assessment 1R);
- species distribution within patches (Assessment 1R);
- other structural attributes of interest to fish/wildlife objectives; and
- near-channel riparian vegetation (Assessments 3R and 4R).

As detailed in Appendix L, the key uncertainty around these performance measures and assessments is a lack of specific objectives/targets for riparian vegetation in the Program Area, beyond revegetation requirements for environmental permitting purposes. Aerial photography analyses and interpretation of changes in riparian vegetation within the Program Area will have a long time lag, and there is uncertainty about the optimal timing and frequency for this mapping. It is currently uncertain what sample sizes and associated frequency of sampling is required to provide sufficient statistical power to detect changes in intensively monitored riparian performance measures. There is also uncertainty as to how these intensive riparian monitoring efforts can be linked to other system assessments (e.g., geomorphic processes, wildlife).

4.5.6 Objective 6: Rehabilitate and protect wildlife habitats and maintain or enhance wildlife populations following implementation

Riparian birds

Performance measures for key assessments related to **Sub-objective 6.1** (maintain Trinity populations and species diversity of birds using the riparian zone in the Program Area):

- abundance (breeding season, post-breeding, migration periods) (*Assessment 1W, 3W, and 4W*);
- diversity (breeding season, post-breeding, migration periods) (*Assessment 1W, 3W, and 4W*); and
- productivity (as defined by the ratio of juveniles to adults) (*Assessment 2W, 3W, and 5W*).

These performance measures all require field-based monitoring and are best addressed using a sampling approach. Productivity estimates and assessing bird condition requires capture and examination of the birds, while estimates of abundance and diversity are obtained from a combination of visual/auditory observation and capture methods. In the short-term, information is needed from a sample of rehabilitation sites to provide feedback to rehabilitation site design. However, presently and in the long-term, information is needed from a sample taken across the entire system (40 miles).

The established sampling design for riparian birds provides system-wide, reach, and site estimates of abundance and diversity for the breeding, post-breeding, and migration seasons. Other components of the Program require information about riparian birds at the site and system-wide scale (see Looking Outward Matrix, Appendix F). There is a need for additional riparian bird monitoring at a sample of rehabilitation sites to provide feedback to site designs. Otherwise, an annual system-wide estimate is sufficient for other disciplines. All bird points are associated with mapped vegetation characteristics obtained from system wide vegetation maps (Section 4.1.8). Additionally, releve plot data were collected at each bird point before rehabilitation began, and we continue to redo a random set of plots every couple of years, or if the habitat at a site has had alterations. The GRTS panel design is another possible option for selecting sites for these assessments, but the existing design provides the information needed at the necessary scales; consequently it does not need to change.

As detailed in Appendix L, some of the key issues remaining to be resolved for riparian bird assessments include: determining the level of precision required to detect a change in abundance, i.e., how much sampling is needed; evaluating the amount of bias in estimates when only using road accessible sites; developing a sampling strategy to address abundance and diversity post breeding season and migration; and determining how banding (i.e., mark recapture) can be used to estimate abundance.

Riverine Birds

Performance measures for key assessments as they relate to **Sub-objectives 6.2** (maintain Trinity River riverine bird populations and species diversity in the Program Area) and **6.3** (minimize impacts of riverine bird predation on fry and smolts):

- abundance (*Assessments 6W and 7W)* ;
- diversity (*Assessment 4W*);
- distribution (*Assessment 8W*); and
- productivity (*Assessment 6W*).

These performance measures all require on-the-ground monitoring. A spatial census obtained via float surveys is feasible for assessing abundance, distribution, diversity, and productivity. The wildlife section has an adequate established sampling design for riverine birds which can provide estimates at any scale (e.g., system-wide or reach).

As described in Appendix L, the remaining issues to address with respect to these performance measures and assessments are to: evaluate the potential bias in distribution data as a result of the time of day surveys are carried out; develop an experimental design to evaluate the effect of alternative hatchery release strategies; and evaluate the utility of the performance measure productivity (which relies on visual identification of adults vs. juveniles) and determine if there are superior alternatives.

Foothill Yellow-legged Frog (FYLF)

Performance measures for key assessments as related to **Sub-objective 6.4** (increase population size, survival, distribution, and recruitment success of Foothill Yellow-legged Frogs):

- abundance (*Assessments 10W and 11W*);
- distribution (*Assessments 10W and 11W*);
- area of breeding habitat (*Assessment 9W*);
- survival (*no associated assessment listed*); and
- recruitment (*Assessment 10W*).

These performance measures all require field-based monitoring. A spatial census is feasible for abundance and distribution. Recruitment may be assessed using either a census or sample depending on the abundance. Survival is not easily assessed for FYLF, but methods could be derived as needed.

As described in Appendix L, the remaining issues to address with respect to these performance measures and assessments are to: determine how many egg masses need to be monitored to estimate survival; identify methods for estimating recruitment; identify metrics for evaluating area of breeding habitat; and integrate with habitat monitoring and 2D modeling to evaluate the impact of alternative flow schedules on egg mass survival.

Western Pond Turtle

Performance measures for key assessments relevant to **Sub-objective 6.5** (increase population size, survival, distribution, and recruitment success of Western Pond Turtles):

- abundance (*Assessment 13W*);
- distribution (*Assessment 13W*);
- recruitment (Assessment 14W); and
- structural and thermal complexity of habitat (*Assessment 12W*).

These performance measures all require field-based monitoring at selected sites. A spatial census is not feasible for any of the performance measures, and sampling designs will have to be developed to assess them.

As detailed in Appendix L, the remaining issues to address with respect to these performance measures and assessments are to: determine the best strategy for integrating the existing design with the GRTS panel design; determine the sample size required to detect changes in abundance and recruitment at the system scale; identify useful metrics for evaluating extent of nesting habitat and develop an appropriate sampling design; and explore the use of adaptive sampling techniques to address the problem of population clusters.

4.6 Recommended sequence of sampling design and field studies

Immediately

- All existing priority assessments that have adequate sampling designs should be continued (e.g., adult escapement and bird point counts).
- In FY09, a GRTS sample from the entire system (40 miles) should be taken for the priority assessments identified in Section 4.5, Appendix H, and Appendix L. Post collection, the data need to be analyzed to develop the details of the panel design (e.g., sample size, strata, revisit frequency, rehab sites). Bring in outside expertise such as Dr. Don Stevens (OSU) to assist with this effort and make subsequent knowledge transfer part of the RFP.
- Existing data should be summarized for all disciplines, beginning with priority assessments (e.g., aerial photographs).
- Adopt a single reference frame (e.g., DWR center line) which all partners use. If the DWR center line is inadequate in some way (e.g., does not have GIS attributes), address this with the IIMS lead directly rather than using something different. Another possibility, as suggested by the SAB (SAB review 2008), is to use a reference frame which is more consistent over time (e.g., valley center line) rather than the river center line which we expect will change as channel migration occurs.
- For priority assessments that do not have an existing sampling design and for which the GRTS approach is not suitable, the sampling design questions (Appendix G) should be addressed and documented.

Rehabilitation sites

- Collect pre and post data (2-3 years post). After that, move sites into a category that gets sampled at some reduced frequency like the rest of the river (say once every 5 years).
- In the short term, include all rehabilitation sites but, at some point soon, move to a random sample of new rehabilitation sites. Once all are complete, take a random sample from rehabilitation sites for continued monitoring or just treat like everywhere else. A potential strategy if we'd like to continue monitoring all rehabilitation sites over time would be to group the sites into panels of ~ 10 sites (this may or may not coincide with the GRTS panel design for the entire system). We could then monitor one panel (~10 sites) each year and rotate through the panels so that within 15 years each rehab site would have been visited 3 times at 5 year intervals. This monitoring could be supplemented with some sites in each panel being monitored in consecutive years to assess the year-to-year changes. It is still not entirely clear what the best strategy is for integrating the rehabilitation sites into the overall system-wide sampling design. Which assessments are better made at the system scale rather than using the rehabilitation sites as the target population?
- Identify a few very specific questions about site design and focus on getting replication of the features in question. Consider whether control sites would be useful. Controls are usually chosen to be similar to the 'pre' condition, but in this example it may actually be more useful to choose controls that look like the desired 'post' condition (e.g., using a natural alcove as a control). It may not be necessary to complete the full suite of monitoring at each of the treatment/control sites to answer the design question. The expectation is that this focused monitoring would occur in the short term only as it is specifically directed at improving rehabilitation site design. Efforts should be focused on the most critical design uncertainties.

Annually ongoing

- Summarize and report data in the Program's central database (IIMS).
- Complete analyses of interest—there's no point collecting data if they aren't going to be analyzed. Program participants have many examples where data have been collected but never analyzed, or not within a useful time frame.

5 years out

- After 5 years remotely sensed data should be formally compared to corresponding field methods to reassess the need for, and required frequency of, both field and remotely sensed assessments.

As time/funds available

- For existing assessments, work through the list of uncertainties and remaining issues to be resolved.
- Where existing designs aren't developed, work through the 'sampling design' questions (Appendix G) for the remaining assessments, going through these assessments in a logical sequence given the current priorities of the Program.
- Complete remaining assessments.

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IAP Glossary Terms and Acronyms

Adaptive Environmental Assessment and Management (AEAM) – The method of management directed by the Secretary of the Interior for the Trinity River Restoration Program. The AEAM method encompasses the scientific process with a strong managerial interface. AEAM is a formal, systematic, and rigorous program of learning from the outcomes of management actions, accommodating change, and improving management (Holling 1978). AEAM uses conceptual and numerical models and the scientific method to develop and test management choices. Decision makers use the results of the AEAM process to manage environments characterized by complexity, shifting conditions, and uncertainty about key system component relations (Haley 1990; McLain and Lee 1996). The AEAM approach to management relies on teams of scientists, managers, and policymakers to jointly identify and bound management problems in quantifiable terms (Holling 1978; Walters 1986). Additionally, the adaptive approach to management "recognizes that the information we base our decisions on is almost always incomplete" (Lestelle *et al.*, 1996). This recognition encourages managers to treat management actions as experiments, whose results can better guide future decisions. AEAM must not only monitor changes in the ecosystem, but also must develop and test hypotheses of the causes of those changes to promote desired outcomes. The results are informed decisions and increasing certainty within the management process.

Age-specific population rates – For mortality and survival we typically calculate "general" population rates applicable to the entire population. Occasionally, it is appropriate to make the estimates age-specific, i.e., applicable only to age-group t to t+1, or to make the estimates sex-specific, say, only applicable to females. Thus an age-specific mortality rate would be the ratio of the number of deaths of animals between ages t and t+1 to the number alive at age t. In probabilistic terms, it is the probability that an animal of age t will die within the next year.

"**age zero**" **fish** – are in their first season of growth after hatching. At this point they are also called "**Young-Of-The-Year**" or, simply Y-O-Ys.

Analyses – The work of inquiring into a subject thoroughly and systematically.

Assessment – A group of AEAM actions including hypotheses, modeling, monitoring, analyses, and reconnaissance-level observations. Prerequisite to the 'Adaptive' part of AEAM.

Assessment Objectives – Objective of each particular assessment. Directs planning for analyses, performance measures, and monitoring for each assessment. Distinct from 'Program Objectives' or 'Program Goals'.

BACI – Before-after Control-impact

BLM – Bureau of Land Management

CDFG – California Dept. of Fish and Game

CEQA – California Environmental Quality Act

CO – Contracting Officer

Cohort – A group of individuals all born simultaneously. In fisheries, frequently synonymous with **"year-class."**

COTR – Contracting Officer Technical Representative

Compliance Monitoring – Monitoring associated with permitting and other regulatory requirements.

CVPIA – Central Valley Project Improvement Act

CWA – Clean Water Act

Dynamic pool model – A concept of a harvestable stock which is a composite (pool) of individual year-classes (or other cohorts) that change in a predictable way through time (dynamic). Beverton and Holt (1957) considered the lifetime contribution of a year-class to a fishery as analogous to the sum of the individual contributions of contemporaneous year-classes to an aggregate annual catch of the fishery.

EIS/EIR – Environmental Impact Statement / Environmental Impact Report

ERP – Expert Review Panel. A panel of experts, compensated by the TRRP, convened to review statements of work and assure fidelity of assessments to the IAP and Flow Study.

FYLF – Foothill Yellow-legged Frog

G2G – Government to Government

GCAO – Grants and Cooperative Agreement Officer

GCAOTR – Grants and Cooperative Agreement Officers Technical Representative

Grilse (Jack) – Precocious salmon or anadromous trout (half-pounder) that appear in spawning runs at a smaller size (and sometimes, younger age) than is characteristic for the species.

Hatchery-origin – fish reared in a hatchery.

Hypothesis Testing – An AEAM and science term that describes a major component of the scientific (Science) process. A hypothesis is a tentative theory about the natural world; a concept that is not yet verified but that if true would explain certain facts or phenomena; a scientific hypothesis that survives experimental testing becomes a scientific theory.

IAP – Integrated Assessment Plan

IEV – Implementation, Effectiveness and Validation

Implementation – primarily the execution of physical manipulations of the Trinity River ecosystem, including infrastructure improvements, channel rehabilitation, coarse sediment augmentation, and flow releases from Lewiston Dam to the Trinity River. The term also applies to execution of assessments associated with adaptively managing the physical manipulations.

IIMS – Integrated Information Management System

IRP – Independent Review Panel. An anonymous panel of experts independent of the TRRP, convened to review, judge, and rank, according to assessment objectives, proposals received by the TRRP in response to an RFP.

Long-Term monitoring – Monitoring directed at analyses with time as the independent variable.

Model (Conceptual, Analytical (correlation, governing equation), Numerical, Heuristic) – a system of postulates, data, and inferences presented as a mathematical description of an entity or state of affairs. Models can be material, visual, or mathematical and are often used in the construction of scientific theories. In some cases models are represented as computer simulations.

Monitoring – The activity of recording data in accord with a study plan aimed at observing the resource response to a management action.

Natural production – progeny of fish that spawned in the river with one or more parents either of natural and/or hatchery-origin.

Natural spawners – both hatchery and naturally produced fish that spawn in the river regardless or natural or hatchery origin.

NCRWQCB – North Coast Regional Water Quality Control Board

NEPA – National Environmental Protection Policy Act

NOAA – National Oceanic and Atmospheric Administration

Objective Specific monitoring – Monitoring directed at analysis of cause and effect relationships, using non-temporal metrics for both the independent and dependent variables.

Observation unit – an object on which a measurement is taken; this is the basic unit of observation.

Out breeding depression - a reduction of fitness of hybrid individuals in immediate generations or later generations.

Performance Measures – A method of assessing the attainment of a Program Goal or Objective, in either quantitative or descriptive terms. More technically, the dependent variable of an assessment, measured during monitoring, calculated during analysis, and reported to the Program, either as an estimate of the performance of one or more relevant management actions against one or more Program Objectives, or the performance of the overall Program relative to Program Goals. There should be one or more performance measures which are relevant to each Program Objective, though some of these may be proxy measures for something that cannot be directly measured (e.g., while flows are measurable precisely, there is no single measure of smolt health).

PFMC – Pacific Fisheries Management Council

Plant alliance – is an assemblage of plants defined by one or two dominant plant species observed in the canopy, such that if there is a shift in species canopy dominance there will likely be a corresponding shift in plant alliance.

Policy – The expression of the political will of Congress, the Department of Interior, or the Trinity Management Council (TMC).

Population – A reproductive community of individuals that share in a common gene pool.

Prediction – That aspect of assessment (scientific process) that makes a statement about the expected outcome of the management action (experiment). The ROD directs the TRRP to use models (Conceptual, Analytical, Numerical) to predict the outcome of flow releases, channel rehabilitation projects, and coarse sediment augmentations (among other management actions). Predictions are compared to observed resource response as part of the assessment portion of AEAM.

Production – 1) The total elaboration of new body substance in a stock in a unit of time, irrespective of whether or not it survives to the end of that time. Also called *net production, *total production; and 2) *Yield.

Program Area – the 40 mile stretch of the upper Trinity River located between Lewiston Dam and the North Fork Trinity confluence.

Program Goals – Desired outcomes from rehabilitation actions articulated in applicable legislation (fish populations), EIS/EIR (Program organization), ROD (Program strategy).

- Goals are broad; objectives are narrow.
- Goals are general intentions; objectives are precise.
- Goals are intangible; objectives are tangible (i.e., measurable).
- Goals are abstract; objectives are concrete.
- Goals can't be validated as is; objectives can be validated.

Program Objectives – The proposed means of achieving Program Goals, or disaggregating goals into logical components. The TRFE (USFWS and HVT 1999) includes a number of Program Objectives, relating to the implementation of actions, the creation of habitat-forming processes, the establishment of habitats and other conditions to support fish and wildlife populations. These Program Objectives are being organized into a hierarchy as part of the development of the IAP. For example, the TRFE

Management Targets (Chapter 8) are a means of achieving the larger Program goal of healthy river attributes.

Recruitment – Addition of new animals to the vulnerable population by growth from among smaller size categories.

Recruitment – The amount of fish added to the exploitable stock each year due to growth and/or migration into the fishing area. For example, the number of fish that grow to become vulnerable to the fishing gear in one year would be the recruitment to the fishable population that year. This term is also used in referring to the number of fish from a year class reaching a certain age. For example, all fish reaching their second year would be age 2 recruits.

Recruitment Curve, Reproduction Curve – A graph of the progeny of a spawning at the time they reach a specified age (for example, the age at which half of the brood has become vulnerable to fishing), plotted against the abundance of the stock that produced them.

Redd superimposition – reuse of redd sites by later-spawning fish.

RFP – Request For Proposal

Releve Plot – a sampling unit commonly used to conduct a semiquantitative vegetation evaluation or to describe the species and structural attributes of a homogeneous patch of vegetation. Releve size is based on the minimal area concept. Individual plant species are sampled in different height strata (i.e., herb, shrub or tree layers) and a categorical cover scale assigned (e.g., Braun Blanquet or Daubenmire scales).

RIG – Rehabilitation and Implementation Group

ROD – Record of Decision

SAB – Science Advisory Board

Sampled population – the collection of all possible observation units that might have been chosen in a sample; the target population from which the sample was taken.

Sampling unit – The unit actually sampled. For example, we may want to study juvenile Chinook salmon but do not have a list of all individual fish in the target population. Instead, stream reaches serve as the sampling units, and the observation units are the individual fish living in each reach.

Science – the process of posing an hypothesis, designing an experiment to test the hypothesis, predicting the outcome of the experiment, conducting the experiment, recording the experimental observations, comparing the observations with the prediction, making a statement about the invalidity of the original hypothesis, then restating the hypothesis.

Strategy – The plan for executing and accomplishing the policy of the TRRP Strategy exists within the political process thus:

1. Legislation (e.g., CVPIA)
2. Policy (e.g., ROD)
3. Strategy (e.g., TRFEFR)
4. Tactics (e.g., IAP)
5. Logistics (e.g., TRRP Budget)

Survival rate (S) – Number of animals alive after a specified time interval, divided by the initial number. Usually calculated on a yearly basis. Survival is the complement of mortality and it can be an especially useful statistic for tracking population events through successive periods of time. For example, to get the number of survivors at age six from a stock of 1000 animals alive at age three, simply multiply the three successive annual survival rates for the intervening years: N_6 = 1000 * S^3.

$$S = e^{-Z}$$

TAMWG – Trinity Adaptive Management Working Group

Target Population – the complete set of individuals or units about which we want to make inferences.

TFWMA – Trinity River Basin Fish and Wildlife Management Act

TMAG – Technical Modeling and Analysis Group

TMC – Trinity Management Council

TRD – Trinity River Division

TRFE – Trinity River Flow Evaluation Final Report

TRH – Trinity River Hatchery

TRRP – Trinity River Restoration Program

USFS – U.S. Forest Service

Wild fish – fish with no hatchery lineage (or set an acceptable number of generations which a wild individual can be removed from hatchery lineage).

WPT – Western Pond Turtle

Year-class – The fish spawned or hatched in a given year. Y**ear-class name** is assigned based on the date of the parental anadromous run of fish.

Appendix A. Trinity River Restoration Program – Required permits and approvals

Federal Endangered Species Act

NOAA Fisheries: TRRP is covered for impacts to threatened SONCC coho salmon via the Oct. 2000 Biological Opinion for the Trinity River Mainstem Fishery Restoration EIS—which includes an incidental Take Statement for non-lethal take of SONCC coho salmon by the project. The BO incorporates the Trinity River Flow Evaluation Study by reference and covers all TRRP projects (e.g., sediment augmentation, flow, and bank rehabilitation) except the bridges work that was completed in summer 2005.

USFWS (N. spotted owl and eagles). TRRP is required to ensure that restoration projects will not adversely affect N. spotted owls or eagles, or adversely modify critical habitat for N. spotted owls. In order to make an evaluation, the project actions and locations must be well defined and information on owls and their habitat in the project area(s) complete. Canyon Creek and Hocker determined no effect on Spotted Owls. Cableway occurred after July 9, 2003 – and no nesting owls were nearby. Now most projects are planned for implementation after fledging of all birds (~August 1). If the Program determines that our restoration action "may affect, but is not likely to adversely affect" spotted owls, the Program must prepare a biological assessment that includes a formal determination of project effects on the species and receive a USFWS concurrence letter of Not Likely to Adversely Affect (NLAA).

Section 404 Clean Water Act (CWA) (ACOE to permit discharge of materials into waters of the USA). For Bank Rehabilitation and Gravel TRRP has used Nationwide permit (e.g., NWP27 for wetland and riparian restoration and creation. NWP 27 only requires documentation of the prior condition of the site (e.g., wetland delineation before project). Thus a wetland delineation is needed but not necessarily revegetation.

Section 401 of the CWA (NCRWQCB – 401 water quality certification). Gravel projects have been permitted under a CEQA exemption #7 for Natural Resource projects. Water Quality Standards are composed of 2 parts: 1) Designated uses of water, and 2) criteria to protect those uses. These are both enforceable limits in the bodies of water for which they have been established. NCRWQCB uses the EA, ACOE 404 application, and CDFG 1600 application to prepare 401 certification, which is only valid when all permits are obtained.

Section 402 CWA: Contractor must send in Notice of Intent to comply with the National Pollution Discharge Elimination System (NPDES) General Permit for storm water Discharges from Construction Activities – this involves development of a Storm Water Pollution Prevention Plan (SWPPP). The General Permit – prohibits discharge of materials other than storm water and all discharges which contain hazardous substances.

Executive Order 11990 (Protection of Wetlands) – Requires federal agencies to follow avoidance, mitigation, and preservation procedures. To comply with EO 11990 the federal agency typically coordinates with the Army Corps.

Executive Order 11998 (Floodplain Management) Requires all federal agencies to take actions to reduce the risk of flood loss, restore and preserve the natural and beneficial values in floodplains, and minimize impacts of floods on human safety, health, and welfare. Covered by County Floodplain development permit.

EO 12898 (Env. Justice) – Requires federal actions to address environmental justice in minority and low-income populations. Env. Justice analyses are required to identify disproportionately high and adverse impacts from proposed actions.

CDFG Section 1602 Streambed Alteration Agreement. TRRP is generally not required to obtain CDFG permits so long as our projects are entirely federal. Where non-federal funds are involved (e.g., where we have been funded partially be CDFG grants = Bridges and probably at Indian Creek) we need to get a 1600 permit.

CDFG California Endangered Species Act (CESA) – Section 2080 of the California Fish and Game Code. Exempt unless non-federal funding.

Section 106 of the National Historic Preservation Act: Requires coordination with the State Historic Preservation Organization (SHPO) and the Advisory Council on Historic Preservation (ACHP) regarding the effects a project may have on properties listed or eligible for listing on the National Register of Historic Places (NRHP). There is a programmatic agreement for the Trinity Project with the US Bureau of Reclamation serving as the responsible federal agent for coordination with SHPO.

Executive Order 13112 (Noxious and Invasive Plant Species). Requires Federal agencies to work to prevent and control the introduction and spread of invasive species. Typical mitigation measures include: Survey for invasive species, use of native material in erosion control (Certified weed free), and cleaning of all attached soil or plant parts from construction equipment prior to entering or leaving construction sites.

Wild and Scenic Rivers Act (Section 7 Determination). In order to do work within the Wild and Scenic River Corridor, the TRRP is required to maintain the Outstandingly Remarkable Values (ORVs) for which the River was designated as Wild and Scenic. The BLM is manager of the Wild and Scenic Corridor established for the designated reach of the Trinity River and is responsible for completing Section 7 analyses and a determination that proposed projects within the corridor will not negatively impact river ORVs.

Environmental Site Assessments: Hazardous material surveys and documentation are needed for all land acquired (temporary or permanent easements)

ENVIRONMENTAL DOCUMENTS COMPLETED – or in process:

- EA/EIR for Bridges 7/03
- EA for Late summer 2003 flows 8/03
- EA/IS for Cableway Gravel 9/03
- CEs for annual Hamilton Pond dredging, Poker Bar road enhancements, piezometer placements, Tullis property acquisition, disposal, and removal, driveway movements, etc..
- Canyon Creek Suite of Sites EA/EIR in Public Draft
- Indian Creek EA/EIR in process

MONITORING:

- ACOE – Re-delineation of wetlands after 3-5 years
- NCRWQCB: Turbidity monitoring when noticeable increases in turbidity
- Many Mitigation Monitoring and Reporting Requirements before and during construction to minimize impacts
- Ties into Technical Modeling and Analysis Group overall monitoring of TRRP success.
- CDFG monitoring requirements for vegetation and vegetation wildlife monitoring pre and post project implementation

Appendix B. Assessment justification worksheet and detailed explanation of criteria

Assessment(s) on this worksheet: ____________________
(use names / numbers from revised Attachment 4, Straw Program Objectives Summary; see definitions of AEAM, Assessments on pg. 19) ____________________
____
____

People who worked on this justification: ____________________
____
____
____

Step 1: Read the detailed (back side of this page).

Step 2: **Fill in Criteria Checklist –** Fill out Section A if this work assists in shorter term, objective-specific AEAM assessments; fill out Section B if this work assists in assessing progress towards longer term, bigger picture goals and objectives. Some work may pertain to both A & B. These criteria are meant to help you draw conclusions on relative priorities. **Use the space under each criterion to add any comments explaining the rationale for your check mark.** BE HONEST!!!

Step 3: **Draw Conclusions.** See the conclusions below the table

Assessment Criteria (The criteria are explained in more detail below after the Conclusions section). **Add the rationale for your response.**	*Enter a check mark (√)* **Definitely**	**Probably**	**Unlikely**	**No**	**Don't Know**
A. For AEAM Assessments (shorter-term, objective specific):					
1. This assessment drives management actions. ____________________	☐	☐	☐	☐	☐
1A. This assessment may result in a large reallocation of water in one or more annual hydrographs (volume and timing). ____________________	☐	☐	☐	☐	☐
2. This assessment can scientifically measure/detect outcomes of a well-founded AEAM experiment (management action) and can compare the outcome to a prediction. ____________________	☐	☐	☐	☐	☐
3. This assessment is financially and logistically feasible. ____________________	☐	☐	☐	☐	☐
4. This assessment can determine the outcome in an acceptable amount of time. ____________________	☐	☐	☐	☐	☐

Assessment Criteria (The criteria are explained in more detail below after the Conclusions section). **Add the rationale for your response.**	***Enter a check mark (√)*** **Definitely**	**Probably**	**Unlikely**	**No**	**Don't Know**
5. This assessment supports other priority assessments. ____	☐	☐	☐	☐	☐
6. This assessment has not been completed before. ____	☐	☐	☐	☐	☐
7. This assessment will bring Program participants to a common understanding of the outcome of management actions. ____	☐	☐	☐	☐	☐
8. Action triggers (i.e., how much of a change in performance measures / assessment outcomes is sufficient to change actions) have been identified. ____	☐	☐	☐	☐	☐
B. For Program Goal assessment (longer term, bigger picture goals and objectives):					
1. This assessment evaluates an important Program Goal or Objective, and the Objective has a quantitative performance measure. ____	☐	☐	☐	☐	☐
2. This assessment can scientifically measure/detect whether objectives are being achieved. ____	☐	☐	☐	☐	☐
3. This assessment is financially and logistically feasible. ____	☐	☐	☐	☐	☐
4. This assessment has adequate baseline information upon which to evaluate change/progress towards Program Objectives. ____	☐	☐	☐	☐	☐
5. This assessment supports other priority assessments. ____	☐	☐	☐	☐	☐
6. This assessment can measure systemic change over an acceptable period of time. ____	☐	☐	☐	☐	☐
7. This assessment will bring Program participants closer to a common understanding of progress towards the Program Goal and Objectives. ____	☐	☐	☐	☐	☐

1

Conclusions:

A. Is this assessment absolutely critical (CORE) for AEAM Assessments? ☐ yes ☐ no

B. Is this assessment absolutely critical (CORE) for Program Goal Assessments? ☐ yes ☐ no

C. How often is this assessment required?

- ☐ every year
- ☐ occasionally (e.g., after major geomorphic change);
- ☐ state-dependent (e.g., if high temperatures occur in the Klamath)

D. What does Program gain from doing the assessment now?

____

____

E. What does Program lose from not doing the assessment at all?

____

____

F. What does Program lose by delaying the assessment to a future time?

____

____

G. How much more time is required to refine assessment methods (e.g., sampling design, power analyses, monitoring protocols)?

____

H. On what spatial scale does this assessment need to be completed (e.g., system-wide assessment for whole 40 miles from Lewiston to N. Fork of Trinity, through census or extrapolation; process understanding at selected representative sites; process understanding at historical (not necessarily representative) sites)?

____

I. What other data / assessments do you need to complete this assessment?

Detailed Explanation of Criteria

A. For AEAM assessments (shorter-term, objective specific):

1. *This assessment drives management actions.*

   How likely is it that flow management, sediment management, channel rehabilitation, watershed management, or other management actions would change if an outcome of this assessment indicates we are not achieving Management Targets of Program Objectives? (This criteria addresses the range of management actions.)

1A. *This assessment may result in a large reallocation of water in one or more annual hydrographs (volume and timing).*

   If the answer to #1 is yes, will the assessment address a flow component that will potentially result in change in annual water allocations from the ROD? This criterion focuses on the <u>scale</u> of potential <u>flow</u> volume and <u>timing</u> change.

2. *This assessment can scientifically measure/detect outcomes of a well-founded AEAM experiment (management action) and can compare the outcome to a prediction.*

   Is the assessment scientifically/analytically feasible for monitoring the outcomes of implemented actions, and determining appropriate changes to management actions? Will assessment provide sufficient accuracy and/or precision to determine appropriate changes to management actions? Do rigorous analyses/predictions support the assessment? Has associated literature been reviewed?

3. *This assessment is financially and logistically feasible.*

   Is the assessment financially feasible? Will the budgeted resources enable adequate monitoring of the outcomes of management actions, and determine appropriate changes to management actions?

4. *This assessment can determine the outcome in an acceptable amount of time.*

   How long would it take to definitively/likely determine if management actions require modification (e.g., one week for flow effects on temperatures, 1 to 5 years for flow effects on sediment depending on water years)?

5. *This assessment supports other priority assessments.*

   Does the assessment provide input information to one or more high priority assessments (e.g., streamflow gaging)?

6. *This assessment has not been completed before.*

   Has the assessment been conducted locally or on a comparatively similar river that would allow direct application to the Trinity River (i.e., are we re-inventing the wheel)? If conducted before, does it need to be conducted again, and is it timely to repeat the assessment now?

7. *This assessment will bring Program participants to a common understanding of the outcome of management actions.*

   Will the assessment resolve significant scientific disagreements that are important to management actions?

B. For Program goal assessment (longer term, bigger picture goals and objectives):

1. *This assessment evaluates an important Program Goal or Objective, and the Objective has a quantitative performance measure.*

   Is this assessment critical for evaluating whether Program Goal and Objectives are being achieved? Are there management targets/performance measures for the Program Objective that is being assessed?

2. *This assessment can scientifically measure/detect whether objectives are being achieved.*

   Is the assessment scientifically/analytically feasible to document outcomes of management actions, and over an acceptable period of time? Will the assessment provide sufficient accuracy and/or precision to document outcomes of implemented actions? Has associated literature been reviewed? Do rigorous analyses (e.g., power analyses to consider natural variability, measurement error, and confounding factors) support the assessment?

3. *This assessment is financially and logistically feasible.*

   Is the assessment financially feasible to document progress towards Program Objectives? Will the budgeted resources enable adequate monitoring of the Performance Measures of a Program Objective?

4. *This assessment has adequate baseline information upon which to evaluate change/progress towards Program Objectives.*

   Do we have baseline (pre-treatment) and control (untreated, as applicable) data for this ecosystem component to assess change and progress?

5. *This assessment supports other priority assessments.*

   Does the assessment provide input information to one or more high priority assessments?

6. *This assessment can measure systemic change over an acceptable period of time*

   Have analyses been completed which quantify what percent change in this ecosystem component could be reliably detected over 5, 10, 15 and 20-year periods (e.g., power analyses which consider measurement error, natural variability and confounding factors)?

7. *This assessment will bring Program participants closer to a common understanding of progress towards the Program Goal and Objectives.*

   Will the assessment resolve significant scientific disagreements that are important to our understanding of progress towards the Program Goal and Objectives?

Appendix C. Developing functional relationships that link across subsystems – Bill Trush

Linking across subsystems requires specifying and understanding key cause-effect pathways. Each pathway, comprised of many inter-dependent linkages, can be constructed as an X-Y analysis (the approach described herein) but there are many other options. Beginning with the management prescription, which typically involves manipulating something physical (e.g., releasing flow, adding coarse sediment, removing an encroached berm), the X-Y analysis establishes an unbroken chain of cause-effect relationships that ultimately culminate in a desired biological response.

To be useful, each X-Y analysis needs: (1) the units for both axes, (2) a measured, modeled, or hypothesized quantitative X-Y relationship, (3) a brief status, (4) reference to a specific location in Chapter 3 describing where and how each X-Y is being, or will be, addressed by the Program, and possibly (5) an appraisal of how important this X-Y might be relative to the entire pathway(s) (to aid prioritization and budgeting). Each type of ROD management action should have an X-Y analysis: (1) coarse bed material introduction, (2) instream flow release of each annual hydrograph component, (3) mainstem channel reconstruction techniques or projects, (4) watershed rehabilitation practices, and (5) hatchery practices. All these actions should shift the juvenile and smolt size/health class distribution at N.F. Trinity River confluence to the right and upward. Piggy-backing flood peaks might be considered a modified management action under (2).

Some X-Y relationships can be established empirically whereas others must be modeled. One important management application of the X-Y analysis is to identify those X-Y relationships dominating the outcome by doing a sensitivity analysis, with the weakest links having the strongest repercussions receiving prioritized funding. In some cases, a scientific panel might be needed to 'best guess' an X-Y relationship before actions can be taken to improve upon it by experimentation and/or monitoring. Each pathway should be written down, with the units of measurement labeled (i.e., no 'conceptual' axes). Each integrative pathway should mature (refining the X-Y's, oftentimes selecting different units of measurement) and be expected to morph through time (replacing X-Y's). Some pathways might be eliminated and/or new ones created. While pathway refinement should be a daily exercise, the Program might want to periodically revisit the pathways to formally re-assess them collectively and to report on triumphs, failures, and future challenges.

For these integrative pathways to become part of everyday science and monitoring, the pathways should be constructed and revised by those responsible for their defense, implementation, and management application. Outside peer review should be done.

While we have advocated an X-Y analysis as a template for constructing integration pathways (or could be called reductionist pathways?), there are other ways -- or less linear adaptations of the X-Y approach -- to chart-out integrative pathways. SALMOD relies on a pathway of quantitative relationships to make biological predictions. I think the X-Y integrative pathways adopt more of a robust top-down approach, than the SALMOD creator's temptation to model from the bottom-up. The template does not matter, provided the necessary quantitative integration occurs and is decipherable.

Example of Integration

Succumbing to the adipose fin syndrome temporarily, the ROD needs to shift the present-day size class distribution of outmigrating Chinook salmon, coho salmon, and steelhead juveniles and smolts upward and to the right (Figure C1). More and larger/healthier juveniles entering the Klamath River should lead to more returning adults overall. Each annual size class distribution will improve by increasing habitat capacity, to shift the distribution upward, and by increasing ecosystem productivity to shift the curve to the right (i.e., juveniles grow more and are healthier in a productive river ecosystem). Therefore, the ROD needs to improve habitat capacity (including reducing risk) and river ecosystem productivity. The Program must offer quantitative goals for both. While the prevailing emphasis has been on increasing habitat capacity, the Program must objectively assess the possibility that ecosystem productivity might be as or more important.

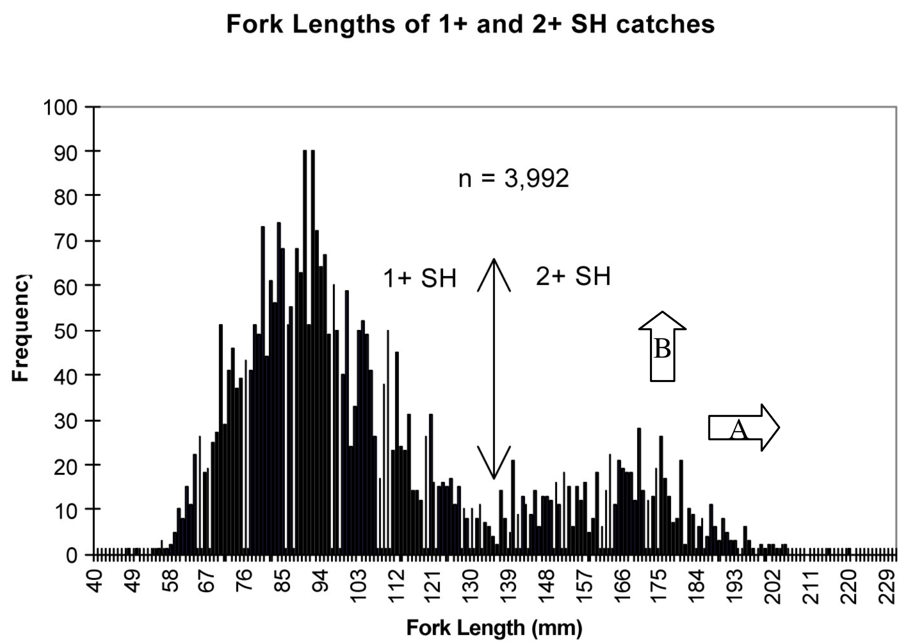

Figure C.1. Example of size class distribution of steelhead juveniles and smolts with shifts upward and to the right to illustrate changes in capacity and productivity. Smolt to adult survival increases substantially when fork lengths are greater than 150 mm, so shifting the size distribution to the right (A) and upwards (B) will improve adult returns.

Benthic macroinvertebrate (BMI) habitat, likely a key to providing more productive salmonid rearing habitat (fish need to eat), has not received adequate attention. In part this is because integration has been lacking. Ultimately, the Program wants to improve the abundance and health/size of juvenile anadromous salmonids passing the North Fork Trinity River and eventually entering the Klamath River: more and bigger/healthier juveniles should return more adults. Streamflows dedicated to improving BMI habitat may not provide, simultaneously, the most juvenile rearing habitat per ac-ft of water released. So what is their (quantity versus quality) relative effectiveness (their role) for increasing adult return for the mainstem channel from Junction City to the North Fork Trinity River confluence (as an example), such that we might want to favor BMI habitat over juvenile Chinook salmon rearing habitat (in our instream flow releases) at certain times of the water year?

This important management concern can be tackled by constructing an integrative pathway. The management prescription, kicking-off the pathway, would be ROD instream flow releases from mid-February through mid-June, during the Chinook salmon fry and juvenile rearing life stages. Although the X-Y approach 'demands' an independent variable for management prescription on the X-axis of the initial X-Y relationship, other adaptations can be made. By considering the ROD releases and streamflow accretion below Lewiston Dam, the Program really is prescribing a unique hydrograph from mid-February through mid-June each water year. So the X-axis, which might seem to be instream flow releases in cfs, actually is a set of hydrographs (say from WY1990 through WY2007). By releasing ROD instream flows, the Program also is prescribing a complimentary set of thermographs from mid-February through mid-June for each water year. The independent variable on the X-axis (Figure C2) focuses on the period between February 15 and June 15, while the dependent Y-axis becomes daily average streamflow (cfs) and daily average water temperature (^{o}C). The linear arrangement of a classic X-Y analysis still remains given that each water year can first be considered separately. then collectively at the end of the analysis. Essentially the X-axis of 'Date' is what the Program does though its ROD instream flow releases. The first X-Y relationship would look like (Figure C2):

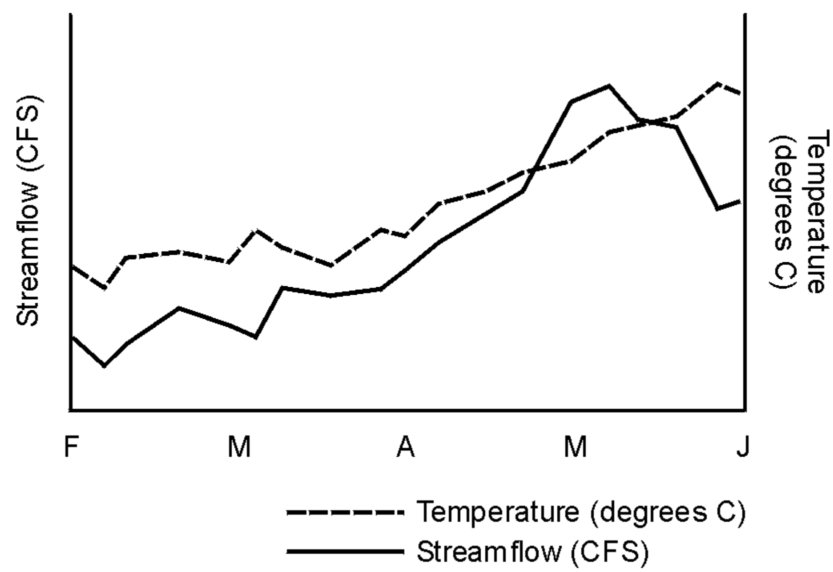

Figure C.2. Example of stream flow and temperature variation over time during fry and juvenile rearing period.

The next step in developing this integrative pathway necessarily bifurcates to address Chinook salmon juvenile abundance and Chinook salmon juvenile growth, because we need to simultaneously address capacity (potential number of fish for a given total habitat area) and productivity (potential growth): abundant habitat but of poor productivity would produce smaller/less healthy juveniles and smolts.

Habitat capacity

To consider habitat capacity first, the next X-Y relationship will retain 'Date' on the X-axis but now have daily juvenile rearing habitat (ft^2) on the Y-axis. The ft^2 of juvenile rearing habitat for each day of the hydrograph can be estimated from the habitat rating curve. Although the habitat rating curve (X-axis = Q and Y-axis = Habitat Area) from Junction City to the North Fork Trinity River confluence will require a significant effort to produce, it does not explicitly appear in the integrative pathway. We call this second

X-Y relationship the ‘WY2000 Juvenile Chinook salmon Habigraph’ because it has Date on the X-axis similar to hydrographs and thermographs. The second X-Y relationship would look like (Figure C3):

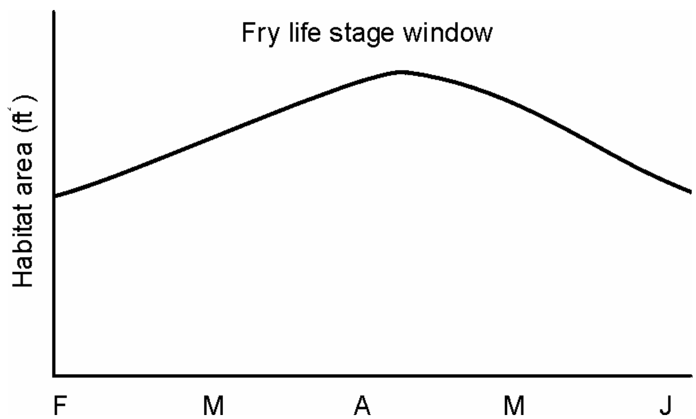

Figure C.3. Hypothetical juvenile Chinook salmon *Habigraph* showing change in fry habitat over time for the life stage window (mid-February to mid-June), from Junction City to the North Fork Trinity River confluence.

The next X-Y relationship is a critical physical-biological crossover, where the X-axis is a physical variable and the Y-axis is a biological variable. These crossover relationships are required in all potential X-Y analyses of the ROD management prescriptions and are vital to an entire pathway’s integrity. The Program must be certain these critical crossover linkages are as good as they can be. If significant error and/or uncertainty still exits and cannot be improved, the entire pathway could be compromised.

For this next X-Y relationship, the X-axis would be Habitat Abundance (ft^2). On first consideration, this variable might appear biological. However total habitat area, estimated by ‘partitioning’ the entire channel bed between Junction City and North Fork Trinity River based on ranges of depth, substrate, velocity, and cover preferred by fry Chinook salmon … still remains a physical variable. To bridge the physical-biological gap, the Y-axis can become daily habitat capacity computed by dividing total ‘preferred’ channel bed area by the minimum area necessary for a fry Chinook salmon. The Y-axis is now a biological variable for fry Chinook salmon capacity. Note that this pathway did not do the traditional switching of the dependent variable from one X-Y relationship to the independent variable of the next X-Y relationship. But actually the switch did occur. The X-axis of Date has no meaning without the total habitat area estimated for that date. Essentially daily total habitat area is the X-axis. This X-Y relationship would look like (Figure C4):

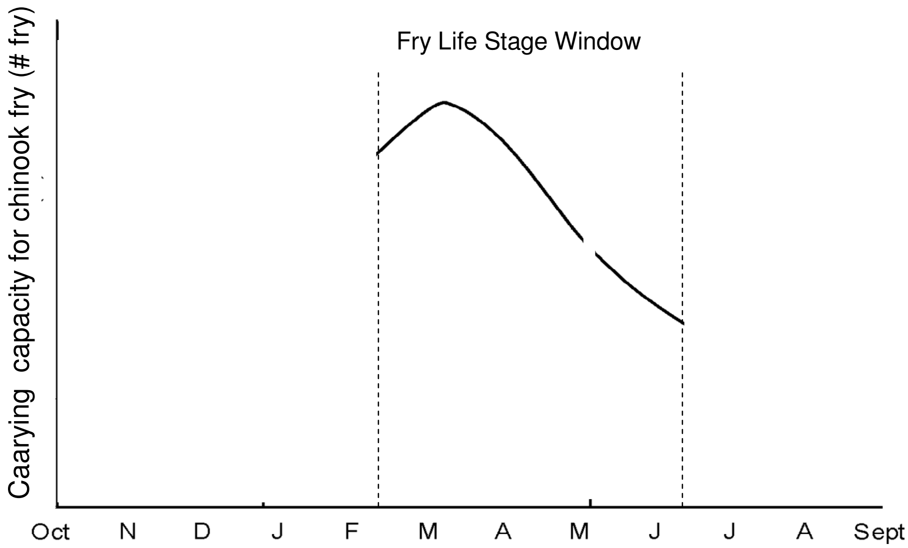

Figure C.4. Example of carrying capacity for Chinook salmon fry as a function of time (daily habitat capacity divided by minimum area required per fry, here assumed to be constant over time).

An estimate of the minimum area needed for each juvenile Chinook salmon is not easy to obtain nor likely a single density value in space or time. Water temperature, food availability, microhabitat features, fish size, and many other possible complicating (and interacting) factors will affect density. This physical-biological cross over should be a high priority monitoring objective, especially If SALMOD will be used to evaluate Program effectiveness. Bad estimates of fry and parr densities will give poor model results, and would defeat efforts to improve other X-Y relationships.

The next X-Y relationship addressing capacity needs to advance fry to the juvenile life stage. The X-axis could be number of potential fry and the Y-axis could be the number of juveniles (parr) (Figure C5):

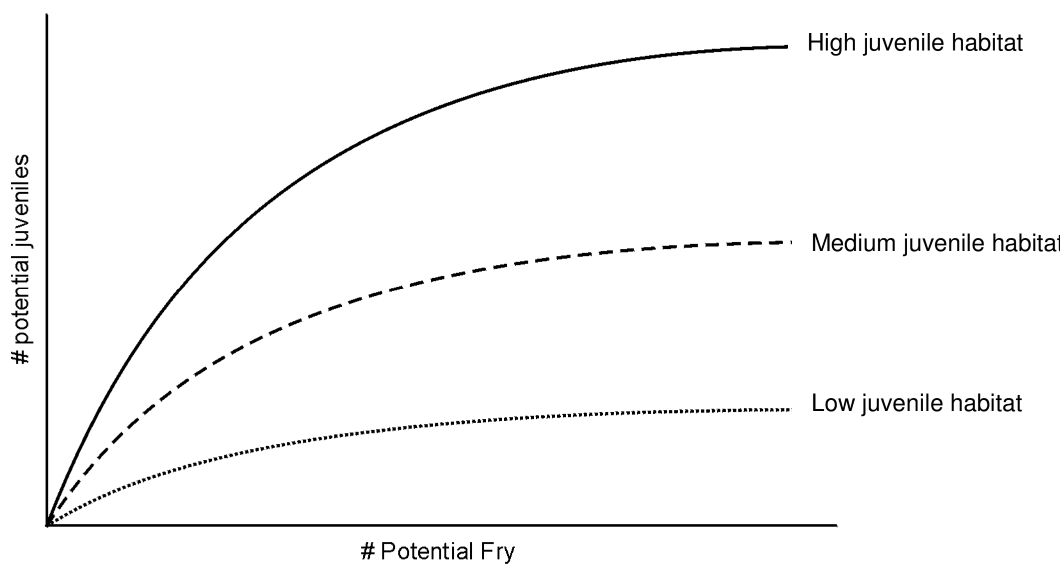

Figure C.5. Example of how # juveniles could vary as a function of # fry, given different amounts of habitat for juveniles.

But, if juvenile habitat capacity cannot support the fry achieving juvenile status, then the X-axis could be juvenile rearing habitat by date and the Y-axis could be the potential number of juveniles when the potential number of fry becoming juveniles exceeds juvenile capacity (Figure C6):

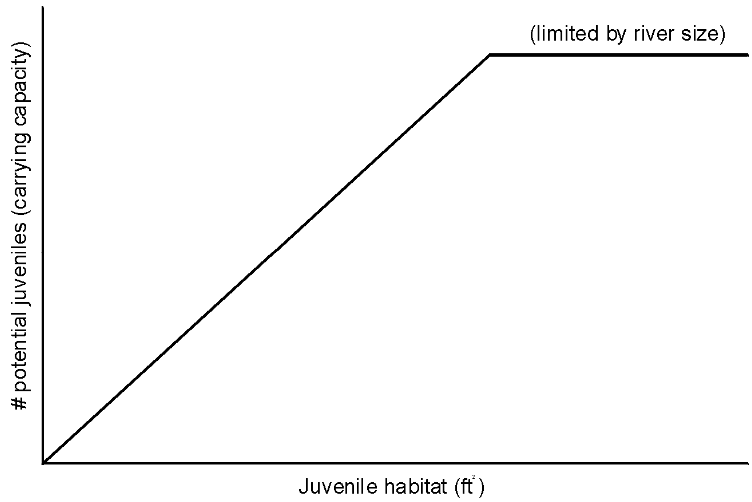

Figure C.6. Carrying capacity for juveniles (# individuals) as a function of the amount of juvenile habitat (ultimately limited by the size of the river and its floodplain).

The former X-Y relationship has the number of fry (and presumably fry habitat) limiting the number of juveniles rearing in the mainstem while this graph has juvenile habitat capacity as the limiting life stage when fry capacity is high. Although the Flow Study contends fry habitat capacity is limiting, juvenile habitat capacity might be limiting in poorer years when fry production is low.

The last two X-Y relationships jointly will determine the potential annual number of rearing juveniles. So far the integrative pathway has lead to an estimate of daily habitat capacity for juvenile Chinook salmon in individual water years originating from the ROD release schedule. But the pathway has not addressed daily habitat quality (i.e., habitat productivity), the other bifurcation in our X-Y pathway noted above.

Habitat productivity

Daily average water temperature should be considered a key ‘player’ influencing habitat quality. Figure C7 illustrates the relationship between water temperature and specific growth rate. Ideally, the Program would want to provide abundant habitat (i.e., provide high habitat capacity) when water temperatures favor juvenile growth. The Program has some influence on daily water temperatures, and therefore can manage habitat capacity AND habitat quality. However, note that Figure C7 displays several curves, each a function of food availability. Can the Program manage food availability as well?

The specific growth rate for juvenile salmonids is highly influenced by food availability (Figure C7). Sullivan *et al.* (2000) note: “As ration increases from maintenance level (no net growth) to satiation or excess level (more than is needed for growth, metabolism, and all physiological functions), the optimum temperature for growth shifts progressively to higher temperatures.” BMIs (as the primary prey source) can be integrated by modifying the specific growth rates for fry and juvenile Chinook salmon. BMIs have a broad water temperature preference range for high productivity that is low relative to optima for juvenile salmonid growth rates.

Rather than ration in Figure C7, expressed as daily percentage of body weight ingested, that distinguishes the several growth curves, the abundance of productive BMI habitat can be substituted. More prey made available by more BMI habitat, from 1.5% body weight captured to 3% captured, would make a big difference in juvenile growth over a wide range of water temperature. Note with poor annual ration levels, inter-annual water temperature differences could cause major swings in size/health, and ultimately survivability, while high annual ration levels would not.

This X-Y relationship is a critical physical⇔biological X-over with X = water temperature and Y = specific growth rate at different abundances of MBIs (Figure C7). Productive BMI habitat would be estimated from a BMI habitat rating curve (developed in the field) and annual thermograph (lower and upper temperature thresholds for high BMI production determined initially from the scientific literature). Targeting Chinook salmon fry and juveniles (from February 15 through June 15), productive BMI habitat availability can be estimated over a set of water years (e.g., WY1990 through WY2007).

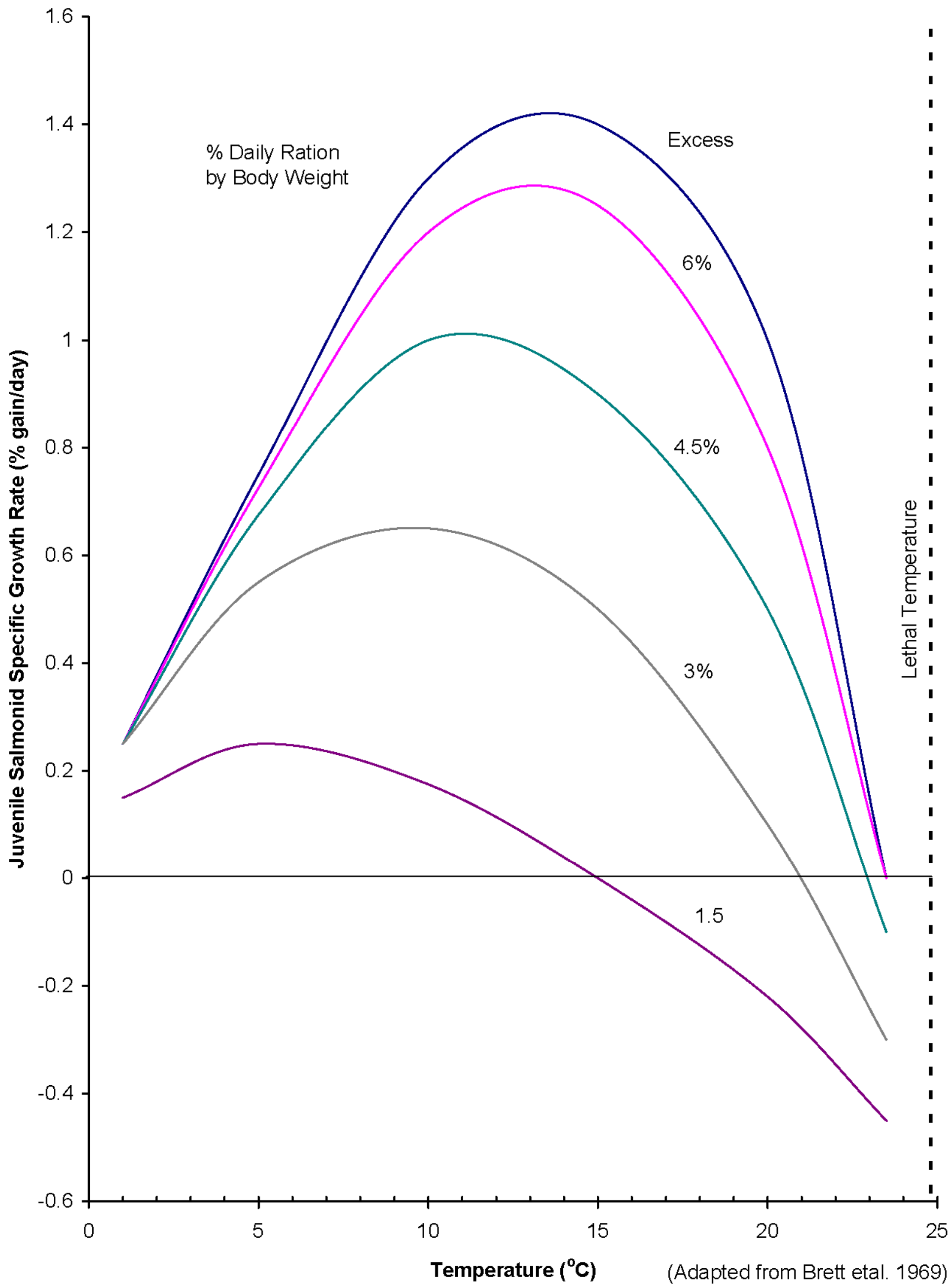

Figure C.7. Juvenile growth as a function of temperature and % daily ration.

Several key needs of this integrative pathway would include: (1) How can productive BMI habitat be identified on the river as a function of depth, velocity, particle size, and water temperature to develop a habitat rating curve and estimate annual habitat availability? (2) How can available productive BMI habitat be substituted for percent ration without requiring a huge research budget? (3) What initial abundance-size class distribution of Chinook salmon fry should be considered to model growth (i.e., an initial fry density (#/ft2))? (4) What are reasonable specific growth rates? (5) How will this abundance-size class (AS-C) distribution of juvenile Chinook salmon be assessed in SALMOD for estimated adult return? (6) How will fry and juvenile density be estimated, for different habitats and river locations possibly affected by seedling levels as well? Chapter 3 would need to address these concerns.

Summary

Two primary X-Y relationships emerged from this preliminary X-Y analysis. One is the "capac-i-graph" (Figure C8) and the other the "grow-a-graph" (Figure C9).

The management goal is to create good habitat for as many days as possible during the Chinook salmon fry and juvenile life stages for as many water years as possible. "Good" means a day with high habitat capacity and high specific growth rates. "High" initially can be estimated as thresholds on the capac-i-graph and growth-a-graph (as noted on both figures). If the window for rearing fry extends from February 15 through May 15, how many days out of this time interval does the Program provide good fry rearing conditions? If the window for rearing juveniles extends from May 01 through June 20, how many days out of this time interval does the Program provide good juvenile rearing conditions?

The next question that should be asked by the Program is how many good days of fry and juvenile rearing conditions are necessary to achieve project goals for adult escapement? This must be approached by applying a population model to forecast survival and adult return. But as more fry and juveniles are produced, presumably from improved habitat capacity, will productivity suffer (i.e., more fish competing for the same food base)? Will producing more, but smaller and possibly less healthy juveniles, result in more returning adults? What is the specific growth rate today, and how does it compare to specific growth rates elsewhere? The present area of productive BMI habitat and present specific growth rate could be used to establish a preliminary baseline.

How does SALMOD incorporate productivity in assessing population responses to ROD management options? Using Bartholow and Henriksen's (2006) application of SALMOD to Klamath River Chinook salmon, fry and juvenile growth was modeled (see page 27) and compared to field data (e.g., in Figure 24, p.65). But SALMOD did not use juvenile size or health directly in modeling population response (i.e., making survival from one life stage to another a partial function of individual length or weight). In their ranking of relative parameter sensitivity (appendix p.108), the first growth parameter (fry growth rate) does not appear until well down on the list (the growth rate would affect when fry become parr, and a different habitat rating curve governing capacity would be modeled). Therefore, if the Program intends to use SALMOD to assess productivity, not just capacity, model modifications will be necessary.

An initial size-class distribution of Chinook salmon fry beginning February 15 can be modeled through June 15 using SALMOD (although the model uses weekly habitat increments rather than daily). The resultant cumulative abundance-size class distribution of Chinook salmon juveniles passing the North Fork Trinity River confluence can be assessed (modeled) for adult return. While SALMOD can apply a survivorship rate to the number of juveniles, the model does not account for the importance of pre-smolt or smolt health/size in adult return. This is a critical information/analytical need for all integrative pathways.

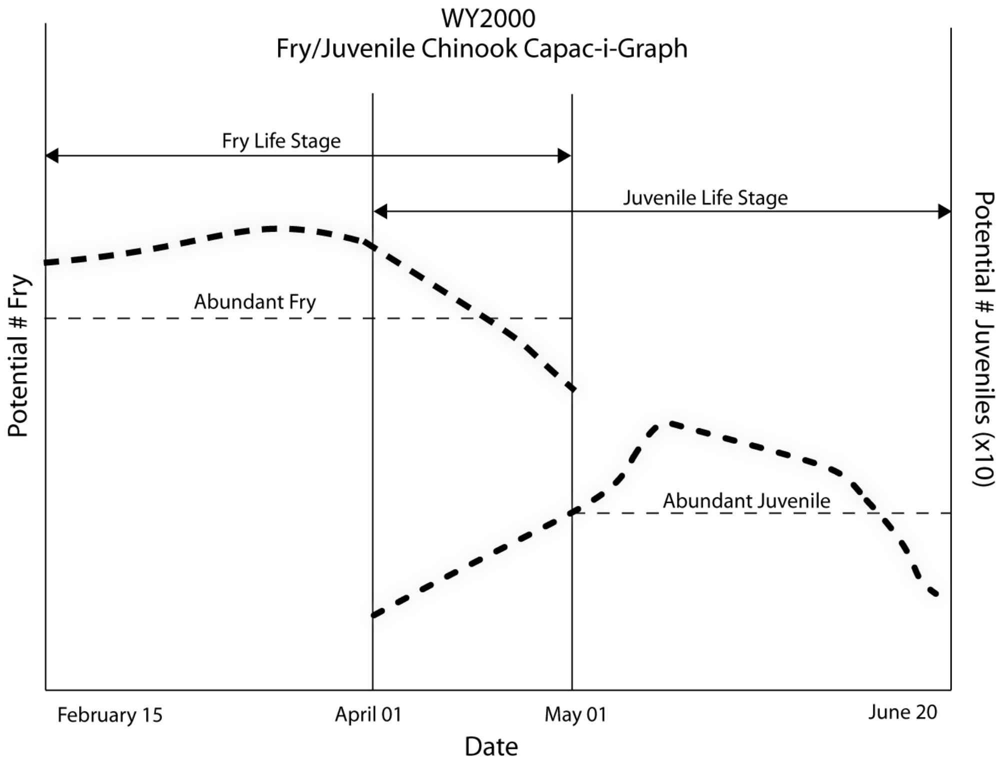

Figure C.8. *Capc-i-graph* showing the potential number of Chinook salmon fry and juveniles as a function of time.

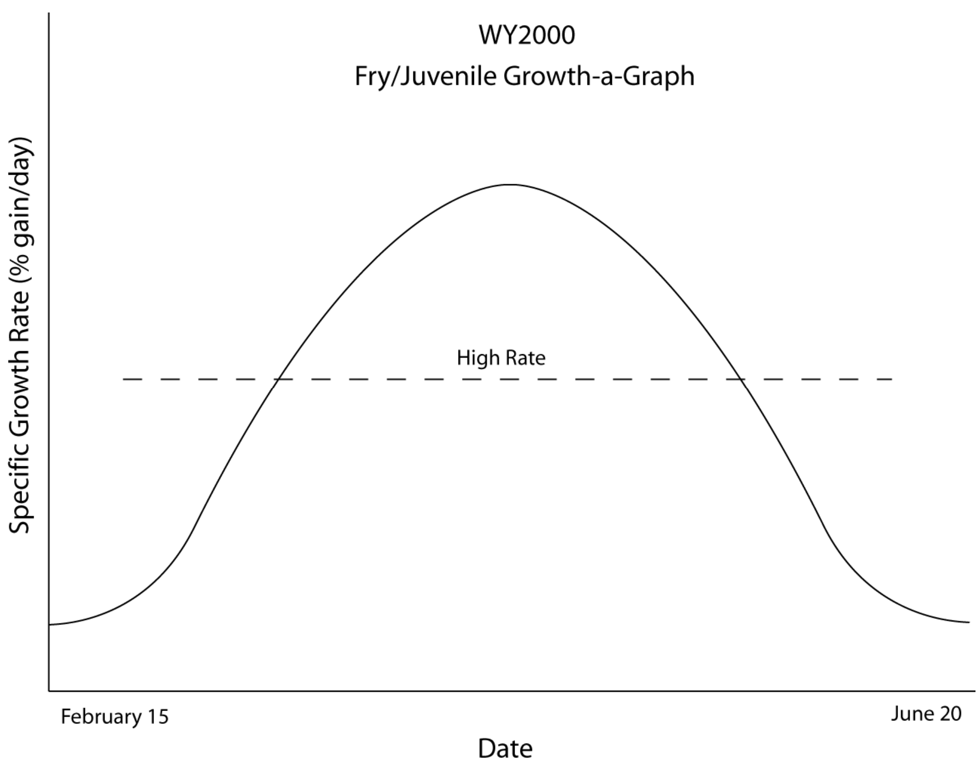

Figure C.9. *Grow-a-graph* showing the daily growth rate as a function of time.

The perception that open point bars (with no overhead vegetative cover) are failures at increasing smolt production ignores several processes, but one likely hugely very important is productivity. A capacity model (with some water temperature mortality thresholds as in SALMOD) for Chinook salmon will undervalue, or not value at all, many river ecosystem components. Productive BMI habitat can be directly connected back to other Program management prescriptions including coarse bed material replenishment creating the alluvial features providing BMI habitat over a wide range of streamflows.

Appendix D. Critical cross-system linkages that need to be understood to conduct AEAM (as identified by participants at IAP Workshop held Nov 6-8, 2007

Linkage Description	Critical Link(s)	Scale(s) of interest (site[28], reach[29], whole system[30])	How would understanding of linkage be used to revise management within AEAM cycle
1) TTRP gravel augmentation leads to improved habitat complexity	Actions → Channel/Sediment → Fish Habitat and Riparian Habitat	Whole system over 10 years +	This linkage would help establish the amount of gravel injections necessary to increase channel/habitat complexity in areas beyond the reach of streambank construction projects
2) Tributary watershed management of fine sediment inputs leads to improved tributary and mainstem fish and wildlife habitat	Watershed management (fine sediment reduction) → Water Quality and Channel/Sediment → Fish and Wildlife Habitat	Tributary reaches and whole system	This linkage would help determine the level of watershed management in tributaries necessary to ensure that aggressive mainstem habitat enhancements are effective
3) TRRP actions create additional fry rearing habitat when 300cfs > Q < 2000 cfs	Actions → channel complexity → fish habitat	Site scale and whole system	If the anticipated habitat response to Actions is not achieved, this would result in changes to management activities, changes to objectives, or changes to the rehabilitation premise
4) TRRP actions create sufficient scour to prevent riparian encroachment and channel simplification	Actions → Channel/Sediment → Riparian	Site scale and reach scale (in Normal and Wet years), and whole system (every 5-10 years)	If anticipated response not achieved then would need to: 1) change the magnitude, duration and frequency of high flow releases, 2) piggyback releases on tributary floods, 3) change amounts of coarse sediment augmentation, and/or 4) change bank rehab site designs
5) TRRP actions create changes in hydrology/temperature/water quality that influence biology of selected wildlife species.	Actions → Hydrology/Temperature/Water Quality → Wildlife	Reach scale	This linkage would identify the desired future condition for wildlife and inform new hypotheses on wildlife response to Actions
6) Improved physical habitat will increase insect production which will increase juvenile fish production.	Actions → Channel/Sediment → Insect Production (Fish Habitat) → Juvenile Fish Production	Whole system (particularly in areas of high juvenile density)	This linkage would help determine optimal substrate types to enhance insect/fish production.
7) Improved riparian habitat will increase insect production which will increase juvenile fish production.	Riparian → Insect Production (Fish Habitat) → Juvenile Fish Production	Whole system (particularly in areas of high juvenile density)	This linkage would help determine optimal riparian planting schemes to undertake to enhance insect/fish production.

[28] Individual bank rehab sites
[29] Downstream of individual bank rehab sites
[30] Lewiston Dam to NF Trinity

Linkage Description	Critical Link(s)	Scale(s) of interest (site[28], reach[29], whole system[30])	How would understanding of linkage be used to revise management within AEAM cycle
8) Actions to increase and improve fry/juvenile habitat will increase juvenile (pre-smolt) production, growth, and survival.	Actions → Hydrology/Temperature/Water Quality and Channel/Sediment → Fish Habitat → Juvenile Fish Production	Whole system (physical habitat – quantity/quality), Lewiston Dam to Weitchpec (temperature). Intra-annual variation in response to managed flows; Inter-annual change in available habitat	This linkage would help determine flows required to change thermal regimes to improve fry growth/survival and alter outmigration timing (dependent on water year type). It would also help to balance long-term geomorph processes with short-term habitat needs. This linkage would also help determine whether to increase or decrease the size or rehab sites or redesign them.
9) Increased diversity of riparian vegetation on different geomorphic surfaces improves fish habitat.	Riparian → Fish Habitat	Site, reach and whole system scales	This linkage would help define targets for riparian vegetation diversity.
10) TRRP actions improve habitat/flow relationships with resulting increases in juvenile fish production. Numbers of spawning adults will simultaneously influence this.	Actions → Hydrology/Temperature/Water Quality and Channel/Sediment → Fish Habitat → Juvenile Fish Production ← Adult Escapement	Whole system or by reach (if expect different number of spawners, flow x habitat relationships or sediment dynamics by reach)	This linkage would help to establish recommended flows to benefit fish. It would also help determine the capacity of the system, refine ideal escapement goals, and lead to development of flow schedules to maximize juvenile fish production as a function of escapement.
11) Riparian condition affects riparian bird abundance (seasonal) and productivity.	Actions → Hydrology/Temperature/Water Quality and Channel/Sediment → Riparian →Wildlife (riparian birds)	Site, reach, and system scales. Measure changes in abundance/productivity of riparian birds in response to changes at each scale	Management conditions affecting riparian vegetation (initiation, survival, development, and characteristics) could be adapted to maximize productivity and abundance of riparian birds.
12) Flow, in the context of Trinity reservoir management, and the ability to supply sufficient cold water to meet temperature requirements	Action (on Flow) → Hydrology/Temperature/Water Quality → Fish Habitat	Whole system (represented by status points – DC, NF, Weichpec) on an interannual basis.	If external conditions lead to depleted cold water pool: 1) coordinate with CVO beforehand (ROD directives); 2) change flow schedule to improve conditions; 3) coordinate with Klamath River basin AO (best candidate possible, etc.) Develop predictive capability (temperature and mass balance models) to identify conditions before they develop – act proactively
13) Management actions affect both temperature and channel morphology which will affect habitat, which affects juvenile production, which then impacts adult escapement	Actions → Temperature → Channel/Sediment → Fish Habitat → Juvenile Fish Production → Adult Escapement	Reach scale (look at temperature, channel, and habitat); System scale (look at juvenile fish production over broad temporal scale; adult recruitment over multiple generation temporal scales)	Linkage provides a long term feedback to management actions and shows how fish populations change in response to full ROD implementation
14) Riparian condition affects fish habitat. Riparian encroachment can however lead to channel simplification. Management actions should lead to inhibition of riparian encroachment.	Actions → Riparian → Channel/Sediment	Site, reach, and system scale to look at issue of riparian encroachment	Understanding how to establish and maintain good fish habitat over a broad range of discharges could give us direct vegetation structure targets. If less costly and more effective methods of limiting encroachment can be found this could allow greater flexibility of vegetation management along the low water.

Appendix E. Nested objectives for the Trinity River Integrated Assessment Plan

Extended Table 2.1, with 3-5 levels of objectives. Levels 4-5 provide greater specificity. The term "achieve" is used when meeting an objective will support another subsubsystem's objective (e.g., achieving riparian objectives supports the fulfillment of wildlife objectives, achieving physical habitat diversity and availability supports fish habitat, riparian and wildlife objectives). The term "linkage" is used when the success of a subsystem's objective depends on the success of another subsystem's objectives, but over which it has no direct influence (e.g., fish production objectives are depends on meeting physical, fish habitat and riparian objectives

Level 1 objectives	**Level 2 Objectives**	**Level 3 Objectives**	**Level 4 Objectives**	**Level 5 Objectives**
1. Create and maintain spatially complex channel morphology	1.1. Increase physical habitat diversity and availability *(achieve Fish Habitat objective 2.1, Riparian objectives 5.1 & 5.2, and Wildlife objectives 6.4.1 & 6.5.1)*	1.1.1.Increase the size, frequency and topographic relief of bar/pool sequences	1.1.1.1 Create and maintain alternate bar morphology	
			1.1.1.2 Maintain pool depths for adult spring-run Chinook salmon holding	
			1.1.1.3 Increase the availability of areas with shallow, low-velocity flow and cover used by juvenile salmonids	
			1.1.1.4 Increase shoreline complexity	
		1.1.2 Increase channel/thalweg sinuosity		
		1.1.3 Increase geomorphic unit and substrate patch diversity		
	1.2 Increase coarse sediment transport and channel dynamics	1.2.1 Increase and maintain target coarse sediment transport rates	1.2.1.1 Release ROD streamflows to provide necessary coarse sediment transport capacity	
			1.2.1.2 Reduce surface grain size distribution of coarse sediment fraction of the bed surface	
		1.2.2 Frequently exceed channel migration, bed mobilization, and bed scour thresholds		
		1.2.3. Encourage bed-level fluctuations on annual to multi-year time scales		
		1.2.4 Route coarse sediment through all reaches	1.2.4.1 Reduce backwater effects at tributary deltas	
	1.3 Increase and maintain coarse sediment storage	1.3.1 Increase bars, side-channels, alcoves, and other complex alluvial features		
	1.4 Reduce fine sediment storage in the mainstem Trinity River	1.4.1 Transport fine sediment through mainstem at a rate greater than tributary input		
		1.4.2 Reduce fine sediment supply from tributary watersheds		
		1.4.3 Encourage fine sediment deposition on floodplains		

Level 1 objectives	Level 2 Objectives	Level 3 Objectives	Level 4 Objectives	Level 5 Objectives
2. Increase/improve habitats for freshwater life stages of anadromous fish to the extent necessary to meet or exceed production goals	2.1 Increase and maintain salmonid habitat availability for all freshwater (in-river and tributary) life stages *(linkage to Riparian Objectives 5.1.2 & 5.2)*	2.1.1 Increase/maintain salmonid fry and juvenile rearing habitat in the upper 40 miles of the mainstem Trinity River by a minimum of 400 % following rehabilitation of fluvial attributes		
		2.1.2 Increase/maintain spawning habitat quantity and quality to 2,550,000 square feet in the upper 40 miles of the mainstem Trinity River		
		2.1.3 Create channel form that reduces loss of fry to stranding in the upper 40 miles of the mainstem Trinity River following rehabilitation during high flows		
		2.1.4 Maintain or increase adult holding habitat from baseline conditions in the mainstem Trinity River		
		2.1.5 Minimize physical impacts to lamprey habitat		
		2.1.6 Minimize physical impacts to other native fish habitats		
		2.1.7 Maintain or increase tributary habitat		
	2.2 Improve riverine thermal conditions for growth and survival of natural anadromous salmonids	2.2.1 Provide optimal temperatures to improve spawning success of spring and fall-run Chinook salmon		
		2..2.2 Improve thermal regimes for rearing growth and survival of juvenile steelhead, coho salmon and Chinook salmon		
		2.2.3 Improve thermal regimes for outmigrant salmonid growth and survival (dependent on water year)		
		2.2.4 Minimize temperature impacts to other native fish habitats		
	2.3 Enhance or maintain food availability for fry and juvenile salmonids	2.3.1 Increase and maintain macroinvertebrate populations *(achieve Fish Production objective 3.1.1)*		
3. Restore and maintain natural production of anadromous fish populations	3.1 Increase spawning, incubation and emergence success of anadromous spawners	3.1.1 Optimize adult utilization of suitable spawning habitat areas in the mainstem within 3-4 brood cycles following rehabilitation of fluvial river processes	3.1.1.1 Maximize flows to spread spawners both down stream and across the channel	
			3.1.1.2 Encourage gravel management to maximize spawning areas both downstream and across channels.	
		3.1.2 Optimize adult utilization of suitable spawning habitat areas in tributaries within 3-4 brood cycles following rehabilitation of fluvial river processes	3.1.2.1 Manage habitat to permit spawner passage to higher elevation habitat	
		3.1.3 Reduce temperature related pre-spawning mortality and protect in-vivo egg viability of anadromous spawners in the mainstem Trinity River		
	3.2 Increase freshwater production of anadromous fish	3.2.1 Increase fry abundance, growth, physical condition, and health from baseline conditions in the mainstem Trinity River within 3-4 brood cycles following rehabilitation of fluvial river processes		

Level 1 objectives	Level 2 Objectives	Level 3 Objectives	Level 4 Objectives	Level 5 Objectives
		3.2.2 Increase outmigrant juvenile life stage abundance, growth, physical condition and health from baseline conditions in the mainstem Trinity River within 3-4 brood cycles following rehabilitation of fluvial river processes		
		3.2.3 Improve juvenile fish production as a function of water temperature and habitat flow relationships from baseline conditions in the mainstem Trinity River within 3-4 brood cycles following rehabilitation of fluvial river processes		
		3.2.4 Reduce clinical disease incidence in Trinity River origin outmigrants in the Klamath River to less than 20% within 5 years		
		3.2.5. Reduce fry stranding in the upper 40 miles of the mainstem Trinity River by 50% following rehabilitation of fluvial river processes		
		3.2.6 Reduce non-native fish predation on naturally produced fish by 50% in the mainstem Trinity River within 3-4 brood cycles following rehabilitation of fluvial river processes (linkage to Wildlife objective 6.3)		
	3.3 Minimize impacts of predation, competition, and genetic interactions between and among hatchery and natural anadromous fish	3.3.1 Limit impacts of hatchery fish predation on naturally produced juvenile salmonids to less than 20% over the 40 miles	3.3.1.1 Reduce competition between naturally produced and hatchery-origin juveniles	3.3.1.1.1 Emphasize rehabilitation of spawning and fry rearing habitat in areas away from the majority of hatchery spawner influence (i.e., 10 miles below hatchery). (*Linkage to Objective 3.1.1)*
				3.3.1.1.2 Avoid rehabilitation in areas of known high proportion of hatchery-origin spawners
			3.3.1.2 Reduce effects of hatchery fish predation on natural fry and juveniles	3.3.1.2..1 Increase escape cover for rearing juveniles [
				3.3.1.2.2 Optimize timing of flows, temperature, and other parameters to encourage rapid movement of steelhead down river
		3.3.2 Increase proportion of Natural Influence (pNI) to 0.7 or greater	3.3.2.1 Encourage genetic diversity of naturally produced adult salmonids	3.3.2.1.1 . Avoid rehabilitation in areas of known high proportion of hatchery-origin spawners
4. Restore and sustain natural production of anadromous fish populations downstream of Lewiston Dam to pre-	4.1 Increase naturally produced fall-run Chinook salmon adult production to the extent necessary to meet or exceed escapement objectives and facilitate expanded harvest opportunity	4.1.1 Increase escapement of naturally produced fall-run Chinook salmon to 62,000 adults		
		4.1.2 Increase harvest of naturally produced fall-run Chinook salmon adults		

Level 1 objectives	Level 2 Objectives	Level 3 Objectives	Level 4 Objectives	Level 5 Objectives
dam levels, to facilitate dependent tribal, commercial, and sport fisheries' full participation in the benefits of restoration via enhanced harvest opportunities	4.2 Increase naturally produced spring-run Chinook salmon adult production to the extent necessary to meet or exceed escapement objectives and facilitate expanded harvest opportunity	4.2.1 Increase escapement of naturally produced spring-run Chinook salmon to 6,000 adults		
		4.2.2 Increase harvest of naturally produced spring-run Chinook salmon adults		
	4.3 Increase naturally produced coho salmon adult production to the extent necessary to meet or exceed escapement objectives and facilitate expanded harvest opportunity	4.3.1 Increase escapement of naturally produced coho salmon to 1,400 adults		
		4.3.2 Increase harvest of naturally produced coho adult salmon adults		
	4.4 Increase naturally produced steelhead adult production to the extent necessary to meet or exceed escapement objectives and facilitate expanded harvest opportunity	4.4.1 Increase escapement of naturally produced steelhead to 40,000 adults		
		4.4.2 Increase harvest of naturally produced steelhead adults		
	4.5 Increase naturally produced Pacific lamprey adult production to the extent necessary to meet or exceed escapement objectives and facilitate expanded harvest opportunity	4.5.1 Increase escapement of Pacific lamprey adults		
		4.5.2 Increase harvest of Pacific lamprey adults		
	4.6 Increase naturally produced green sturgeon adult production to the extent necessary to meet or exceed escapement objectives and facilitate expanded harvest opportunity	4.6.1 Increase escapement of green sturgeon adults		
		4.6.2 Increase harvest of green sturgeon adults		
5. Establish and maintain riparian vegetation that supports fish and wildlife	5.1 Promote diverse native riparian vegetation on different geomorphic surfaces that contribute to complex channel morphology and high quality aquatic and terrestrial habitat *(achieve Fish Habitat objective 2, Fish Production objective. 3.1, and Wildlife objective 6.1)*	5.1.1 Increase species, structural, and age diversity of riparian vegetation to improve and maintain wildlife habitat	5.1.1.1 Provide hydrology to support riparian establishment on floodplains	
			5.1.1.2 Create floodplains by bar building and fine sediment deposition (link to riparian regeneration on FP's section).	
		5.1.2 Encourage establishment of riparian species on surfaces within the future channel migration corridor that will recruit LWD	5.1.2.1 Target the recruitment of riparian tree species on floodplains during wetter water years to contribute future large woody debris supply.	
			5.1. 2.2 Encourage lateral channel migration into mature riparian vegetation	
		5.1.3 Encourage establishment of vegetation that provides habitat for anadromous fish, aquatic organisms and aquatic / riparian wildlife	5.1.3.1 Inundate vegetation on floodplains during High flows (6000 CFS)	
			5.1.3.2 Inundate vegetation on upper bars during Medium flows (450-2000 CFS)	
			5.1.3.3 Inundate vegetation along low water fringe to provide cover during summer fall base flows (above 300 CFS)	
	5.2 Prevent riparian vegetation from exceeding thresholds leading to encroachment that simplifies channel morphology and degrades aquatic	5.2.1 Manage flows, coarse sediment augmentation, and channel rehabilitation that cause sufficient riparian plant mortality along low water margins to prevent channel simplification leading to degraded fish habitat	5.2.1.1 Encourage berm erosion/decomposition.	
			5.2.1.2 Encourage lateral channel migration and point bar deposition to maintain age and species diverse riparian vegetation	

Level 1 objectives	Level 2 Objectives	Level 3 Objectives	Level 4 Objectives	Level 5 Objectives
	habitat quality *(achieve Wildlife Objectives 6.2 & 6.4)*		5.2.1.3 Encourage local scour around roughness features (boulders, large woody debris, bedrock) to scour riparian vegetation along low flow channel fringes.	
			5.2.1.4 Inundate point bars to discourage riparian vegetation initiation on bars	
			5.2.1.5 Scour up to three-year-old (extremely wet), two-year-old (wet years), and one-year-old (normal years) riparian vegetation along low flow channel margins and scour younger plants higher on banks (vertical scour).	
	5.3 Recover riparian vegetation area equal to or greater than that disturbed by physical rehabilitation (achieve Wildlife Objective 6.1)			
6. Rehabilitate and protect wildlife habitats and maintain or enhance wildlife populations following implementation	6.1 Maintain Trinity River populations and species diversity of birds using the riparian zone in the Program area	6.1.1 Enhance quality and maintain quantity of riparian bird nesting and foraging habitats *(linkage to Riparian objective. 5.1)*	6.1.1.1 Increase or maintain abundance of riparian birds during breeding, migration, and over-wintering seasons in existing and developing riparian habitat.	
			6.1.1.2 Increase or maintain productivity (reproductive success) of riparian birds.	
			6.1.1.3 Maintain or increase the number of riparian bird species.	
			6.1.1.4 Increase riparian plant species and structural diversity within the 40 miles. *(linkage to Objectives 5.1, 1.1.3, and 1.1.4)*	
			6.1.1.5 Develop an area of riparian habitat through initiation and revegetation that is equal to the amount before implementation. *(linkage to Objectives 5.1.1 and 5.1.3)*	
	6.2 Maintain Trinity River riverine bird populations and species diversity in the Program area *(linkage to Riparian Objectives 5.1.2 & 5.2)*	6.2.1 Enhance quality and maintain quantity of riverine bird nesting and foraging habitats *(linkage to Physical objective 1.1, Fish Habitat objective 2.3.1, Fish Production objectives 3.2.1 & 3.2.2 and Riparian objectives 5.1 & 5.2)*	6.1.2.1 Increase or maintain abundance of riverine birds. *(linkage to Objectives 1.1, 2, 3.1, 3.2, and 3.3)*	
			6.1.2.2 Increase or maintain productivity of riverine birds. *(linkage to Objectives 1.1, 2, 3.1, 3.2, 3.3, and 5)*	
			6.1.2.3 Maintain species diversity of riverine of birds. *(linkage to Objectives 1, 2, 3.1, 3.2, 3.3, and 5.2)*	
			6.1.2.4 Increase complexity of riverine bird foraging habitats (including: gravel bars and juvenile fish habitat). *(linkage to Objectives 1, 2, 3.1, 3.2, 3.3, and 5.2)*	
	6.3 Minimize impacts of riverine bird predation on fry and smolts	6.3.1 Adapt timing of hatchery release alter distribution of avian predators and minimize predation on natural fry and smolts *(achieve Fish Production objective. 3.3.3)*		
	6.4 Increase population size, survival, distribution, and recruitment success	6.4.1 Increase population size, survival, distribution, and recruitment success of Foothill Yellow-legged Frogs	6.4.1.1 Increase population size and distribution.	
			6.4.1.2 Increase survival and recruitment.	

Level 1 objectives	Level 2 Objectives	Level 3 Objectives	Level 4 Objectives	Level 5 Objectives
	of Foothill Yellow-legged Frogs (FYLF)	6.4.2 Increase quality and quantity of breeding and rearing habitat for Foothill Yellow-legged Frogs *(linkage to Riparian objectives 5.1 & 5.2)*	6.4.2.1 Adjust hydrograph timing to make appropriate habitat (cobble bars) available during breeding season (May-June). (*linkage to Objective 1).*	
			6.4.2.2 Minimize river stage change during egg development to reduce desiccation risk. *(linkage to Objective 1)*	
			6.4.2.3 Provide edgewater habitat to facilitate reaching temperature threshold for oviposition (>12oC). *(linkage to Objectives 1 and 2.2)*	
			6.4.2.4 Establish and maintain alternating point bar channel morphology. *(linkage to Objective 1)*	
			6.4.2.5 Reduce/discourage riparian encroachment on open bars. *(linkage to Objectives 1 and 5.2)*	
	6.5 Increase population size, survival, distribution, and recruitment success of Western Pond Turtle (WPT)	6.5.1 Increase population size, survival, distribution, and recruitment success of Western Pond Turtles	6.5.1.1 Increase population size and distribution.	
			6.5.1.2 Increase survival and recruitment.	
		6.5.2 Increase structural and thermal diversity of aquatic habitats used by various age classes of Western Pond Turtles	6.5.2.1 Increase basking structures *[linkage to Objective 1, LWD]*	
			6.5.2.2 Promote formation of pools and backwaters to increase available habitat quantity and achieve thermal diversity [Achieved by Objectives 1, 2.2, and 6.6]	
		6.5.3 Increase recruitment of younger age classes of Western Pond Turtles	6.5.3.1 Increase nesting habitat *(linkage to Objective 1.4)*	
			6.5.3.2. Increase nest success by reducing nest predation.	
			6.5.3.3 Promote formation of pools and backwaters and marshes for rearing. *(linkage to Objectives 1 and 6.5.1)*	
			6.5.3.4 Control invasive species (bullfrog) in key rearing areas. *(linkage Objectives 6.5.4 and 6.6.1)*	
	6.6 Minimize adverse impacts to additional native riparian or aquatic associated wildlife from Program activities. Focus on wildlife species associated with a healthy river ecosystem, not necessarily all species	6.6.1. Discourage invasive species		

Appendix F. Looking outward matrix (LOM) of subsystem information transfer for undertaking assessments at different spatial scales

The LOM indicates for each subsystem (represented by a column) the information that is required from other subsystems (represented by rows) to generate the desired performance measures for the particular subsystem. The information transferred could be sampled information or modeled indicators. This matrix describes linkages among habitat and population assessments (fish and wildlife). Physical conditions to habitat linkages are not represented in the matrix but these are discussed in sections 3.1 and 3.2 of chapter 3.

SCALE: WHOLE SYSTEM			
Applied To ⇒ **Info Derived From ⇓**	**Juvenile Fish Population Assessments** 1) Lewiston to N. Fork {habitat + temp}; 2) N. Fork to Willow Ck / Weitchpec {temp + size benefits of upper system treatment + other tributary effects};	**Adult Fish Population Assessments – For Fall Chinook salmon** upper 40 miles *to Weitchepec ** to Willow Creek *** to estuary *Notes:* • annual time scale unless otherwise defined	**Wildlife Population Assessments**
Habitat Assessments	• Daily area of suitable spawning and fry rearing habitat from Lewiston to N. Fork, for Chinook salmon, relative to target area needed to meet escapement objectives; or aggregated habitat vs. flow relationship (summarized from reach scale inputs), *which builds towards:* • # good fry habitat days (enough area to meet fry rearing target, good temp range), *integrated with:* • # good benthic riffle habitat days (estimated by stage-discharge relationship at each riffle to get wetted riffle area via a water routing model; need minimum # days (e.g. 6 weeks during insect colonization period) to be used to estimate food availability	• Distribution (*clumpedness*), quality, and quantity of spawning habitat • Distribution, quality, and quantity of rearing habitat • Distribution, quality, and quantity of adult holding habitat* • *want a single number / index that sums up condition for the whole river for each year*	**Birds:** • Habitat amount and location • Habitat quality (e.g., temperature, depth, flow) • LWD for bird cover and access to prey, cover for prey and predators • Macro-invertebrate biomass and diversity **Amphibians/Reptiles:** • Amount and location of habitat suitable for frog reproduction (oviposition and egg development, tadpole survival) • Extent of habitat that includes turtle basking sites (e.g., LWD, rocks), and foraging areas (e.g., side channels) • Macroinvertebrate biomass and diversity

SCALE: WHOLE SYSTEM			
Applied To ⇒ **Info Derived From ⇓**	**Juvenile Fish Population Assessments**	**Adult Fish Population Assessments – For Fall Chinook salmon**	**Wildlife Population Assessments**
Juvenile Fish Population Assessments		• Smolt abundance** • Condition index** • Smolt health (disease) *** • Proportion natural:hatchery • Fry:smolt emigration pattern **	**Birds:** • Hatchery releases (timing and abundance) • Fry and smolt densities by location and season **Amphibians/Reptiles:** • Fry to smolt growth rates at different temperatures
Adult Fish Population Assessments	• annual # successful female natural spawners as measured by carcasses, by 7 reaches to N. Fork, broken down by hatchery origin vs. natural origin fish (uses weir as well) • annual # redds on maps for Chinook salmon, from Lewiston to Weitchpec • estimate of # eggs from size-fecundity relationships, or age-fecundity relationships based on carcass counts and scales		**Birds**: • Spawning locations **Amphibians/Reptiles:** • General location and abundance of salmonid predators (fish utilization map)
Wildlife Population Assessments	• annual index of density of piscivorous aquatic birds over whole system	n/a	
Physical	• SUM (degree days) from fry emergence to fry emigration (refine further) • estimate of daily max and min temperature at nodes throughout system for egg incubation and fry rearing areas between Lewiston and Weitchpec (need less resolution further downstream) • 3.3.1 substrate composition (degree of embeddedness) for both egg incubation index (for spawning areas with potential fine sediment issues, e.g., below Grass Valley Creek) as well as insect production (for rearing areas, riffles)	• Index of river complexity • Metric of gravel introduction *(related to spawning habitat quality up above)* • Index of bar distribution and size • Instream flow*** • Temperature*	**Birds:** • Daily flow rate and days of inundation of riparian habitat by date to estimate potential for nest flooding • Geomorphic mapping showing area of various types of exposed sediments (after major events) as foraging and nesting habitat • In-Channel stream unit map (riffles; pools and runs; bathymetry), (general map for whole 40 miles providing major habitat features) **Amphibians/Reptiles:** • Daily flow and temperature (both of these required to estimate life stage initiations and potential for egg/juveniles scour and/or dewatering) • Inundation map with number of good days for egg masses and tadpoles • Geomorphic mapping showing area of various types of exposed sediments (after major events) as oviposition habitat

SCALE: WHOLE SYSTEM			
Applied To ⇒ **Info Derived From ⇓**	**Juvenile Fish Population Assessments**	**Adult Fish Population Assessments – For Fall Chinook salmon**	**Wildlife Population Assessments**
Riparian		n/a	**Birds:** • Map of vegetation types extending approx. 500m on either side of the river corridor, to be updated with future changes in riparian vegetation (including removal, planting, initiation, age and structure, species composition and patch characteristics) **Amphibians/Reptiles:** • Map of vegetation types extending approx. 500m on either side of the river corridor, to be updated with future changes in riparian vegetation (including removal, planting, initiation, age and structure, species composition and patch characteristics)
SCALE: REACH and LONGITUDINAL SEGMENT			
Applied To ⇒ **Info Derived From ⇓**	**Juvenile Fish Population Assessments**	**Adult Fish Population Assessments**	**Wildlife Population Assessments**

SCALE: REACH and LONGITUDINAL SEGMENT			
Applied To ⇒ **Info Derived From ⇓**	**Juvenile Fish Population Assessments** **Use topographic regions 1-6, and then subdivide region 2 into 3 parts (above canyon, canyon, below canyon).**	**Adult Fish Population Assessments**	**Wildlife Population Assessments**
Habitat Assessments	FOR SALMOD:- daily area of suitable spawning and fry rearing habitat from Lewiston to N. Fork, for Chinook salmon, relative to target area needed to meet escapement objectives (by reach); habitat vs. flow relationship for each stream margin edge types and % of these types / reach[31], FOR REHAB EVALUATION: Currently being done in Trinity at rehab sites only. Stratified by geomorphic / meso-habitat / sub meso-habitat type (Martin and Goodman 2007 / 08). Maps of usable area at a range of flows (e.g., 300, 450, 2000 cfs, reflecting the range of flows that exist throughout fry rearing period) FOR EMPIRICAL ANALYSIS: - • # good fry habitat days (enough area to meet fry rearing target, good temp range) by reach, for time period of interest • # good benthic riffle habitat days (estimated by stage-discharge relationship at each riffle to get wetted riffle area via a water routing model; need minimum # days (e.g., 6 weeks during insect colonization period) to be used to estimate food availability	n/a	**Birds:** n/a **Amphibians/Reptiles:** n/a
Juvenile Fish Population Assessments		n/a	**Birds:** n/a **Amphibians/Reptiles:** n/a

[31] This was done in Klamath. Has not been done yet in Trinity. Vegetative / cover types (stream margin / edge type) e.g. < 2'/sec, <3' of depth, within 2' of cover

SCALE: REACH and LONGITUDINAL SEGMENT			
Applied To ⇒ **Info Derived From ⇓**	**Juvenile Fish Population Assessments**	**Adult Fish Population Assessments**	**Wildlife Population Assessments**
Adult Fish Population Assessments	• annual # successful female natural spawners as measured by carcasses, by 7 reaches to N. Fork • annual # redds on maps for Chinook salmon, to confirm locations • estimate of # eggs from size-fecundity relationships, or age-fecundity relationships based on carcass counts and scales		**Birds:** • Spawning locations **Amphibians/Reptiles:** n/a
Wildlife Population Assessments	• density of piscivorous aquatic birds by reach and longitudinal segment during fry emergence period	n/a	
Physical	• use USGS flow stations, or Mike Deas temp model estimated flows for each reach	n/a	**Birds:** • In-Channel stream unit map (riffles; pools and runs; bathymetry) (detailed maps for representative reaches of 1.5 miles) ~ 7.5 miles total mapped in detail and used to extrapolate **Amphibians/Reptiles:** • Annual index of gravel bars/area by reach • Measure of change in sinuosity
Riparian		n/a	**Birds:** • Map of vegetation types extending approx. 500m on either side of the river corridor, to be updated with future changes in riparian vegetation (including removal, planting, initiation, age and structure, species composition and patch characteristics) **Amphibians/Reptiles:** n/a

SCALE: SITE *{need to specify what this means}*			
Applied To ⇒ **Info Derived From ⇓**	**Juvenile Fish Population Assessments**	**Adult Fish Population Assessments**	**Wildlife Population Assessments**

SCALE: SITE *{need to specify what this means}*			
Applied To ⇒ **Info Derived From ⇓**	**Juvenile Fish Population Assessments**	**Adult Fish Population Assessments**	**Wildlife Population Assessments**
Habitat Assessments	• habitat assessors build up to a reach from specific sites and transects; • fry assessors go to a 50m reach. There may be ~7 different cover types.	n/a	**Birds:** • Habitat amount and location • Habitat quality (e.g., temperature, depth, flow) • LWD for bird cover and access to prey, cover for prey and predators • Macroinvertebrate biomass and diversity **Amphibians/Reptiles:** • Number of suitable breeding days for FYL frogs • Amount and location of habitat suitable for frog reproduction (oviposition and egg development, tadpole survival) • Extent of habitat that includes turtle basking sites (e.g., LWD, rocks), and foraging areas (e.g., side channels) • Macroinvertebrate biomass and diversity
Juvenile Fish Population Assessments		n/a	**Birds:** **Amphibians/Reptiles:**
Adult Fish Population Assessments	• annual # spawners at rehab sites and upstream control sites, for Chinook salmon, coho salmon and steelhead		**Birds:** **Amphibians/Reptiles:** • Density of brown trout
Wildlife Population Assessments	• density of piscivorous aquatic birds at rehab sites and upstream control sites, during fry emergence period	n/a	
Physical	• visual estimate of embeddedness to relate to fry standing stock estimates	n/a	**Birds:** • Substrate facies map that can show area of various types of exposed sediments at rehabilitation sites **Amphibians/Reptiles:** • Medium priority: Substrate facies map that can show area of various types of exposed sediments at rehabilitation sites • Change in gravel bar area pre/post rehab site construction

SCALE: SITE *{need to specify what this means}*			
Applied To ⇒ **Info Derived From ⇓**	**Juvenile Fish Population Assessments**	**Adult Fish Population Assessments**	**Wildlife Population Assessments**
Riparian		n/a	**Birds:** • Map of vegetation types covering the extent of actions and changes at each rehab site, to be updated with future changes in riparian vegetation (including removal, planting, initiation, age and structure, species composition and patch characteristics) • **Amphibians/Reptiles:** • Proximity of riparian vegetation to Shoreline • Map of vegetation types covering the extent of actions and changes at each rehab site, to be updated with future changes in riparian vegetation (including removal, planting, initiation, age and structure, species composition and patch characteristics

Appendix G. Required information to develop a sampling design

The following list has been modified from Province of British Columbia (2008).

The intention of this list of questions is to act as a guide when developing a sampling design. The order of the questions as presented here is not absolute, rather answering these questions will require an iterative approach where some questions will be revisited and refined in response to answers to other questions.

1. Clearly state the study objective.

2. Performance Measure (PM)
    - *What information do you need in order to assess the objectives?*

3. Data needs
    - *What data do you need to collect in order to generate the PM? (For example you need age-structure, natural:hatchery, harvest, escapement etc… in order to estimate 'Recruitment.')*

4. Describe how you intend to **analyze** the data, i.e., describe what you would do with the data if you had it?
    - *Trend analysis.*
    - *Before/after comparisons.*
    - *Control vs. Rehab sites.*
    - *Formal experiments of different hydrographs or gravel regimes.*
    - *Multiple regression analyses.*

5. Baseline data
    - *How much baseline data is available, if any? What is the quality of the data? Can you use it for before/after comparisons? Can existing data be used to provide initial estimates of variability that can be used in power analyses or sample size calculations?*

6. Key uncertainties
    - *What are the key uncertainties that need to be addressed within each assessment? (This may be identified in other documents and only needs to be pulled out from there or you can point us to the relevant section). These can help identify where an RFP may be helpful.*

7. Protocols
    - *What are existing or proposed protocols?*
    - *Is there much controversy in the methods (if so, describe) or are they well established?*
    - *What monitoring is done now?*
    - *How is it done?*
    - *How much effort?*
    - *Estimated cost*?

8. Describe any important life history characteristics or logistical constraints.
    - *Are there any life history characteristics or logistical constraints that will affect the sampling design? (e.g., behavior, timing, logistical difficulties due to flows…)*

9. Define the target population.
    - *Consider space and time, habitat availability in summer vs. winter. Need to be explicit. Are there any exclusion criteria (locations you aren't interested in for some reason)?*

10. Define an appropriate sampling unit.
    - *The size and shape of a sampling unit can affect the efficiency of the estimate, both in a statistical sense (minimizing confidence intervals) and a logistical sense (minimizing effort).*
    - *May want to take the following into consideration when choosing sampling units:*
        - *convenient*
        - *efficient*
        - *minimize variability among sampling units*
        - *easy to obtain sampling frame*

11. Determine how sampling units should be positioned (stratified, systematic)
    - *Is stratification appropriate? (i.e., is between strata variability > within stratum variability).*
    - *How is the attribute distributed? Are there any known gradients in the target population? This information can be used to help determine between a random, systematic, or GRTS design (see Appendix I).*

12. Determine an appropriate sample size at each step of the design
    - *Having some idea of what size change you wish to be able to detect will help us to answer this.*
    - *Additionally determining what existing data you have will help as we can use this to do preliminary power analyses.*

13. Determine an appropriate sampling frequency
    - *There are really 2 questions here: frequency/timing of sampling 1) within a year, and 2) across years.*
    - *What time of day should you sample.*
    - *What time of the year should you sample.*
    - *Do you need multiple measurements in time (i.e. monthly or daily mean).*
    - *Should you use permanent or. temporary sites (or some combination).*

14. With what other assessments would you want to integrate to get better information? How would you integrate with them?
    - *Think about who is dependent on the data produced by the assessment? What data collected by other assessments do you need?*
    - *Consider where you would like to have overlap—rehabilitation sites, non-rehabilitation sites, confined, unconfined?*

Appendix H. Table of assessments[1]

In developing the inclusive, integrated sampling design for Chapter 4, we catalogued all proposed assessments (Table H.1), and reviewed all existing sampling designs and monitoring protocols with Program scientists (Appendix L). As described in Section 2.4 of the IAP, Table H.1 includes two forms of prioritization: efforts by IAP authors to prioritize *within each component* (i.e., physical, fish habitat, juvenile fish production, adult fish production, riparian, wildlife), based on the consensus judgment of the authors working within that component; and 2) efforts by the IAP Steering Committee to prioritize assessments *across components* through an overall ranking, both over the short term (2009-2013) and over the long term (2014 and beyond). Assessments are listed below grouped by component (not ranked order), and include other information on each assessment.

Table H.1. List of Program assessments, including prioritization within individual components.

IAP Component	Objective(s)	Assessment	Assessment type (primary benefit)	Description	Priority within component	General ranking guideline	Scale	Survey Type (See IAP section 4.5)	How often are data needed? (See IAP section 4.5)	Contingent Assessment? (Y/N - See IAP section 2.4)	If Contingent, describe what objective (column B) and assessment (column C) that it is contingent upon	Potential Clustered Assessment? (Y/N)	If Clustered Assessment, list what objective (column B) and assessment (column C) that it is contingent upon
Physical	1.1.1	1P	Both	Quantify changes in channel width/geometry and geomorphic features within the wetted channel (including sinuosity, radius of curvature, thalweg crossings, controls, length of edge (banklength), etc.)	First	9	System wide	Census	After channel changing flow events	N		Y	1.1.1 12P; 1.1.1 2P; 5.2.1 15P
Physical	1.1.1	12P	Needed to revise rehab proj	Assess design performance of specific design features (alcoves, side channels, lowered floodplains, etc)	First	14	Site	Sample and model	Annual	N		N	
Physical	1.2.1, 1.2.4, 1.3.1	14P	Needed to revise flow	Predict sediment transport and use predictions to help guide annual flow scheduling process.	First	15	System wide	Model	Annual	Y	Physical processes subgroup needs to discuss predictions using rating curves or model	Y	1.2.1 7P
Physical	1.2.1	5P	Needed to revise specific actions	Monitor bedload transport rates, compute coarse sediment loads, and evaluate coarse sediment rating curves that are expected to change over time in response to management actions.	First	17	System wide	Non-rep / model	Annual	N		Y	1.3.2 8P
Physical	1.2.2	6P	Needed to revise specific actions	Monitor bed mobility and scour thresholds	First	19	System wide	Sample	Annual	N		Y	5.2.1 3R
Physical	1.4.1, 3.1.1	16P	Progress towards goals	Evaluate spawning gravel quality in upper reach(es)	First	29	Site	Sample	Annual	Y	Pilot project being conducted in 2009, more extensive sampling depends on results of pilot effort	N	
Physical	1.4.1	9P	Needed to revise specific actions	Map and quantify fine sediment storage on the bed surface of the mainstem	First	30	Reach	Sample	Annual	Y	Do this assessment if field observations suggest large changes in fine sediment storage on the bed surface	Y	1.1.1 13P
Physical	1.2.1, 1.2.2, 1.2.3, 1.2.4	7P	Needed to revise specific actions	Predict changes in gravel storage as determined from coarse sediment budget calculations	First	38	System wide	Non-rep / model	Annual	Y	depends on mainstem coarse sediment transport data	Y	1.2.1 14P
Physical	1.3.2	8P	Needed to revise specific actions	Monitor coarse sediment inputs from tributaries	First	39	System wide	Non-rep / model	Annual	Y	do this assessment if topographic differencing method doesn't work	Y	1.2.1 5P; 1.4.2 11P
Physical	1.1.1	2P	Needed to revise specific actions	Monitor variability in bed elevations	First	46	Reach	Sample	Annual	N		Y	1.1.1 1P
Physical	1.4.1, 3.1.1	17P	Progress towards goals	Compute fine sediment budget (input, output, change in storage).	First	47	Site	Sample	Annual	Y	depends on mainstem coarse sediment transport data	Y	1.2.1 7P; 1.2.1 14P
Physical	1.1.1	3P	Needed to revise specific actions	Assess hydraulic parameter variability in 2-D model	Second	57	System wide	Sample	Annual	Y	Possibly assess this if other channel complexity performance measures don't pan out	N	

IAP Component	Objective(s)	Assessment	Assessment type (primary benefit)	Description	Priority within component	General ranking guideline	Scale	Survey Type (See IAP section 4.5)	How often are data needed? (See IAP section 4.5)	Contingent Assessment? (Y/N - See IAP section 2.4)	If Contingent, describe what objective (column B) and assessment (column C) that it is contingent upon	Potential Clustered Assessment? (Y/N)	If Clustered Assessment, list what objective (column B) and assessment (column C) that it is contingent upon
Physical	1.1.1	4P	Needed to revise specific actions	Monitor water surface elevations and water surface slopes	Second	58	System wide	Sample	Annual	N		N	
Physical	1.4.1, 1.4.3	10P	Needed to revise specific actions	Monitor fine sediment removal/migration from mainstem berms and river banks	Second	59	System wide	Non-rep	Annual	Y	Assess this if we see field evidence of sand berm removal from fluvial processes	Y	1.1.1 15P
Physical	1.4.2	11P	Needed to revise specific actions	Monitor fine sediment delivery from tributary streams	Second	60	System wide	Sample	Infrequent	Y	Possibly re-assess this when larger scale watershed rehabiltation occurs	Y	1.2.1 5P; 1.3.2 8P
Physical	1.1.1	13P	Progress towards goals	Map coarse bed-surface grain sizes	Second	61	Reach	Census	After channel changing flow events	Y	Perhaps a longer-term revisit after substantial change has occurred?	Y	1.4.1 9P
Physical	1.1.1, 5.2.1	15P	Progress towards goals	Quantify historic and future topographic change to document lateral scour, deposition, and riparian berm evolution	Second	62	System wide	Sample	After channel changing flow events	Y	Perhaps a longer-term revisit after substantial change has occurred?	Y	1.4.1 10P
Habitat	2.1.1, 2.1.7	2H	Both	Map and quantify the extent (area) of available fry/juvenile rearing habitat throughout the mainstem	First	1	System wide	GRTS - Rotating Panel	Dependent on rotating panel	N		Y	2,3 J
Habitat	2.1.1	1H	Both	Map and quantify the extent (area) of available fry/juvenile rearing habitat at rehab sites	First	2	Site	GRTS - Rotating Panel	Dependent on rotating panel	N		Y	2,3 J
Habitat	2.2.1. 2.2.2, 2.2.3	7H	Needed to revise specific actions	Monitor water temperatures at existing Trinity River temperature stations (supplemented where necessary) to model achievement of species-specific Water Year and seasonal temperature targets for rearing juveniles, outmigrating smolts and spawning adults	First	6	System wide	Model	Daily / Seasonal	N		Y	3.2.2, 3.2.3, 3.2.4
Habitat	3.2.1	3H and 4H	Progress towards goals	Map and quantify the extent (area) of available adult spawning habitat at rehab sites and throughout the mainstem	Second	18	System wide	GRTS	After channel changing flow events	N		Y	3.1.1, 3.1.2
Habitat	2.2.2	8H	Both	Monitor the degree of thermal heterogeneity for the program area	Second	35	System wide	Census	After channel changing flow events	Y	do side chanenls and other changes to the river benefit growth and survivlal of coho or steelhead especially by late summer, sufficent refugia at low flow for steelhead adult springers etc.	N	
Habitat	2.2.1. 2.2.2, 2.2.3	12H	Needed to revise specific actions	Re-evaluate appropriateness of the species-specific Water Year and seasonal temperature targets for rearing juveniles, outmigrating smolts and spawning adults being used in the Trinity River	Third	36	System wide	Model	Infrequent	Y	after rehabs have been done - should we readress the effects of water temps on survial etc., stop migrating after 22 degrees, effects on temp., any new info in literature on influence of temp on survial and growth by species.	N	
Habitat	3.2.1	13H	Progress towards goals	Determine potential habitat carrying capacity for anadromous fish species	Third	40	System wide	Model	After channel changing flow events	N		Y	3.2.1, 3.2.3
Habitat	2.1.2, 2.1.7	3H and 4H	Progress towards goals	Map and quantify the extent (area) of available adult holding habitat at rehab sites and throughout the mainstem	Second	44	System wide	GRTS	After channel changing flow events	Y	rehab sites and effects of gravel addtions and changes, geomorphic changes that influence depth and location of deeper areas.	N	
Habitat	2.1.7	6H	Progress towards goals	Map and quantify the available spawning and rearing habitat in tributaries	Second	48	System wide	GRTS	Infrequent	Y	more specific to coho and steelhead and maybe spring Chinook . Evidence of non natal rearing in lower Klamath and mid klamth - do we need to look at this in the Trinity because coho is a listed species?	what about GRTS non rotating panel	

IAP Component	Objective(s)	Assessment	Assessment type (primary benefit)	Description	Priority within component	General ranking guideline	Scale	Survey Type (See IAP section 4.5)	How often are data needed? (See IAP section 4.5)	Contingent Assessment? (Y/N - See IAP section 2.4)	If Contingent, describe what objective (column B) and assessment (column C) that it is contingent upon	Potential Clustered Assessment? (Y/N)	If Clustered Assessment, list what objective (column B) and assessment (column C) that it is contingent upon
Habitat	2.3.1	9H	Progress towards goals	Monitor abundance of macroinvertebrate prey available as drift	Third	49	Site or reach	GRTS	seasonally infrequent	Y	if CVPIA report and data collected seems to indicate that food is limiting on Trinity	what about GRTS non rotating panel	
Habitat	2.3.1	10H	Both	Monitor standing crop and production rates of macroinvertebrate populations	Third	50	Site or reach	Sample	seasonally infrequent	Y	if CVPIA report and data collected seems to indicate that food limiting on Trinity	N	
Habitat	2.1.1, 2.1.2, 2.1.3, 2.1.4	5H	Progress towards goals	Map the full suite of microhabitats (depths and velocities) available for different life stages within selected mainstem reaches of species not covered by 2H.	Third	54	System wide	GRTS - Rotating Panel	After channel changing flow events	Y	this appears redundant - what is really meant?	N	
Habitat	2.3.1	11H	Needed to revise specific actions	Monitor extent (area) of available macroinvertebrate habitat and the duration of inundation of specific macroinvertebrate habitats under a range of flows	Third	66	Reach	Census	seasonally infrequent	Y	if CVPIA report and data collected seems to indicate that food os limiting - is food limiting on Trinity?	N	
Fish (adult)	4.1.1, 4.2.1, 4.3.1	22A	Progress towards goals	Develop cohort reconstructions for Chinook and coho and evaluate cohort performance or year class strength, and population growth rate	First	20	System wide	Model	Annual	N		Y	4.2.1-13a, 17a,18a
Fish (adult)	4.1.2	16A	Progress towards goals	Monitor harvest (tribal, sport and commercial) of naturally produced spring Chinook	Second	25	System wide	Sample	Annual	N		N	
Fish (adult)	3.1.1, 3.1.2, 3.1.3	3A	Progress towards goals	Monitor pre-spawning mortality to assess the number and proportion of un-spawned or partially spawned female Chinook and coho salmon	First	31	System wide	Exist - census	Annual	N		Y	3.1.1, 3.1.2
Fish (adult)	4.3.2	18A	Progress towards goals	Monitor harvest (tribal, sport and commercial) of naturally produced coho	Second	41	System wide	Exist - census	Annual	N		N	
Fish (adult)	4.4.2	19A	Progress towards goals	Monitor harvest (tribal, sport and commercial) of naturally produced steelhead	Second	42	System wide	Sample	Annual	N		N	
Fish (adult)	4.1.1, 4.2.1, 4.3.1	23A	Progress towards goals	Model the variation in brood year performance for Chinook and coho attributable to in-river conditions and ocean conditions	First	45	System wide	Model	Annual	N		Y	4.2.1-13a, 17a,18a
Fish (adult)	3.1.1, 3.1.2	2A	Progress towards goals	Monitor redd superimposition metrics	Third	67	System wide	Census	Annual	Y	if too many redds in an area then detail placment of redds to estimate superimposition may be needed	Y	3.1.1, 3.1.2
Fish (adult)	3.3.2	9A	Progress towards goals	Monitor pNI	Third	68	System wide	Model	Every 5 years	N		Y	4.2.1-13a, 3.1.1,3.1.2; 1A
Fish (adult)	3.1.3	4A	Progress towards goals	Monitor in-vivo egg viability	Third	69	System wide	Sample	Infrequent	Y	If temperatures were very high in river would we be concerned	N	
Fish (adult)	4.5.1	14A	Progress towards goals	Monitor adult escapement of Pacific lamprey	Third	70	System wide	Census	Infrequent	Y	if tie to our management actions	N	
Fish (adult)	4.5.2	20A	Progress towards goals	Monitor harvest (tribal) of naturally produced Pacific lamprey	Third	71	System wide	Sample	Infrequent	Y	if tie to our management actions	N	
Fish (adult)	4.6.1	15A	Progress towards goals	Monitor adult escapement of Green Sturgeon	Third	72	System wide	Census	Infrequent	Y	if listed, if tie to our management actions	N	
Fish (adult)	4.6.2	21A	Progress towards goals	Monitor harvest (tribal) of naturally produced green sturgeon	Third	73	System wide	Sample	Annual	Y	if tie to our management actions	N	
Fish (adult)	4.1.1, 4.2.1, 4.3.1	22A	Progress towards goals	Develop cohort reconstructions for Chinook and coho and evaluate cohort performance or year class strength, and population growth rate	First	20	System wide	Model	Annual	N		Y	4.2.1-13a, 17a,18a
Fish (adult)	4.1.2	16A	Progress towards goals	Monitor harvest (tribal, sport and commercial) of naturally produced spring Chinook	Second	25	System wide	Sample	Annual	N		N	
Fish (adult)	3.1.1, 3.1.2, 3.1.3	3A	Progress towards goals	Monitor pre-spawning mortality to assess the number and proportion of un-spawned or partially spawned female Chinook and coho salmon	First	31	System wide	Exist - census	Annual	N		Y	3.1.1, 3.1.2

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Fish (juvenile)	3.2.1, 3.2.3	1J	Progress towards goals	Monitor fry density and abundance at rehab sites	Second	21	Site	GRTS - Rotating Panel	Dependent on rotating panel	N		Y	2.1,1, 2.1.7,
Fish (juvenile)	3.2.2, 3.2.3, 3.2.4	4J-SHD and COH	Progress towards goals	Monitor smolt outmigrant numbers	First	23	System wide	Sample	Annual	N		Y	3.2.2, 3.2.3, 3.2.4
Fish (juvenile)	3.2.1	3J	Progress towards goals	Monitor size (length/wt and condition of fry)(fish in hand)	First	24	System wide	GRTS - Rotating Panel	Dependent on rotating panel	N		Y	2.1,1, 2.1.7,
Fish (juvenile)	3.3.1	9J	Progress towards goals	Monitor the proportion of hatchery reared to natural smolt outmigrants (best undertaken in conjunction with assessment 4J)	First	32	System wide	Sample	Annual	N		Y	3.2.2, 3.2.3, 3.2.4
Fish (juvenile)	3.3.1	8J	Progress towards goals	Monitor predation rates by hatchery reared fish (primarily steelhead) on natural fry	Third	53	System wide	Sample	Infrequent	Y	if do not see an increase in netural after rehqb then woud begin to ook in detail at these factors again	N	
Fish (juvenile)	3.2.5	5J	Needed to revise specific actions	Monitor fry strandings numbers and evaluate as proportion of annual production	Third	55	System wide	Sample	Annual	Y	major geomorphic or channel change do we still have stranding in places we knew were problematic, or after completion of Phase or 1	N	
Fish (juvenile)	3.3.1	7J	Progress towards goals	Monitor abundance of non-native predatory fish species and their predation rates on fry and smolts	Third	56	Reach	Sample	Infrequent	Y	non recovery or slow recovery, initial pop estimate for brown trout	Y	3.3.3; 3.6.6
Fish (juvenile)	3.2.6	6J	Progress towards goals	Monitor abundance of non-native predatory fish species and their predation rates on fry and smolts at rehab sites	Third	65	Site	Sample	Annual	Y	initail pop estimate for brown trout	Y	
Fish (juvenile)	3.2.1, 3.2.3	1J	Progress towards goals	Monitor fry density and abundance at rehab sites	Second	21	Site	GRTS - Rotating Panel	Dependent on rotating panel	N		Y	2.1,1, 2.1.7,
Fish (juvenile)	3.2.2, 3.2.3, 3.2.4	4J-SHD and COH	Progress towards goals	Monitor smolt outmigrant numbers	First	23	System wide	Sample	Annual	N		Y	3.2.2, 3.2.3, 3.2.4
Fish (juvenile)	3.2.1	3J	Progress towards goals	Monitor size (length/wt and condition of fry)(fish in hand)	First	24	System wide	GRTS - Rotating Panel	Dependent on rotating panel	N		Y	2.1,1, 2.1.7,
Fish (juvenile)	3.3.1	9J	Progress towards goals	Monitor the proportion of hatchery reared to natural smolt outmigrants (best undertaken in conjunction with assessment 4J)	First	32	System wide	Sample	Annual	N		Y	3.2.2, 3.2.3, 3.2.4
Riparian	5.1.1, 5.1.2, 5.1.3, 1.1.1	1R	Needed to revise specific actions	Map and quantify changes in riparian floodplain vegetation (e.g., species, age-class, initiation success, structural attributes) at GRTS sites, including near-channel vegetation	First	10	Site	GRTS	Annual	N		Y	5.2.1 3R; 5.1.1 2R
Riparian	5.2.1	3R	Needed to revise specific actions	Map and quantify the state of near-channel riparian vegetation at GRTS sites	First	16	System wide	GRTS	Dependent on rotating panel	N		Y	1.2.2 6P; 5.2.1 4R; 5.1.1 2R
Riparian	5.2.1	5R	Needed to revise specific actions	Model how streamflow actions will affect the bank location of initiating seedlings	First	26	Site	Non-rep / model	Annual	Y	If we have a Wet or Extremely Wet water year	N	
Riparian	5.1.1, 5.1.2, 5.1.3, 1.1.1	2R	Progress towards goals	Map and quantify the distribution of vegetation types in the river's floodplain riparian zone and across the valley bottom	Second	34	System wide	Census	Infrequent	N		Y	5.1.1 1R; 5.2.1 3R
Riparian	5.2.1, 1.1.1	4R	Needed to revise specific actions	Monitor plant induced berm-growth	Second	63	Site	Non-rep	Annual	Y	Assess this if we see field evidence of sand berm formation from riparian encroachment	Y	5.2.1 3R
Wildlife													

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Wildlife	6.1.1	4W	Progress towards goals	Monitor abundance and composition (richness/diversity) of riparian bird species during breeding, post-breeding and migration periods	First	11	Reach and/or system wide	Sample	Annual	N		N	
Wildlife	6.4.1	11W	Progress towards goals	Monitor the abundance and distribution of FYLF egg masses throughout the forty mile system	First	22	System wide	Sample	Annual	N		Y	2H: 2.1.1, 2.1.7. 7H: 2.2.1, 2.2.2, 2.2.3. 4P 1.1.0
Wildlife	6.5.1	13W	Progress towards goals	Monitor the distribution and abundance of WPT	First	27	Reach and/or system wide	Census	Annual	N		Y	15P: 1.1.1. 8H: 2.2.2
Wildlife	6.4.1	10W	Needed to revise specific actions	Monitor the abundance/density of multiple FYLF lifestages, and reproductive output and/or reproductive success (recruitment) at rehab sites	Second	28	Site	Sample	Annual	N		Y	2H: 2.1.1, 2.1.7. 7H: 2.2.1, 2.2.2, 2.2.3. 4P 1.1.1
Wildlife	6.1.1	1W	Needed to revise specific actions	Monitor abundance/density and composition (richness/diversity) of riparian bird species during breeding, post-breeding and migration periods at rehab sites	Second	33	Site	Sample	Annual	N		Y	1R: 5.1-3; 2R: 5.1-3
Wildlife	6.1.1	2W	Needed to revise specific actions	Monitor age ratios, health, breeding condition, and reproductive success (productivity) of riparian bird species over the 40 mile reach	Third	37	Site	Sample	Annual	N		Y	1R: 5.1-3; 2R: 5.1-4
Wildlife	6.2.1	6W	Progress towards goals	Monitor abundance and productivity (as measured by the ratio of juveniles to adults observed) of riverine bird species	First	43	System wide	Census	Annual	N		Y	2H: 2.2.1; 3R: 5.1, 5.2; 2R: 5.1
Wildlife	6.4.2	9W	Progress towards goals	Map and quantify the extent (area) of available Foothill Yellow-legged frog (FYLF) breeding habitat at a range of flows	Second	51	System wide	Census	Infrequent	Y	Habitat _2H: 2.1.1, 2.1.7. Physical _4p 1.1.2	Y	2H: 2.1.1, 2.1.7; 4P 1.1.2
Wildlife	6.5.2	12W	Needed to revise specific actions	Monitor the structural and thermal complexity of habitats available for Western Pond turtles (WPT) at rehab sites	Second	52	Site	Sample	Annual	Y	Physical _15P: 1.1.1. Habitat _8H: 2.2.2, Large woody debris	Y	15P: 1.1.1. 8H: 2.2.2
Wildlife	6.1.1	5W	Progress towards goals	Monitor age ratios, health and breeding condition (productivity) of riparian bird species	Second	64	Reach and/or system wide	Sample	Infrequent	Y		Y	1R: 5.1-3; 2R: 5.1-4
Wildlife	6.1.1	3W	Needed to revise specific actions	Model how changes in riparian habitat conditions relate to associated responses in riparian bird abundance and productivity (linked to assessments 1W and 2W)	Third	74	Site	Sample	Infrequent	N		Y	1R: 5.1-3; 2R: 5.1-5
Wildlife	6.2.1	7W	Needed to revise specific actions	Model how changes in riverine and riparian habitat conditions relate to associated response in riverine bird abundance	Third	75	System wide	Census	Infrequent	N		Y	2H: 2.2.1; 3R: 5.1, 5.2; 2R: 5.2
Wildlife	6.5.3	14W	Progress towards goals	Monitor the demographic structure (proportion of different age classes) and survivorship of WPT populations	Third	76	Reach and/or system wide	Sample	Infrequent	Y	Physical _15P: 1.1.1. Habitat _8H: 2.2.2, Large woody debris	Y	15P: 1.1.1; 8H: 2.2.2
Wildlife	6.6.1	15W	Needed to revise specific actions	Monitor abundance of invasives (e.g., bull frogs, New Zealand Mud snails)	Third	77	Site	Sample	Infrequent	Y		N	

* Assessment numbering in this table is not consistently sequential as the original list of assessments has changed over time as various assessments have been identified, accepted or excluded (i.e., there will be gaps in the current numbered order of assessments within each IAP component)

Appendix I. Comparison of SRS, SysRS, and GRTS approaches for sampling design

The following comparison has been modified from Wieckowski *et al.* (2008).

The Trinity River has six geomorphic areas; consequently, the cost of covering all types of sites every year will likely be substantial. Additionally, the diversity of habitat types, restored vs. non-restored sites, and confined vs. unconfined reaches makes it important to ensure proper spatial coverage of sample sites. The GRTS approach (Generalized Random Tessellation Stratified) provides a nice alternative that can deal with some of the complications that arise in practice when using either SRS (simple random sample) or SysRS. We provide a brief comparison of these three approaches (Tables I1 to I8).

Table I.1. Comparison of SRS, SysRS, and GRTS estimates of precision

Approach	Description
SRS	Simple to compute
SysRS	A proper estimate of precision is very difficult to compute for a (single) systematic sample unless you are willing to make strong assumptions about self-randomization (in which case a systematic sample is equivalent to an SRS) or have knowledge about any "trend" in the population that the systematic sample can measure. To get around these issues, replicated systematic samples are often done. For example, rather than taking a single systematic sample of size 100, you may take 4 independent systematic samples of 25. Compute an estimate of SE from each systematic sample of size 25 and then the variance in the 4 estimates can be used to get an overall SE
GRTS	Slightly more complicated to deal with, but Stevens and Olsen (2004) give details on computations of simpler forms and the R library (spsurvey) documents the analytical tools.

Dealing with "refusals" or “non-response”: In many cases, after the sample points (locations) have been selected it is not possible to use them because landowners will not give permission, they are inaccessible, or the location is not safe. Each approach deals with this scenario differently and some are more robust to the problem than others (Table I2).

Table I.2. Comparison of SRS, SysRS, and GRTS under “refusals” or “non-response” scenario.

Approach	Description
SRS	Simply draw a new point at random. There is no impact on variance computations.
SysRS	Non-response is a problem for this design. You cannot simply choose another point and all the formulae for estimates are affected because of the missing data. You could over sample, but now the gaps will be unequally spaced in the data.
GRTS	Robust to this problem because it allows over sampling (Theobold *et al.* 2007). Simply choose the next point (after reverse hierarchal ordering). This is equivalent to SRS simply choosing another point.

Accommodating different sampling intensities: In some cases, two different "surveys" are to be conducted simultaneously with different sampling intensities. For example, you may wish to sample 25 points for survey A and 100 points for survey B. Each sampling method requires a slightly different procedure that is outlined in Table I3.

Table I.3. Procedure for accommodating different sampling regimes when using SRS, SysRS, and GRTS.

Approach	Description
SRS	Draw 100 points for survey B, and then randomly select 25 from those 100 for survey A. This way 25 points get both A and B; and the remaining 75 points get B only. Both are SRS so it is easy to compute estimates and variance.
SysRS	Draw SysRS of size 100, and then do a second SysRS of size 25 from those 100 points chosen. Both are systematic samples with same problems in dealing with missing data and variance computation.
GRTS	Draw first 100 in reverse hierarchical ordering for B. Use first 25 for A. Both samples are GRTS, so no problems in computing estimates and variance.

Spatial coverage: If there is correlation among units (i.e., units close together will tend to be more similar than units further apart), then a sampling design with good spatial coverage is a good thing. When spatial correlation exists there is no need to sample two points very close together as they will tend to have the same response and would lead to "wasting" of samples. Generally, when a correlation between units is present, designs that are more spatially spread out will tend to have better precision (i.e., lower SE) than SRS because there is no "wasting" of samples at points that are close together. Table I4 outlines the ability of each approach to take into account spatial coverage.

Table I.4. Comparison of spatial coverage of SRS, SysRS, and GRTS approaches.

Approach	Description
SRS	Poor spatial coverage. Any single realization of a SRS often results in areas with clusters of samples and areas with no samples (Theobold *et al.* 2007).
SysRS	High spatial coverage. The problem with SysRS designs is that in the presence of "correlation" among units, it is not clear how to compute the variance for a systematic design.
GRTS	Intermediate between both. The way the GRTS sample is taken tends to spread samples out more than an SRS but not as regularly as a SysRS.

Variable selection probabilities: For example, if sampling units are of different sizes, e.g., watersheds, it may be preferable to have the probability of selection proportional to the size of the watershed, under the assumption that larger watersheds contribute more to the overall quality of a regional habitat than very small watersheds. The ease of varying selection probability using each method is discussed in Table I5.

Table I.5. Comparison of SRS, SysRS, and GRTS approaches when using variable selection probabilities.

Approach	Description
SRS	Need to switch selection probabilities so they are proportional to size, but computations are straight forward.
SysRS	Need to switch to a systematic sample on the size variable, but now estimates and variance issues are much more complicated.
GRTS	Need to switch selection probabilities so they are proportional to size, but computations are straight forward.

Inverse sampling: When using inverse sampling, units are selected one at a time until some preset criteria is met, i.e., at least 10 sites with a special attribute that cannot be identified in advance. If you could identify the attribute in advance, then it is more efficient to use the attribute as a stratification variable. Table I6 outlines the relative ease or difficulty of using inverse sampling with each approach.

Table I.6. Comparison of SRS, SysRS, and GRTS approaches and inverse sampling

Approach	Description
SRS	Not a problem, just draw one unit at a time.
SysRS	Not clear how to do this.
GRTS	Not a problem, just select units one at a time in reverse hierarchical ordering. Some care needs to be taken in computing variances as "n" is now random, but this is usually ignored and the actual sample size "n" is treated as specified in advance.

Stratification: As described in Section 4.1.2, stratification can be a useful tool for improving the efficiency of a design (see Table I7 for a comparison of stratification using alternative methods).

Table I.7. Comparison of SRS, SysRS, and GRTS approaches and stratification.

Approach	Description
SRS	No problem
SysRS	No problem
GRTS	No problem; can be applied to the GRTS in much the same way as any other design.

Dealing with continuous sampling units: As described in Appendix G, the target population and sampling unit need to be defined. In some cases the target population does not have any obvious splits to separate into sampling units. For example, rivers are "continuous", i.e., they do not have fixed sampling stations, so how should a river be split into sampling units? Table I8 lists how each method would deal with continuous sampling units.

Table I.8. Comparison of SRS, SysRS, and GRTS approaches with continuous sampling units.

Approach	Description
SRS	Discretize streams into individual points, or arrange on a line (like GRTS) and take SRS of points on the line.
SysRS	Same as above.
GRTS	Same as above.

Creating and implementing a GRTS design can be difficult, as the estimate and variance calculations are complicated and hand computations are not really feasible. It is also difficult to generate a spatially explicit sampling frame for a large geographic scale; however, GIS technology has made this possible and relatively straightforward. The actual generation of sampling frames depends on the study objectives, target populations, and the extent to which the digital coverage reflects the target population (as it would with any design). The selection of a GRTS sample, and associated computations, has been automated to a great extent. Software packages required to create GRTS designs include psurvey.design (free for download from the U.S. Environmental Protection Agency (EPA) Aquatic Resources Monitoring website (www.epa.gov/nheerl/arm/designing/design_intro.htm), R statistical package and ArcGIS)

Appendix J. Determining precision requirements

The EPA's DQO process (EPA 2000) is a logical decision process to guide the development and evaluation of alternative study designs. The DQO process requires working through 7 steps, each associated with a series of qualitative and quantitative statements that help to clarify monitoring program objectives, define the appropriate types of data to collect/analyze and specify the tolerable limits on potential decision errors (Figure J1). This therefore provides a basis for establishing the quality and quantity of data needed to support decisions. Steps 5 and 6 of the DQO process are a useful guide for determining required levels of precision; more details can be found in the full EPA report.

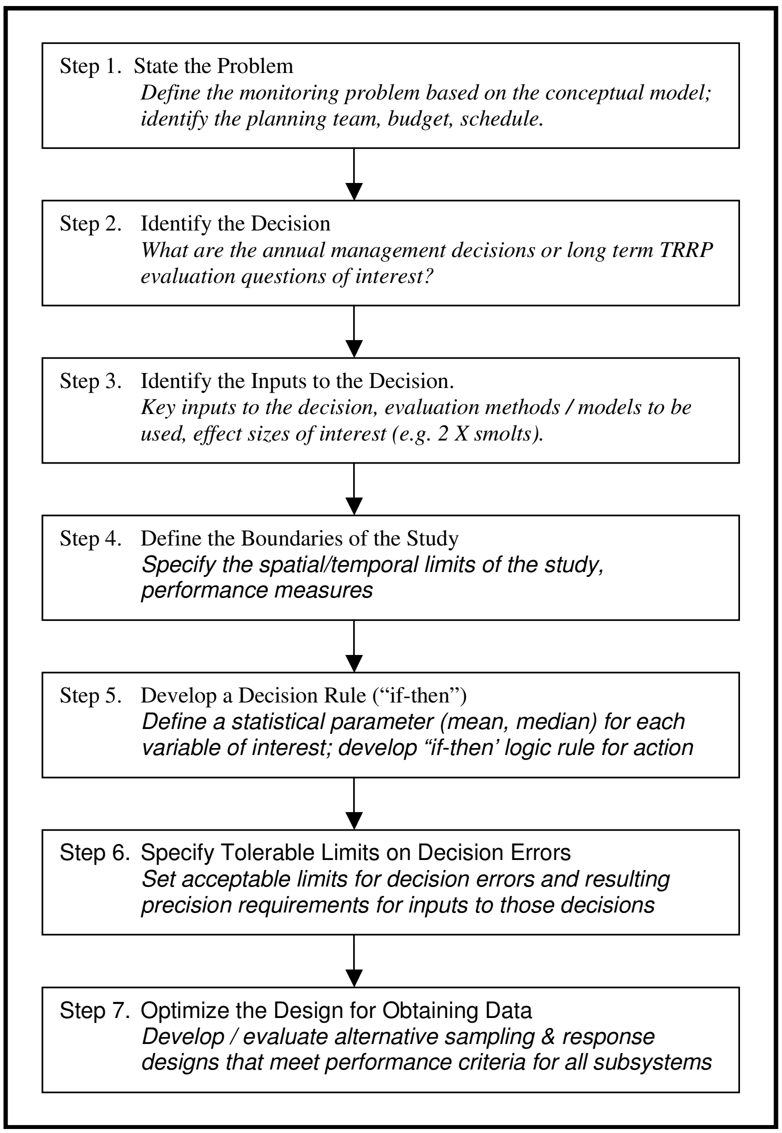

Figure J.1. Adapted from the EPA's Data Quality Objectives Process (DQO) (source: EPA 2000).

Step 5. Develop a decision rule

- What are the critical population or habitat performance measures (PMs) and their associated parameter(s) (e.g., mean, median, percentile, etc.) that will be important in making either short term or long term decisions about these target PMs? PMs are available in Chapter 3.
- What is the critical Action Level(s) (i.e., effect size) related to this parameter? This must be explored by analysts using their professional judgment, or a reasonable range if it is not already clearly quantified within TRRP agency mandates/regulations.
- Develop a theoretical decision rule based on this population/habitat parameter(s), and critical Action Levels (If…then…statement)
- What are the potential consequences of decision errors (i.e., incorrectly concluding that the Action Level has/has not been reached for this population/habitat parameter)? These errors would include taking mitigative actions that were not really necessary, or not taking mitigative actions that were necessary.

Step 6. Specify tolerable limits on decision errors

- What is the plausible range of values for the population parameter(s) used to evaluate the decision (i.e., approximation of upper and lower bounds based on available knowledge, historical data and expert judgment)?
- What are the sources of total study error (i.e., total variability) in the datasets available for making the decision?
- What component of this total study error relates to sampling design error?
- What component of this total study error relates to measurement error?
- Are there ways to manage/minimize either of these sources of error?
- What is the apparent current baseline condition of this population parameter? How was this established?
- What level of Type I vs. Type II error (i.e., false rejection vs. false acceptance) will be acceptable for this population parameter? Or restated: what are the acceptable limits on decision errors (α and β)? β)? α is the probability of concluding that there was a change in condition when in fact there wasn't any change (false positive). β is the probability of concluding that there was no change in condition when in fact there was a change (false negative).
- What is the best way to evaluate/represent the quality of the decision process that uses data relating to the population parameter?
    - e.g., simulation models, Decision Performance Curves (EPA 2000, etc.)

Appendix K. An overview of environmental field studies (excerpt from Schwarz 2007)

Example A. Descriptive study. A manager is interested in examining the natural regeneration in a cutblock harvested by clearcutting. The objective is to measure the amount of regeneration. A suitable response measure will be the density of newly grown trees. A series of sample plots is systematically located within a single cut- block and the density is measured on each sample plot. The mean density over all plots is computed along with a measure of precision, the standard error. There is only one response variable, the density on each plot, and no explanatory variables. This is a Descriptive Survey as no comparisons will be made with other cut blocks and the information pertains only to that particular cut-block. No inferences about the density in other cutblocks is possible.

Example B. Observational study. This same manager now notices that north facing slopes seem to have a lower insect infestation rates than south facing slopes. One block from a north facing slope and one block from a south facing slope are selected. Sample plots are located on each cutblock, and the insect infestation is measured on each sample plot. The response variable is the amount of infestation in each plot. The orientation of the slope is an explanatory variable. Estimates of the mean infestation are obtained for each block. The sample means for each block likely differ, but with information on the variation within each block, it is possible to determine if there is evidence that the population means also differ, i.e., to determine if there is evidence that the true average infestation in the two blocks differs. This is an Observational Study as two convenient blocks were selected and compared. However, the results are only applicable to the two blocks sampled and cannot be extrapolated to other blocks, nor to the effects of north and south facing slopes. The reason for this weak inference is that the observed differences between the blocks may be a result of just natural variation unrelated to the direction of the slope; no information has been collected on the variability among blocks with the same orientation.

Example C. Analytical survey. The manager expands the above survey. Within the Forest Management Unit (FMU), blocks are randomly chosen in pairs so that within each pair, one block is on a north facing slope and the other is on a south facing slope. Sample plots are randomly located in each block, and the insect infestation is measured in each sample plot. The response variable is the amount of infestation in each plot. Orientation is an explanatory variable. Estimates of the mean infestation are obtained for each type of slope along with a measure of precision. The manager then compares the two means using information on both the within block variability and the variability among blocks with the same orientation. It may appear that plots on south facing slopes have a higher infestation than plots on north facing slopes. This is an Analytical Survey, as a comparison was made over an entire population of cutblocks in the FMU. This differs from a controlled experiment in that the orientation of the cut- blocks cannot be controlled by the manager. An alternate explanation for this observed result is that it was some other unknown factor that caused the insect infestations to be different on the two orientations.

Example D. Designed experiment. The manager is interested in testing the effect of two different types of fertilizer on regeneration growth. Experimental plots in several homogeneous cutblocks are established. Within each cutblock, plots are randomly assigned to one of the fertilizers. The regeneration growth of the plots treated with the two fertilizers is then compared. The response variable is the amount of growth; the explanatory variable is the fertilizer type. Because plots were randomly assigned to the fertilizers, the effects of any other, uncontrollable, lurking factor should, on average, be about equal in the two treatment groups, and consequently any difference in the mean regeneration growth can be attributed to the fertilizer. The primary differences between this example and Example C are that the manager has control over the explanatory factor and can randomly assign experimental units to treatments. These two differences in the protocol allow stronger inferences than in Analytical Studies.

Example E. Impact study. The manager wishes to examine if clear cutting is changing the water quality on nearby streams. A control site in a provincial park is selected with similar soil and topography as the experimental site. Water quality readings are taken from both streams several times before harvesting, and several times after harvesting. The response variable is the water quality; the explanatory variable is the presence or absence of nearby clearcutting. The changes in water quality in the control and experimental sites are compared. If the objective is to examine if there is a difference in water quality between these two specific sites, then the study will answer the question. This is similar to the strength of inference for observational studies (Example B). If the objective is to extrapolate from this pair of sites to the effects of clear- cutting in general, the inference is much more limited. First, there is no replication of the control or impacted sites and so it is not possible to know if the observed differences are within the range of natural variation. This could be partly resolved by adding multiple control sites and assuming that the variability among control sites is representative of that among impact sites. However, the lack of randomization of the impact will still limit the extent to which the results can be generalized. But in the longer term, if there are several such pairs of sites, and all show the same type of impact, there are good grounds for assigning a causal relationship, even though randomization never took place. This would be based on the idea of a super-population consisting of all possible pairs of sites; it is not likely that unobservable, latent factors would be operating in the same direction in all experiments. This last form is the closest to a designed experiment for an impact study.

These five examples differ in two important dimensions:

1. The amount of control over the explanatory factor. In descriptive studies there is the least amount of control while in designed experiments there is maximal control.
2. The degree of extrapolation to other settings. Again, in descriptive studies, inference is limited to those surveyed populations while in designed experiments on randomly selected experimental units, inference can be made about future effects of the explanatory factors.

In general, the more control or manipulation in a study, the stronger the inferences that can be made as shown in Figure K1 below:

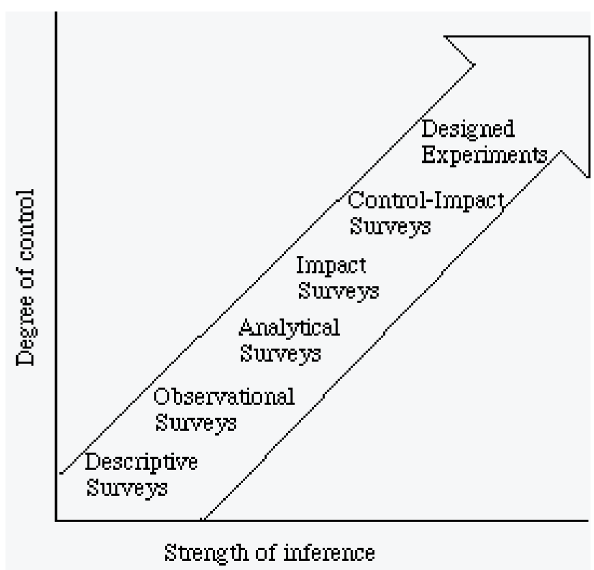

Figure K.1. Relationship between degree of control, strength of inference, and type of study design.

Appendix L. Reviews of existing sampling designs and monitoring protocols

The following reviews formed the basis for the integrated sampling design, and recommended sequence of further design studies, as presented in Chapter 4. The tables below summarize existing methods for proposed performance measures (PMs), some of the uncertainties and limitations of these methods, and remaining issues to be resolved. After reviewing the existing protocols and sampling designs, we grouped each of the PM/Assessments into one of the five categories described in the sampling framework (Section 4.2): 1) established valid protocols; 2) a census is feasible; 3) GRTS panel design is feasible; 4) an alternative sample design is required; and 5) an experiment or process based study is required. This can be used to guide future work by showing how the PMs/Assessments fit into the overall sampling framework and identifying areas where more work is required.

Objective 1: Create and maintain spatially complex channel morphology

Sub-objective(s) / topic(s): 1.1 Increase physical habitat diversity and availability

PM and Assessment(s): *Aerial photos*[32]
Method (Aerial photographs: Census / Existing protocol)
• At present, aerial photographs are completed for the entire Program Area as soon as the flows drop down to 450cfs and as close to June 21st as possible (shadows are smallest). Historically the photographs have been taken in November. There is an interest in taking photos during both the summer and fall to get a comparison of the river under different extents of vegetation cover. While the photographs are a spatial census, they are only completed once per year; as a result there is a temporal component to the sampling design. This is important to consider because many of the performance measures obtained from the aerial photographs vary with time in some way. For example, both flow and foliage condition may affect the ability to assess certain performance measures.
Uncertainties / Limitations
• The data processing for this protocol is very intensive and there is often a large time lag between data collection and processing. There is strong support from all partners to continue to collect these data and obtain the related performance measures; however there is some question about how frequently it should be completed.

PM and Assessment(s): *LIDAR*[33]
Method (LIDAR: Census / Existing protocol)
• The EAARL (Experimental Advanced Airborne Research LIDAR) is an airborne LIDAR that provides green-wavelength (532 nm) LIDAR designed to map near-shore bathymetry, topography, and vegetation structure simultaneously (USGS 2007). The technology has been steadily improving and the current system is accurate to within 2-5 cm depending on variations in the target reflectivity from pulse to pulse (USGS 2007). Like the aerial photographs a spatial census of the entire Program Area is completed, but due to cost and availability it is probably only feasible to complete periodically (i.e., once every 3–5 yrs). LIDAR is best completed at low flows as it is most accurate on dry ground (Philip Bailey, ESSA, pers. comm.). Otherwise the only sampling component to LIDAR based assessments is the frequency of sampling.
Uncertainties / Limitations
• This equipment is very expensive and not readily available, so the frequency of the sampling is limited. Furthermore, LIDAR requires a minimum water depth of 30cm to produce accurate results, therefore it will not be very good at mapping the

[32] Aerial photos can be used to inform multiple performance measures including: bank length, sinuosity, frequency of geomorphic units, and frequency of meso-habitats.
[33] The intention is to use LIDAR to inform 2-D modeling, as well as multiple performance measures including: thalweg crossings and longitudinal profile. At present, LIDAR is used to map the bathymetry of the Trinity River.

bathymetry along the edges of the Trinity River.

- It is not clear which assessments can be addressed effectively with LIDAR data.[34] As the technology improves there may be new opportunities to use this data. For example, a new tool is being developed to identify the thalweg of the river from LIDAR data (P. Bailey pers. comm.); this can be used along with slope to develop a longitudinal profile of the river.

PM and Assessment(s): *Transect based*[35]

Method (Transects: Sample / GRTS design)

- Detailed field channel and hydraulic measurements such as: width, depth, velocity, and boundary shear stress require a sampling strategy as a census is not feasible. Estimates of suitable habitat at the system scale are needed to provide feedback to the overall program goals and hydraulic data are an important input to most methods. However, transect evolution is also of interest, requiring at least some sites to be revisited periodically. Traditionally transects have been selected by expert opinion, but this limits the ability to make inferences beyond the transect itself and has the potential to lead to serious bias. Randomly selected transects from the entire Program Area allow for estimates to be extrapolated to the system. Additionally it would be very useful to have co-located sites for the physical transects and the other disciplines to facilitate the integration of data and understanding the linkages between processes. The GRTS panel design would address each of these concerns and should be used to select transect locations.

Uncertainties / Limitations

- The general structure of the GRTS panel design should be a suitable approach but there are still a number of details that remain to be addressed. The proposed analyses and the required precision should be clearly documented. It is not clear how many samples should be taken each year, what time of year they should be taken, how many strata (if any) should be used, how frequently sites should be re-visited, etc. The rehabilitation sites add an extra complication. Within a year it would be quite simple to stratify on rehabilitation sites vs. non-rehabilitation sites. However across years within a panel design it is not clear what is the best approach to account for the fact that many sites will change from non-rehabilitation sites to rehabilitation sites over the next few years.

PM and Assessment(s): *Berm development*

Method (Experiment / Process)

- Not intended to be long term monitoring, but instead short term focused study to understand process of berm formation.
- Appropriate study design. What treatments or geomorphic features should be assessed at how many flows?
- Why do berms form in some places and not in others?
- Are > 3 year old seedlings removed with current flows?
- Can we manage flows differently to prevent encroachment?
- Are berms reforming at rehabilitation sites?
- Cause and effect monitoring of riparian encroachment (using scour cores and marked rocks)

Uncertainties / Limitations

- Need to decide on the target population of berms for which inferences are desired, and then rigorously select a subset of these to study. Change from non-rehabilitation sites to rehabilitation sites over the next few years.

Remaining issues to be resolved for Sub-objective 1.1 assessment methods in order of priority:

- Clarify the definition of 'complexity' (see Section 3.1.1)
- Determine the best approach to incorporate both rehabilitation and non-rehabilitation sites into the design.
- Develop an experimental framework to specifically address the process of berm formation and how it can be prevented. Experimental framework should also provide information about scour and seedling development
- In 2009, collect a reasonably large sample of transect data from a GRTS selected design that covers all possible strata.

[34] This has not yet been sufficiently explored.
[35] Transects would provide information on channel morphology, and can be used in to inform similar performance measures to those addressed by LIDAR. Additionally, transects, if done in sufficient quantity, can inform 2-D modeling.

Use this information to evaluate which strata are most appropriate and the appropriate sample size in each year and strata.

- Compare the data/information provided by the remotely sensed protocols (aerial photographs/LIDAR) and the ground based surveys (boat sonar, transects) to determine which procedures are most appropriate for which assessments and whether the effort for either (number of sites or frequency of sampling) can be reduced.
- Scientists from the different disciplines should become familiar with the capabilities of the new LIDAR and determine where it might be useful (e.g., can it provide much of the input needed for the 2-D habitat modeling?)

Sub-objective(s) / topic(s): 1.2 Increase coarse sediment transport and channel dynamics

PM and Assessment(s): *Bedload transport & coarse sediment loads (Assessment 7P)*

Method (Sample (Alternative design)/Existing protocol)

- Sediment samples are collected multiple times each year at four sites in the first 20 miles below Lewiston dam (Figure 3.1). The sites were not chosen randomly, rather they were chosen based on their position relative to tributaries. The sites are visited multiple times throughout the spring release. This design is adequate to assess the objective.

Uncertainties / Limitations

- How frequently does this assessment need to occur? It is quite costly; therefore want to make sure oversampling is not occurring.
- The existing protocol is adequate; the uncertainty is around the need for information. Do we need to sample mainstem transport every year or should we do it every five years, every ten years, or after major coarse sediment augmentation?

PM and Assessment(s): *Bed-surface grain size*

Method (Sample / Alternative design)

- Sampling design will be driven by the hypothesis. Possible questions: Does sand go out of the system? Is spawning habitat substrate high quality?
- Fines can be assessed by visual estimation alone.
- Coarse sediment can be assessed by visual estimation combined with validation using a more detailed protocol.
- The frequency of sampling will depend on whether the bed surface is coarse or fine grain sediment as well as where you are in the system, i.e., not all areas need to be sampled with the same frequency, some areas are more likely to be used for spawning. Rotating panel design may be appropriate.

Uncertainties / Limitations

- Need to further clarify precisely what hypothesis this assessment is testing.
- It is not possible to survey the entire Program Area in a day, but how much area could you cover using the visual estimation strategy?
- Particle size distributions have high variability, requiring large sample sizes to detect changes (Roper *et al.* 2002).
- The necessary sample size needs to be calculated (how many total sites, how many validation sites). We can assess the efficiency of the proposed protocol itself (i.e. visual estimation, with large sample size vs. a more detailed protocol with fewer sites). The tradeoff is in measurement error vs. sampling error and this can be quantified given initial estimates from either approach. Double sampling (Thompson 2002) describes the procedure to improve the accuracy of a visual estimate, where a large area is sampled using the visual estimate and a small subset is sampled using a more intensive method. The forest industry uses this approach to obtain estimates of stand volume.
- Clarify scale: just a sample of specific areas; or whole system? If a sample for the whole system is required then it would be possible to select sites according to the GRTS panel design. However there may be additional considerations such as selecting sites relative to tributaries, distance from the dam or potential spawning areas.

PM and Assessment(s): *Scour cores & marked rocks*

Method (Sample / Alternative design)

- Scour cores are used to evaluate scour and subsequent deposition (S. McBain pers. comm.). Marked rocks are used to evaluate bed mobility; the field protocol is described in McBain & Trush (1997). At co-located sites riparian band transects are completed to provide the link between flow, physical processes, and risk of riparian encroachment. Information on how bed mobility and scour varies with flow, and how they affect riparian encroachment, provides important feedback to management actions. Historically these assessments have been completed at non-randomly selected sites. However, the sample size was reasonably large which alleviates some of the risk of the non-random selection. Approximately ten sites were monitored for each of five different river features over a range of flows (less than 6,000 cfs). These protocols require moderate effort (~2 sites can be completed per day).

Uncertainties / Limitations

- There are substantial historical data available for each of these assessments for the Trinity River. However the information has primarily been collected for flows less than 6,000 cfs. As a result we don't have a good understanding of these processes at higher flows. The non-random strategy used to select sites should be evaluated and justified. There's a tradeoff between maintaining historical time series at non-random sites, versus obtaining a truly representative sample.

Remaining issues to be resolved for Sub-objective 1.2 assessment methods in order of priority:

- Evaluate bed mobility and scour at co-located riparian band transect sites during high flow years to provide a wider range of flows for key functional relationships.

5 **Sub-objective(s) / topic(s):** 1.3 Increase and maintain coarse sediment storage

PM and Assessment(s): *Coarse sediment inputs from tributaries*

Method (Method not yet identified / Alternative design)

- Coarse sediment inputs from major tributaries have been quantified in the past through delta surveys and bedload sediment sampling in the tributaries as described in Section 3.1.3. Both of these approaches require on the ground monitoring with multiple visits within the year. Tributaries are the target population for this assessment and so a unique sampling design is necessary. For delta surveys, either a census or sample of tributaries can used, where the difference in delta volume before and after the winter storm season is used to approximate the volume of coarse sediment (Section 3.1.3). Likewise a census or sample of tributaries can used for sediment sampling completed during winter storm events.

Uncertainties / Limitations

- The best protocol for assessing tributary inputs has not yet been determined. Both delta surveys and tributary surveys have weaknesses. From a sampling design perspective either approach (as described in Section 3.1.3) is straightforward. Perhaps there is some combined approach that would help compensate for the weaknesses. For example, perhaps you could use delta surveys at all tributaries but then have a small sample of tributaries where bedload sediment sampling occurs and the difference between the estimates at the subset of sites could be used to correct the rest of the delta sites.
- The SAB (Scientific Advisory Board 2006a:7) suggested that it was not necessary to measure tributary inputs of coarse sediment with a sufficient level of precision and accuracy to perform coarse sediment storage calculations. Rather, they felt it was sufficient to obtain a general understanding of the magnitude of tributary inputs to assist the gravel augmentation program.

Remaining issues to be resolved for Sub-objective 1.3 assessment methods in order of priority:

1. Determine the frequency of sampling required to inform the performance measure of bedload transport and coarse sediment load.

Sub-objective(s) / topic(s): 1.4 Reduce fine sediment storage in the mainstem Trinity River

PM and Assessment(s): *Quantity of fine sediment inputs from tributaries*

Method (Method not yet identified / Alternative design)

- Fine sediment inputs from tributaries can be obtained by sampling tributaries, similar to the sampling described for coarse sediment inputs or as a residual term in the fine sediment budget as described in Section 3.1.4. The quantity of fine sediment in the mainstem requires field monitoring and can be completed as part of the bed-surface grain size monitoring. More detailed field performance measures would require an efficient sampling design. Depending on the target population and the specific question the GRTS panel design might be a suitable approach.

Uncertainties / Limitations

- Need to define the method for quantifying fine sediment, in particular the conversion from aerial coverage to volume of sediment.
- Identify the biological parameter of interest (i.e., what size substrate are you most interested in)
- Uncertainty around whether any realistic level of sampling effort can produce satisfactory estimates of these inputs

Remaining issues to be resolved for Sub-objective 1.4 assessment methods in order of priority:

- Clarify what subsurface attribute is of biological interest
- Methods for quantifying fine sediment stored on the bed surface have not been fully defined. In particular, concern has been expressed regarding the conversion from aerial coverage to volume of sediment. However, methods for making this conversion are under development.
- Determine the sample size necessary to obtain useful information using the subsurface bulk sampling or substrate sampling.
- Evaluate sampling strategies for obtaining useful estimates of fine sediment inputs from tributaries.

Objective 2: Increase/improve habitats for freshwater life stages of anadromous fish to the extent necessary to meet or exceed production goals

Sub-objective(s) / topic(s): 2.1 increase and maintain salmonid habitat availability for all freshwater (n-rivner and tributary) life stages and 2.2 improve riverine thermal conditions for growth and survival of natural anadromous salmonids.

PM and Assessment(s): *Area of suitable habitat (by species & life-stage) (Assessments 1H, 2H, 3H, 4H, 5H, and 6H)*

Method (Sample / GRTS panel design)

- The habitat suitability criteria proposed for Chinook salmon and coho salmon juveniles as well as Chinook salmon, coho salmon, and steelhead spawners were presented at the TRRP April 2008 workshop (Chamberlain *et al.* 2007; Chamberlain 2008). These criteria include:
  - Velocity
  - Depth
  - Cover type
  - Distance to cover
  - Substrate embeddedness
  - Size of dominant substrate
- While we are interested in estimates for the above species at all flows, estimates for Chinook salmon and coho salmon juvenile habitat area at summer base flow (450 cfs) may be used as a long term index of habitat area. Increasing Chinook salmon fry rearing habitat was identified as a priority in the TRFE. The summer base flow is recommended because it is more consistent within and between years than winter base flows which varies more with storm activity. It is necessary to have a flow that is available for a long enough period to complete the sampling. Higher flows are typically only available for short durations which would not provide sufficient time for an adequate sample. It will provide a consistent measure for assessing trends over time.
- Annual estimates will provide:
  - inputs to analyses for other disciplines (e.g., as a covariate in analyses of fry and juvenile abundance)
  - ability to assess trend over time in the area of suitable habitat at the system scale
  - feedback to determine if the target area of suitable habitat is maintained (targets not yet established)

Uncertainties / Limitations

- How many levels should be used to describe suitability of habitat?
  - binary (suitable/unsuitable), 3 levels (unsuitable, suitable, high quality), WUA

- Binary is current SBHM method (must satisfy all criteria)
- WUA was rejected at April 2008 workshop
- 3 levels were proposed at the April 2008 workshop

- Targets need to be identified as progress towards targets will guide future management decisions/priorities
- Sample size selection (how many flows, how many sites?)
- Evaluate alternative strata

PM and Assessment(s): *Potential Habitat Capacity (Section 3.2.1) (Assessment 13H)*

Method (Census / Existing protocol)

- Potential Habitat Capacity can be measured from channel slope, configuration, and confinement. Will be further refined using estimates of carrying capacity (see details in Appendix C).

Uncertainties / Limitations

- How accurate will the estimates of potential habitat capacity be?
- Should habitat capacity be related to growth, abundance size distribution?

PM and Assessment(s): *Evaluate the role of a hierarchy of scales on the linkages between fish abundance, habitat and geomorphology.*

Method (Sample / Field protocol under development / GRTS panel design possible)

- A GRTS panel design could be used to select spatially balanced sites at a subset of the sites used for the habitat and geomorphic mapping where fish abundance and distribution will be determined.

Uncertainties / Limitations

- What variables =re useful to describe the geomorphic features that fish respond =o?
- Can we establish = relationship between geomorphic features and quantity or quality or capacity of habitat?.
- Can we establish = relationship between fish abundance and distribution and geomorphic features at different scales?)

PM and Assessment(s): *Habitat x flow curve (by species & life-stage) (Section 3.2.1) (Assessments 1H, 2H, 3H, 4H, 5H, and 6H)*

Method (Sample / Field protocol under development / GRTS panel design possible)

- As described in Section 3.2.1 TRRP participants decided upon a hybrid monitoring approach for fish habitat. This approach is intended to draw upon the combined strengths of the 2-D modeling and the Habitat Suitability Mapping methods. A GRTS panel design could be used to select spatially balanced sites at a subset of the sites used for the habitat suitability mapping. In the short term it is more likely that these comparisons will occur opportunistically at sites where 2-D modeling (or extensive transects) are already planned.

Uncertainties / Limitations

- How would the hybrid field protocol and inference actually work?
- Evaluate the risk to using opportunistically selected sites to build the habitat x flow curve.
- Sample size selection (how many flows, how many sites?)
- How should this performance measure be analyzed over time?
  - Could consider 5 distinct flows and use habitat area at each flow as 5 different PMs
  - Use methods described in Appendix C
  - Use curves to determine PMs during critical periods (e.g. minimum 5-day median fry rearing area in each water year)
  - Use as input to SALMOD

PM and Assessment(s): *Temperature (Section 3.2.2) (Assessments 7H and 8H)*

Method (Sample (Alternative design) / Existing protocol)

- Currently, a temperature monitoring network is in place to monitor longitudinal water temperature faced by salmonids throughout the Trinity River and lower Klamath River.

Uncertainties / Limitations

- Water temperature objectives for the Trinity River Flow Evaluation study are literature based. Will these temperatures be maintained every year, or deliberately varied (i.e. with associated monitoring of fish health, growth, etc.) to provide long-term feedback regarding the effectiveness of these targets?

PM and Assessment(s): *Macroinvertebrates (Section 3.2.3) (Assessments 9H, 10H, and 11H)*

Method (Sample / Field protocol to be identified / design yet to be determined)

- Protocols to assess macro invertebrate performance for the Program Area have yet to be identified. One possibility is to use a rapid bio-assessment (e.g. Metzeling *et al.* 2003). A GRTS-panel sampling design could provide an appropriate framework to allow for co-location with other assessments, particularly those for juvenile fish.

Uncertainties / Limitations

- Establish baseline and target levels of food availability. Current status of macroinvertebrates in the Trinity River is unknown.
- Determine what flow releases increase quantity and availability of macroinvertebrate habitat (e.g. analyses across water years, or deliberate manipulation of flows)
- Identify specific metrics to inform macroinvertebrate performance measures (e.g., production, standing crop, species richness etc.)
- Identify a feasible macroinvertebrate protocol

Remaining issues to be resolved for objective 2 assessment methods in order of priority:

- 2009 fish habitat sampling design should be developed to get a system wide estimate to:
    - Assess the proposed strata
    - Collect the information necessary to calculate the appropriate sample size for future designs.
    - Consider how to handle situation where sites change from non-rehab to rehab strata (how would this affect a panel design?)
    - Decide between 2 and 3 categories for suitability (as per recommendation from April 2008 workshop). If 3 categories are chosen they need to be clearly described and added to the habitat suitability criteria.
- Develop sampling strategies for remaining assessments using Appendix G as a guide.
- Existing data (especially Pre-ROD) should be compiled so that it can be used in before/after comparisons or trend analyses.
    - 1984 transects
    - Air photos
    - Update all existing data records to reference the 'standardized river mile', so they can be used for baseline or trend data.
- Develop and validate hybrid protocol
    - Clearly describe the hybrid approach
    - Determine an efficient way to collect the data required for both approaches (ideally using a single crew)
    - Determine which flows should be sampled and why
    - Clarification of the calibration required for the hybrid strategy (how often, how many sites, which flows)
    - Validate ability of 2-D model to predict habitat at other flows (get flow x habitat relationships with both SBHM and 2-D and compare). Validate relationship at least three locations including both simple and complex channel types.
    - Assess the ability of the new LIDAR information (+/- 15cm elevation) to inform the 2-D modeling effort.
    - Statistical expansion or model based expansion – which will be more effective?

<u>Possible outcomes:</u>

Hybrid works:

- 2-D models provide an adequate estimate of habitat but not as good as the SBHM:
    - Use SBHM to map a randomly selected set of GRTS sites at 450 cfs (summer baseflow) for Chinook/coho salmon

Remaining issues to be resolved for objective 2 assessment methods in order of priority:

fry rearing guild and then at a subset of sites use 2-D modeling to obtain flow x habitat relationships for all species and flows.

- Use SBHM to map a randomly selected set of GRTS sites at predominant flows (that are feasible to sample: 450-2000 cfs). At a subset of sites use 2-D modeling to obtain flow x habitat relationships for > 2000 cfs. Use flow x habitat relationship from SBHM for flows <2000 cfs and knit that together with the flow x habitat relationship from 2-D model for flows >2000 cfs.

Hybrid does not work**:**

- 2-D models provide poor estimate of habitat:
  - Drop the 2-D modeling approach and expand the SBHM effort to a range of flows (3-5)
- 2-D models provide an excellent estimate of habitat:
  - Drop the SBHM modeling approach and expand the 2-D modeling approach.
- After 5 years and periodically thereafter compare the remotely sensed indicators (air photos and LIDAR) of habitat to determine if they provide adequate indicators of habitat to justify dropping the field assessments or reducing their frequency.
- Determine and document criteria for additional native species of interest (lamprey and sturgeon).
- If juvenile fish size and growth data suggest that food availability may be a problem (see Section 3.2.3), then identify performance measures, metrics, and protocols for macroinvertebrate assessment

Objective 3: Restore and maintain natural production of anadromous fish populations

Sub-objective(s) / topic(s): 3.1 Increase spawning, incubation, and emergence success of anadromous spawners.

PM and Assessment(s): *Density and number of redds / spawning habitat and distribution (Section 3.3.1) (Assessment 1A)*

Method (Spatial census / Existing protocol)

- Weekly float surveys of the river during spawning period for Chinook salmon (early September to 1 week before Christmas). Lewiston Dam to North Fork is surveyed weekly, North Fork to Cedar Flats and Hawkins Bar to the mouth of the Trinity are surveyed in alternate weeks. Redds are counted and the locations are recorded on physical geo-referenced maps (every 1/10 km marked). Carcasses are counted simultaneously. Redd and carcass surveys have been taking place since 2002.

Uncertainties / Limitations

- Only survey redds once a week, i.e., not a complete census.
- Lots of superimposition takes place, particularly in reach 1 where there are lots of hatchery strays making it very difficult to count the number of redds
- Current methods may underestimate the total number of redds due to superimposition. High densities of fish lead to underestimates of redds in Idaho (Claire McGrath, May 2008 AFS presentation, pers. comm.). However, this bias exists in historical data and it may not be advisable to change methods now and confuse the time-series.
- Redd surveys alone will underestimate the number of spawners (need to do redd and carcass counts together)
- Can flows be managed differently in reach 1 to encourage and/or discourage spawning?
- Is it possible to increase usability of downstream spawning habitat and re-distribute spawning?

PM and Assessment(s): *Redd superimposition (Assessment 2A)*

Method (Method not yet identified)

- Currently, no established method exists and all evidence for superimposition thus far is anecdotal. In order to get an estimate of the rate of superimposition you need to know the number of spawners and egg survival rates in areas where superimposition takes place (C. Chamberlain, pers. comm.). Because superimposition is of greatest concern in Reach 1, Program may want to focus efforts in that reach. One could develop a monitoring method that expands effort outside of reach 1 to other areas as a function of run size (the rationale being that the larger the run, the greater the probability that superimposition will occur in other reaches).

Uncertainties / Limitations

- See above points under density and number of redds
- Difficult if not impossible to assign a species and or race to redd in the field.

PM and Assessment(s): *Number of un-spawned or partially spawned females (Assessment 3A)*

Method (Spatial census / Existing protocol)

- The study area includes the mainstem Trinity River from its upstream limit of anadromy at Lewiston Dam downstream to the Cedar Flat Recreational Area. The study area is divided into 10 reaches. Reaches are surveyed between mid-September and late December. Reaches are stratified so that the most effort is placed in reaches where the most fish are known to occur. Two rafting teams (CDFG and Yurok crews) survey reaches 1-5 weekly by starting at reaches one and working downstream through reach five. Crews also attempt to survey reaches six and seven weekly, while reaches 8-10 are surveyed on a bi-weekly basis. Logistical constraints cause some reaches to be occasionally excluded. Surveys have been taking place since 1977. For more detail on the methods used see Garrison (2008) and Kautsky *et al.* (2004) as examples.

Uncertainties / Limitations

- No tributaries are surveyed for un-spawned or partially spawned females. The target population of these surveys is the mainstem population, although tributaries are important

Remaining issues to be resolved for Sub-objective 3.1 assessment methods in order of priority:

- Explore different methods for generating estimates of spawner abundance from visual surveys (e.g., peak count, mean count, trapezoidal area-under-the-curve (AUC), and likelihood AUC). This can be used for estimating rates of redd superimposition.
- Develop a method for determining the extent of redd superimposition
    - Explore possibility of using time-lapse photography to get better idea of rates of superimposition
    - Need to test the hypothesis about whether alterations in flow can be used as a tool for reducing rates of superimposition

2. Decide whether it is useful to the Program to use a fish production model. See discussion in Section 3.3.1. If SALMOD to be used, acquire information on prespawn mortality and in-vivo egg viability.

5 Sub-objective(s) / topic(s): 3.2 Increase freshwater production of anadromous fish.

PM and Assessment(s): *Fry density and abundance (Assessments 1J and 2J)*

Method (Sample (Alternative design) / Existing protocol)

- Currently, rotary screw traps (RST) are placed at several locations in the Trinity River (Willow Creek, Junction City, Pear Tree, Weitchpec, and Blue Creek). For more detail on RST methodology see USFWS (2004).

Method (Sample / GRTS panel design)

- Snorkel counts and/or fyke nets at co-located sites with fish habitat mapping. Could go out early in the season before hatchery Chinook salmon are released to get an estimate of natural fry abundance and reach specific densities. Emergence of fry generally occurs between January and April (dependent on species).

Uncertainties / Limitations

- Uncertainty over which population estimation technique is the best
- Clarify the target population (e.g., are fry from tributaries to be included?). Tributaries are currently not sampled.
- RST effectiveness for other species is uncertain (catch plenty of Chinook salmon, not so many steelhead and coho salmon)
- Using RST it is difficult to get an estimate of natural fry vs. hatchery fry abundances (i.e., only 25% of hatchery fish are marked). Taking a GRTS sample prior to release of hatchery fish could potentially get around this problem.
- RSTs only provide an estimate of abundance, cannot get relative density across the river.
- Unclear how to separate fall and spring Chinook salmon. May need to do analysis just on “Chinook salmon”

PM and Assessment(s): *Outmigration timing and duration, fry and juvenile size distribution, and presmolt and smolt condition/overall health[36] (Assessment 4J)*
Method (Sample (Alternative design) / Existing protocol) • Currently, RSTs are placed at several locations in the Trinity River (Willow Creek, Junction City, Pear Tree, Weitchpec, and Blue Creek). Willow Creek has three traps spread across the width of the river (left bank, middle, and right bank). • A biosample of 30 fish are taken from each RST every day that it is operational. These fish are examined for their condition/overall health and fork-length. • Radio telemetry and PIT tags have been used for wild coho salmon to estimate survival rates. The focus has been on coho salmon because they are a listed species.
Uncertainties / Limitations • RST effectiveness is uncertain • Traps not operational during high flows (safety concerns), therefore don't collect data on outmigration, size, and condition during a critical period when many fish leave. • RSTs are not in the water year round (generally taken out in late fall and put back in early spring) – Covers the migration period for most fish, excluding steelhead, however RSTs aren't effective at catching steelhead in any case. • Don't have rates of survival for natural fish (except for coho salmon). • Key sources of mortality have not been quantified for any species. • One of the key hurdles to estimating survival is finding a method that can mark fish very quickly and in large quantities (i.e., it would be too costly to use telemetry and PIT tags for Chinook salmon because a very large number of fish need to be marked)

PM and Assessment(s): *Growth rate (Assessments 3J and 4J)*
Method (Sample (Alternative design)/ Existing protocol for coho salmon) • Radio telemetry and PIT tags have been used for wild coho salmon to estimate growth rates every month (coho salmon are tracked and trapped) • There is no protocol currently being used for other species' growth rates
Uncertainties / Limitations • There is no protocol currently being used for other species' growth rates. • One of the key hurdles for estimating growth rates for other species is finding a method to mark fish very quickly and in large quantities (e.g., it's costly to use telemetry and PIT tags for Chinook salmon because a very large number of fish would need to be marked). • Another strategy might be to simply collect a sample of juveniles at different times throughout the rearing period and record the length and weight for each fish. From this a size distribution corresponding to each time interval can be obtained and compared across time intervals.

PM and Assessment(s): *Predation rate on fry and smolts (Assessments 6J, 7J, and 8J)*
Method (Sample / design yet to be determined) • No established method exists, although Naman (2008) could be used as a basis for gut content analysis and survey/capture methods at a given site for fish species. One possibility is to use the GRTS panel design to select sites where a sample of the predator species[37] could be taken to assess the degree of predation upon naturally produced juvenile salmonids by hatchery fish. A possible stratifying variable for the design could be rearing habitat vs. non rearing areas.
Uncertainties / Limitations • Determining population size by life stage for each species of concern and accurately measuring predation rate will likely be challenging. • Open population vs. closed population. Difficult to apply this to an open population

[36] Rotary screw traps can be used to inform all of these performance measures.
[37] Species that prey on juvenile Chinook and coho include: brown trout, mergansers, and steelhead,

- Need to identify what species are really preying on natural fish
- Timing and frequency of samples will have to be addressed.

Remaining issues to be resolved for Sub-objective 3.2 assessment methods in order of priority:

- Develop a GRTS panel sampling design to co-locate fry counts with areas that are being mapped for habitat. Will allow you to get reach specific abundances
- For RST, compute population estimates using several estimation techniques (including but not limited to the volume ratio abundance index method (Pinnix *et al.* 2007), simple (pooled) Peterson Method, stratified-weekly Peterson Method, 4-strata Peterson Method (as defined by Green *et al.* 2004), Darroch Method, smoothing method).
  - Evaluate population estimation techniques and develop program-level protocols and guidance
- Refine the population estimation simulation tool initially developed by Carl Schwarz
- Classify remaining assessments and PMs not discussed in this section with respect to the five method categories in Figure 4.1. Identify uncertainties and associated tasks for these assessments
- Create an electronic database that will consolidate RST data into central location
- Determine how fry abundance data can be used to inform SALMOD
- Determine rates of survival and sources of mortality (for juvenile life stages) for natural fish

Sub-objective(s) / topic(s): 3.3 Minimize impacts of predation, competition, and genetic interactions between and among hatchery and natural anadromous fish.

5 Juveniles

PM and Assessment(s): *Predation rate on natural juveniles (Assessment 8J)*

Method (Sample / design yet to be determined)

- See above discussion of predation on fry and smolts

Uncertainties / Limitations

- See above discussion of predation on fry and smolts

PM and Assessment(s): *Proportion of hatchery to natural juveniles (Assessment 9J)*

Method (Sample (Alternative design) / Existing protocol)

- RSTs as described above

Method (Sample / GRTS panel design)

- Site selection could occur using a GRTS panel design, as discussed above for fry abundance.

Uncertainties / Limitations

- Only 25% of Chinook salmon hatchery fish are marked (100% of coho salmon and steelhead are marked)
- May be difficult to distinguish between hatchery and naturals without handling the fish. Sampling before and after hatchery releases may help.

PM and Assessment(s): *Degree of overlap of rearing habitat niches (between hatchery and natural juvenile salmon and steelhead) (Assessment 10J)*

Method (Sample / GRTS panel design)

- No established method exists. The same method described for Proportion of hatchery to natural juveniles could be used. Habitat mapping may also be used to determine if different types of habitat are preferred by natural fish relative to hatchery fish, e.g., snorkeling at sites that have had fish habitat mapped.
- Could do this analytically and/or spatially. Analytically develop habitat suitability curves for both wild and hatchery fish and then look at the degree of overlap. Spatial method would require going out in the field and observing what habitat are used by hatchery and natural juveniles of each species.

Uncertainties / Limitations

- See points described above in 'proportion of hatchery to natural juveniles'
- Habitat suitability curves for all species have not yet been developed.

Adults

PM and Assessment(s): *Proportion of hatchery to natural spawners in natural areas (Assessment 1A)*

Method (Spatial census / Existing protocol)

- Use carcass surveys as described for Number of un-spawned or partially spawned females.
- Multiply number of CWT found in each reach with a tag group multiplier to determine the number of hatchery fish in a reach. All production that cannot be explained by this is attributed to natural production
- Fish are also marked at the weirs and marked carcasses found during carcass surveys are used as a recapture.

Uncertainties / Limitations

- Only 25% of Chinook salmon hatchery fish are marked with CWT (100% of coho salmon and steelhead are marked)

PM and Assessment(s): *Degree of overlap of spawning habitat niches (between hatchery and natural adult salmon and steelhead) (Assessment 5A)*

Method (Spatial census / Existing protocol)

- Could used the same as that described for *Number of un-spawned or partially spawned females*, where the proportion of hatchery fish and natural fish would be recorded for each identified spawning area. Will also require estimates of superimposition and differences in entry timing. Past investigations have revealed that hatchery spawners are most common in the first 5-10 km downstream of TRH; consequently, may want to incorporate this knowledge into the protocol.

Uncertainties / Limitations

- Only 25% of Chinook salmon hatchery fish are marked with CWT (100% of coho salmon and steelhead are marked)

PM and Assessment(s): *Emergence success for hatchery and natural fish in natural habitat (Assessment 12A)*

Method (Experiment / Process)

- A controlled experiment investigating the emergence success of hatchery and natural fry in natural habitat will have to be developed.

Uncertainties / Limitations

- It will be difficult to distinguish between redds from natural fish versus those from hatchery fish.

Remaining issues to be resolved for Sub-objective 3.3 assessment methods in order of priority:

- Develop methods for delineating stable hybrid zone and determining the extent of reduced spawning success due to hatchery fish in natural spawning areas. Will likely require their own experimental design.
- Identify performance measure for genetic diversity (Assessment 9A); and hybridization (Assessment 10A)
- Investigate link between genetics and expression of phenotypic traits (Assessment 11A)

Objective 4: Restore and sustain natural production of anadromous fish populations downstream of Lewiston Dam to pre-dam levels, to facilitate dependent tribal, commercial, and sport fisheries full participation in the benefits of restoration via enhanced harvest opportunities.

Sub-objective(s) / topic(s): 4.1 to 4.6 Increase production of naturally produced anadromous fish populations (fall and spring Chinook salmon, coho salmon, steelhead, Pacific lamprey and green sturgeon).

PM and Assessment(s): *Escapement of naturally produced anadromous fish (Assessments 13A to 15A)*

Method (Sample (Alternative design) / Existing protocol)

- Studies began in 1977 with the trapping, tagging, and recapture of fall Chinook salmon (fall Chinook salmon), coho salmon (coho salmon), and fall steelhead (steelhead). In 1978, similar studies were added to include spring-run Chinook salmon (spring Chinook salmon). Steelhead were dropped from the program in 1985 through 1989 and reinstated in 1990. For example, in 2005 trapping and tagging operations were conducted from July through late November at temporary weir sites near the towns of Willow Creek and Junction City on the mainstem Trinity River. At both weir sites, trapping was attempted during a five day period beginning late afternoon on Sunday and ending mid afternoon on Friday. Each trapping day the weir was opened for approximately four hours to allow fish to pass unimpeded through the weir site. Occasionally, trapping schedules were modified for holidays or for safety purposes during high flows. Tags returned from anglers to the TRRP Arcata field office through June 1, 2006 were included in assessing harvest and catch and release rates. Tags returned after are not included in estimates. See Knechtle and Sinnen (2008) for more detail.

Uncertainties / Limitations

- Not all tags are returned from anglers
- May have possible bias in estimate because of modification in trapping schedule for safety reasons (depends on extent of modification and how fish respond to these high flows, i.e., are the migrating in greater numbers during high flow)
- Sampling steelhead is a huge source of uncertainty. Weirs are not particularly useful for monitoring steelhead escapement because they are not in the water for a long enough period (i.e., steelhead migration occurs over a longer period of time)
- Can capture tributary production using this method (i.e., weirs), but cannot distinguish them from mainstem fish.
- It is not known how many years of monitoring will be required to detect a biologically significant change in escapement.

PM and Assessment(s): *Contribution of Trinity River naturally produced anadromous fish to dependent sport, tribal, and commercial fisheries and recruitment (Assessments 16A to 21A)*

Method (Method not yet identified)

- Specific methods for teasing out Trinity contribution to lower Klamath and ocean harvest have not yet been developed
- Sport fishery fishing mortality is assessed using tag recovery in the Trinity River and creel surveys in the lower Klamath (creel surveys are only done for fall Chinook salmon). Currently, tags returned from anglers to the TRRP Arcata field office through June 1, 2006 are included in assessing harvest and catch and release rates in the sport fishery. Tags returned after this date are not included in estimates. Harvest rates are calculated for each species (and race of Chinook salmon) by dividing the number of angler-returned tags from harvested fish by the number of fish that were effectively tagged. See Sinnen (2008) for more detail on the methods.
- One possible method to differentiate Trinity River from Klamath River stock proportions in the commercial and tribal fisheries is to use genetics to proportion out the catch to Klamath and Trinity rivers. Andrew Kizinger has been working on this for commercial ocean fisheries

Uncertainties / Limitations

- Since not all tags are returned from anglers, the precision of the estimate for fishing mortality in the Trinity River could be biased.
- Difficult to separate out Trinity naturals from Klamath stock in lower Klamath River; current methods are not deemed adequate
- Not necessary to assess coho salmon harvest because there are no sport, tribal, or commercial fisheries on the lower Klamath River.
- Do not have an accurate estimate of sport fishery fishing mortality in lower Klamath River for spring Chinook salmon because creel surveys are not conducted

PM and Assessment(s): *Cohort performance or year class (Assessments 22A and 23A)*
Method (Sample (Alternative design) / Existing protocol) • Cohort reconstruction is done for spring and fall hatchery Chinook salmon using CWT recovered at hatcheries and from carcasses at weirs. • Scale samples are also taken from Spring and Fall Chinook salmon at the weirs, from tribal harvest, and from fall Chinook salmon during the creel surveys. Scales are aged to determine the adult grilse separation, as well as to determine the number of age 3 fish. Age distribution data from scale analyses is added to that from the CWT for cohort reconstruction • Fall Chinook salmon creel surveys take place in the lower Klamath River from early August to early November. The weekly sampling schedule in the lower Klamath River was to sample each site three days per Julian week. For weeks that were sampled using a schedule other than that mentioned above, the data were expanded accordingly. Each angling access site is sampled throughout the day to account for total catch and effort for that particular site (see Borok (2008) for a more detailed description of the methods used).
Uncertainties / Limitations • Hard to separate out Trinity naturals from unmarked hatchery fish • Application of hatchery cohort reconstruction to naturals is uncertain; not known if both groups have similar or different rates of survival • Samples taken from fall Chinook salmon during creel surveys may be biased towards larger or smaller fish depending on gear selectivity. Likewise, age distribution of fish (both fall and spring Chinook salmon) arriving at the weir may be biased as a consequence of gear selectivity in commercial and tribal fisheries.

PM and Assessment(s): *Number of age 3 ocean recruits of fall-run Chinook salmon (Assessment 22A)*
Method (Sample (Alternative design) / Existing protocol) • Number of age three recruits is determined from the cohort reconstruction. • Length at age curve based on empirical fork length and CWT data are currently used to determine number of age 3 fish for Chinook. It is possible to use length at age to get an accurate estimate of number of age 3s, because there are only two returning age classes.
Uncertainties / Limitations • Difficult to separate Trinity naturals from unmarked hatchery for Chinook salmon. • Using the current scale monitoring method, it is not possible to distinguish Klamath from Trinity stocks. • Current methods are not adequate, need to refine them further or develop new ones.

Remaining issues to be resolved for objective 4 assessment methods in order of priority:
• Develop a method for assessing the contribution of Trinity River fish to sport, tribal, and commercial fisheries (Assessments 16–21). • Develop superior methods for cohort reconstruction and identification of age 3 fish. Need a method for each species.

Objective 5: Establish and maintain riparian vegetation that supports fish and wildlife**.**

Sub-objective(s) / topic(s): 5.1 Promote diverse riparian vegetation on different geomorphic surfaces that contribute to complex channel morphology and high quality aquatic and terrestrial habitat, and 5.2 Prevent riparian vegetation from exceeding thresholds that simplifies channel morphology, and degrades aquatic habitat quality.

PM and Assessment(s): *Patch area, Patch type, Patch location (Assessments 1R and 2R)*

Method (Census (aerial photo) + sample validation / Existing protocol)

- Aerial photographs of the Program Area including at least X m from the center line are obtained. The photos are divided into vegetation patch types by qualified ecologists (computer interpretation may be feasible – see ortho photo interpretation). A subsample of patches is then visited to validate photo interpretation.
- Frequency for new photos: every 3-5 years or after major geomorphic events. The outcome of this effort is a map divided into polygons of different patch types. There are a total of ~10-12 vegetation patch types (McBain & Trush 2005).

Uncertainties / Limitations

- Interpretation and analyses typically have a long time lag.
- Uncertainty around timing: when (at what time of year) should you go out and do this?
- Uncertainty around frequency. Historically photos have been taken annually, but you probably only have to redo aerial photos after major flood events or other process changes. In dry years, may want to only map areas where riparian vegetation is established.
    - One option is to have someone float/walk the Program Area each year as an alternative to annual mapping, or you could just walk the rehab sites where you expect to see re-growth
- Specific objectives/targets have not been identified for riparian vegetation species, although revegetation requirements do exist for environmental permitting purposes.
- How far away from the river's edge should the upland mapping boundary be, i.e., what is a realistic distance? Mapping all of the vegetation within the 500m distance either side of the channel centerline as specified by the TMAG may not be needed for the entire Program Area

PM and Assessment(s): *Patch characteristics (e.g., age-class, diversity, and distribution) (Assessment 1R)*

Method (Sample (Alternative design) / Existing protocol)

- Patch characteristics were originally defined using a stratified random sample of vegetation patches with more effort allocated to dominant patch types. Within a selected patch a 400m^2 rectangular plot was selected. Within the plot the species, age-structure, dominant plants in the canopy, shrub, and herb layers were documented. The information was then extrapolated to the rest of the patches within the same stratum. The plots require significant effort (1-3 days per plot – John Bair pers. comm.). The existing sampling design provides information at the site and system scale.
- Currently, a variable width band transect is used to capture the species composition and structural patch characteristics of patch types intersected during band transect sampling. The observed patch type development monitored at band transects can be related to the more general patch type descriptions derived using the releve sampling (described in previous bullet). The opportunity to quickly get at patch diversity and structural complexity while doing the band transects seemed like a natural thing to do.
- Opportunity for using the GRTS panel design to get co-located sites may be limited because GRTS uses river mile as the target population and these sites can be away from the river as well.

Uncertainties / Limitations

- Specific objectives/targets have not been identified for riparian vegetation
- There is a pretty good understanding of what these patch types are, and there is does not appear to be a need to sample again. However, there may be interest in sampling them to see if they are changing. If this is the case:
  - How many plots per strata (patch type) should be sampled?
  - How frequently should this be done?
- What question(s) are you trying to answer with this assessment?
- How is the location of the variable width band transect selected within the patch?
- Uncertainty around how you would use and link this information to other assessments (e.g., wildlife)
- Need to consider best way to link these data to riparian bird monitoring

PM and Assessment(s): *Initiation, establishment of riparian vegetation (Assessments 3R)*

Method (Existing design inadequate (the within transect protocol is valid) / GRTS panel, Alternative design, two stage design should be considered)

- Historically 2-6 band transects were monitored at all rehabilitation sites (i.e., a census of bank rehabilitation sites). The location of transects within the site is not randomly selected but instead is chosen to be located on the two cross sections in the middle of the site to capture the different types of features within the site. Transects are monitored twice per year to evaluate the effect of both winter peak flow and managed peak flow on age and species structure. From this it has been possible to evaluate the risk of encroachment. At each transect all plant species are listed and woody plants are counted and measured within a variable width band (15m wide for trees, 5m wide for shrubs, 1m wide for seedlings). The bank location of individual plant species are not currently monitored using transects, but would be easy to do and should be done in the fall transect.
- It takes two people approximately one day to complete a single transect takes (J. Bair, pers. comm.), although it may be possible to improve the efficiency by subsampling different bank locations with seedlings. The information cannot be extrapolated to the system with the current sampling design. If there were an interest in doing so, the GRTS panel design would be an appropriate method to select sites. Additionally, the current judgment based selection of sites within a rehabilitation site restricts the use of the information collected to the single transect location as it isn't clear how the information should be expanded to represent the full rehabilitation site.

Uncertainties / Limitations

- The required number of transects to provide sufficient information is not known.
- Clarify what question or hypothesis this information is used to test exactly? For example, if only assessing seedling initiation then perhaps it could be more efficient by dropping the shrub/tree portion.
- Determine how this assessment links to geomorphic processes.
- Another option is to have someone float/walk the Program Area each year to assess initiation and establishment of riparian vegetation as an alternative to the detailed transects.

PM and Assessment(s): *Photopoint qualitative assessments*

Method (Sample (Alternative design) / existing protocol → could use GRTS panel design)

- Fixed point photo-monitoring of fixed sites over time to understand site scale evolution. 120 sites were assessed in 2001. These provide a different perspective from aerial photos allowing more detailed assessment of vegetation and channel structure. This protocol may not allow quantitative assessments, but photographs are a powerful tool to communicate information to stake holders and to capture information that we didn't think to measure. The current non-random selection of sites limits the inference (qualitative or quantitative) to the sites observed. This could be addressed by using the GRTS panel design to select the sites. It would be useful to collect several photos at each rehabilitation site (e.g., pre, as-built, 2-3 years post construction, periodically thereafter). A sample of non-rehabilitation sites could be selected for periodic sampling using the GRTS panel design.

Uncertainties / Limitations

- Determine how many sites would be sufficient to provide useful information.
- This is a protocol not a performance measure and some more thought needs to be put in to tie it into an assessment.

Remaining issues to be resolved for objective 5 assessment methods in order of priority:

- Determine an appropriate sampling design for vegetation structure that can provide site and system-wide estimates and is integrated with riparian bird assessments. Complete power analyses to determine the appropriate sample size for each stratum and clarify the selection of the plot within the patch sampled.
- Identify set of simple criteria for designating whether riparian areas are healthy and functioning to a degree that satisfies environmental compliance objectives
- Clarify what the band transect data will be used to evaluate. Then assess the appropriate sample size and selection of sites.
- Determine appropriate time frame for aerial photographs (Continue with annual assessment until shown otherwise)
- Photopoint monitoring – consider sample size and selection of sites.

Objective 6: Rehabilitate and protect wildlife habitats and maintain or enhance wildlife populations following implementation**.**

Sub-objective(s) / topic(s): 6.1 to 6.4 Maintain Trinity populations and species diversity of riparian and riverine birds using in the Program Area, and maintain populations of Foothill Yellow-Legged Frog and Western Pond Turtle

Riparian birds

PM and Assessment(s): *Abundance and diversity (breeding season) (Assessments 1W, 3W, and 4W)*

Method (Sample (Alternative design) / Existing protocol)

- Point counts for riparian birds have been completed at 422 systematically selected points (~every 250-350m on both sides of the river) along the river throughout the Program Area and at 32 points in rehabilitation design areas. Additionally, about 60 sample points are located on tributaries along the Program Area and above the Lewiston dam. Area search surveys (Ralph *et al.* 1993) are conducted at points located in rehabilitation sites and at a random selection of points across the Program Area. All birds detected, and their distance from the observer, are recorded during counts. The protocols used for the point counts and area searches are described in (Miller *et al.* 2005). The points are selected in a two-stage sampling framework. The system is first divided into 16 reaches (primary sampling units or psu's). The systematically located points within each reach are the secondary sampling units. Each year either all 422 river points in the Program area or all of the points within a random sample of the 16 reaches are surveyed.
- Diversity is defined as species richness and can be determined from point counts and area searches.
- Abundance is also measured at constant-effort capture stations. Capture rate (number of birds captured per hour each net is open) is an index to abundance (Ralph and Dunn 2004). Six stations were established in 2002-2003 to monitor birds across the Program Area. Some station locations were selected to monitor bird trends near rehabilitation sites and some to serve as controls as rehabilitation progresses. Station selection was also influenced by capture rates during pilot sessions at potential sites. Capture efficiency is influenced by habitat and bird activity, but serves as an index to abundance that measures population trends.

Uncertainties / Limitations

- In some years certain points (particularly those that are not road accessible) are not available to be sampled due to logistical constraints. If these points are missing at random, then it may not be a serious problem to simply ignore the missing points and analyze the data normally. If however the points that are logistically difficult to sample (i.e., those not road accessible) have some relationship to the response (i.e., abundance and diversity) then there may be a bias in the estimates. This uncertainty should be evaluated by comparing estimates with and without road accessible points for those years where all points were sampled.
- The bird group should evaluate the trade-off in efficiency between the two stage sampling design and a random sample of points from the entire collection of possible points. The selection of 50 points from the entire 40 miles is different from the selection of 50 points from only 4 reaches. Preliminary analyses using GLIMMIX to test for a 'reach' effect suggested that reach was not important but we would still recommend that variance estimates and corresponding power calculations are completed using a two-stage estimate (reaches = psu, points=ssu). See any sampling text for details, e.g., Cochran (1977; page 276). Logistically it may be easier to sample all points in one reach than to sample half of the points in 2 reaches.

Given information about the time/cost to move between points and between reaches and estimates of variability within and between reaches, it should be possible to determine an optimal approach. In other words we can determine how many reaches should be selected and how many sites within each reach should be selected to optimize the sampling effort and statistical precision.

- Depending on the outcome of the above power analyses, the GRTS panel design could be considered. If the cost/effort of moving between reaches is large, then the GRTS design will likely not be an improvement. However, the GRTS panel design might make it easier to overlap sites with the riparian vegetation monitoring (i.e., variable width band transect).

PM and Assessment(s): *Abundance and diversity (post-breeding season and migration) (Assessments 1W, 3W, and 4W)*

Method (Sample (Alternative design) / Existing protocol)

- Abundance during non-breeding and migration season is assessed using a combination of area searches and capture stations (see details above)
- Diversity is defined as species richness and can be determined from point counts.

Uncertainties / Limitations

- Addressed above.

PM and Assessment(s): *Productivity (condition & survival) (Assessments 2W, 3W, and 5W)*

Method (Sample (Alternative design) / Existing protocol)

- Productivity is defined as the ratio of juveniles to adults. Age is determined when handling birds caught by mist nets. Mist nets are a standard procedure for capturing birds (Ralph and Dunn 2004) Capture stations were not chosen randomly (see explanation under “Abundance”). Instead, sites were selected to maximize the number of birds caught. During the breeding season the measured age structure is related to the local habitat surrounding the stations. During post-breeding, as adults and young begin to forage more widely, the measured age structure represents breeding success over a larger area. As birds begin to migrate, abundance of young and adults may differ, but represent habitat quality for this key period for survival.
- Condition is also determined when handling birds that have been captured in mist nets. The criteria used to define condition are described in Miller *et al.* (2005). By evaluating the health of birds we can assess potential causes of any observed trends in productivity.
- Birds are banded at the mist net sites, thus providing some opportunity to estimate survival from recapture data, particularly within a year, and may potentially provide another strategy for assessing abundance. Mist netting and banding take place at some rehabilitation sites prior, during, and after rehabilitation actions have been carried out.

Uncertainties / Limitations

- The relationship between bird condition (health) and reproductive success is now being examined.
- Area search surveys are conducted each day of capture and abundance estimates are compared from the two methods.
- Fires are a source of confounding, particularly if they burn large sections of riparian vegetation at the site.

5 Riverine birds

PM and Assessment(s): *Abundance (Assessments 6W and 7W)*

Method (Spatial census / Existing protocol)

- Wildlife float surveys of the complete Program Area take place once per month for 5 months. Each full survey requires 2 days to complete and the river is always surveyed in the same way so that all reaches are roughly surveyed at the same time of day. The consistent, 2-day survey is the most logistically feasible sampling design to avoid effects of time of day the index to abundance.
- The count for each species is documented as the “count per river segment (250m-350m each)”. This information may be reported at any scale of interest to other disciplines, so long as it is larger than the river segment.

Uncertainties / Limitations

- Riverine birds are highly mobile and have large ranges. Consequently the scale may vary for appropriate integration with other assessments.

PM and Assessment(s): *Distribution (Assessments 6W and 7W)*

Method (Spatial census / Existing protocol)

- Estimates of distribution can be obtained from the data collected during the monthly float surveys as described above.
- Distribution refers to the spatial arrangement of individual birds or groups in the Program Area. Birds may be clustered, random, or spaced at some regular interval. The distributions will vary by species and season.

Uncertainties / Limitations

- Repeated sampling at multiple times (in a special study) could generate a time-of-day bias correction, so that river segment counts could be used for spatial analyses (e.g., comparing rehabilitation sites and reference areas)

PM and Assessment(s): *Productivity (Assessment 6W)*

Method (Spatial census / Existing protocol)

- Productivity is defined as the ratio of juveniles to adults. This is assessed by visual identification of individuals observed during the float surveys.

Uncertainties / Limitations

- Age for riverine birds is determined from plumage characteristics observed during surveys. Because some species tend to flush when boats approach, it is only possible to determine age for a portion of the birds observed. A power analysis will be conducted using the current survey data to determine if the data provide sufficient precision for detecting trends in age ratios.
- It isn't known how much bias exists when using visual observation to age birds

PM and Assessment(s): *Riverine bird predation on fry and smolts (Assessment 8W)*

Method (Experiment / Process)

- Currently, the predation rate on fry and smolts by riverine birds is not assessed and no method or sampling design has been identified.
- There may be a need for experimental manipulation

  Treatment variable:
    - Alternative hatchery fish release strategies or contrasts between release periods and non-release periods

  Response variable(s):
    - Bird distribution (counts per segment from float surveys)
    - Bird foraging behavior (observation from float surveys)
- By identifying stable isotopes in hatchery (and natural) fry and smolts, we could test riverine birds (particularly Common Mergansers) to determine their potential impacts on the fry and smolt survival.

Uncertainties / Limitations

- Need to evaluate the potential for using stable isotope measurements to assess predation rates on fry.
- Need to coordinate with the hatchery managers to determine an appropriate series of treatments (i.e. alternative hatchery release strategies)

Foothill Yellow-legged Frog

PM and Assessment(s): *Abundance (Assessments 10W and 11W)*

Method (spatial census from DC-NF / Existing protocol is adequate for inference within DC-NF)

- An index of reproductive effort (total number of egg masses) is used to assess relative abundance. Each egg mass is indicative of a single breeding female as females don't double clutch. The method is modeled after redd counts which are commonly used as an index of salmonid abundance (see Section 4.5.1 – *Density of redds and Number of redds/spawning habitat*).
- Egg masses are counted at all cobble bars (FYLF breeding habitat) during bi-weekly float surveys from Douglas City to the North Fork. A single survey from Douglas City to the North Fork takes approximately 2 to 3 days.
- Conditions in the Lewiston to Douglas City portion of the Program Area are expected to improve over time. The existing protocol does not monitor this area, but future sampling efforts should periodically sample the area to see if FYLF have begun to colonize this area. GRTS panel design may be an appropriate sampling design for this river section.

Uncertainties / Limitations

- No inference is possible for the Lewiston to Douglas City portion of the Program Area.
- Current sampling strategy just monitors gravel bars, which are known to be the preferred breeding habitat for this species in alluvial systems. FYLF do occasionally stray from these bars. Therefore it may be important to periodically monitor areas that are less optimal habitat.

PM and Assessment(s): *Survival (egg mass to metamorphosis and all stages in between)*

Method (Sample or census (Alternative design) / existing protocol)

- Survival of egg masses to hatching is the easiest assessment to complete. Once egg masses have been identified they are observed at bi-weekly intervals until hatching or failure. This may be completed for either a random sample of observed egg masses or for all observed egg masses.
- Due to the limited population size and distribution, the current protocol is not conducive to a GRTS design, nor will it be possible to deliberately have co-located sites for this performance measure. Until the population rebounds, this assessment will have to rely on opportunistic co-location.

Uncertainties / Limitations

- Determine guidelines for how many egg masses should be tracked to reliably estimate the survival.
- Not sure of the best approach for assessing the survival of later life-stages (i.e., performance measure, sampling design and protocol).

PM and Assessment(s): *Flow & desiccation*

Method (Sample (Alternative design) / yet to be determined)

- Integrate with Physical and Fish Habitat subgroups to measure the cross section profile of the river at egg mass locations that are tracked for survival. This information can be used to assess the likelihood of desiccation under a variety of flow release scenarios.

Uncertainties / Limitations

- Need to understand the biological or environmental triggers that initiate breeding. If this was better understood it could be used to inform hydrograph decisions.

PM and Assessment(s): *Area of breeding habitat (Assessment 9W)*

Method (Sample or census (Alternative design or GRTS) / yet to be determined)

- Map or count gravel bars from aerial photos (census)
- Map or count gravel bars from float surveys (at range of flows?) (census)
- Map or estimate area of shallow edgewater associated with gravels bars from fish habitat survey assessments (sample)

Uncertainties / Limitations

- What is the most useful performance measure?

PM and Assessment(s): *Recruitment (Assessment 10W)*

Method (Sample (Alternative design) /yet to be determined)

- Surveys for the previous year's cohort would occur during spring to get a relative index of recruitment. The survey design would likely be driven by the location of egg masses along with information about dispersal (time and distance) and proximity to source tributaries.
- Maybe able to refine assessment by use of cohort marking such as elastomer dye, PIT tags, or toe –clipping.

Uncertainties / Limitations

- Not sure the best approach to assess this performance measure

Western Pond Turtle

PM and Assessment(s): *Abundance (Assessment 13W)*

Method (Sample / Existing design inadequate / GRTS panel or Alternative designs such as, adaptive sampling should be considered)

- Historical monitoring of abundance using Mark-recapture protocols has been periodic (1991-3 and 2005-7) and has only been completed for a small portion of the Program Area (reaches 10 and 11 as defined by Wilson *et al.* 1991). This should be supplemented with additional surveys at a sample of sites to provide a system-wide estimate. A GRTS design would also enable assessment of the relationship between abundance and habitat. Each site needs to be visited multiple times per season to assess population status.
- If GRTS selected sites are too inefficient, adaptive sampling (Thompson 2002) may be an alternative as it is designed specifically for the clustered distributions, such as the western pond turtle displays (J. Betteso, pers. comm.).

Uncertainties / Limitations

- Current design provides no ability to make inference to the system and limited ability to understand relationships between turtles and other disciplines.
- Turtles aren't randomly distributed across the Program Area, they occur in clusters. Sampling design needs to be able to account for this.
- The number of sites required to obtain a useful system-wide estimate is not known

PM and Assessment(s): *Distribution (Assessment 13W)*

Method (Census or sample / yet to be determined)

- Could assess by completing float surveys of the entire Program Area and documenting all encounters (Census).
- Could assess by dive surveys of selected locations. Locations could be selected by GRTS, by results of float surveys, or by revisiting known locations of historic population clusters

Uncertainties / Limitations

- Not clear what the most effective approach is to assess distribution

PM and Assessment(s): *Recruitment (Assessment 14W)*

Method (Sample / yet to be determined)

- Recruitment can be determined by monitoring age-structure. Typically, turtles can be accurately aged up until 10 years (J. Bettaso, pers. comm.). Revisiting sites periodically over time (i.e., every 3-5 years) would improve the ability to assess recruitment because new individuals to the population would be easily identified (J. Bettaso, pers. comm.; Bury and Germano 1998). A panel design (where sites are revisited over time) would be appropriate. Ideally a GRTS design will be used, but if this is too inefficient (see discussion under Abundance) then alternative designs may need to be considered.

Uncertainties / Limitations

- The number of sites required to obtain a useful system-wide estimate is not known

Remaining issues to be resolved for objective 6 assessment methods:

Riparian birds

- Power analyses using two-stage estimate
- Evaluate bias when using road accessible sites only
- Determine if and how banding (i.e., mark recapture) can be used to estimate abundance
- Work through the sampling design questions (Appendix G) and develop a sampling strategy to address the post-breeding season and migration abundance and diversity assessments.

Riverine birds

- Develop an experimental design to evaluate effects of alternative hatchery release strategies.
- Consider small study to evaluate time-of-day bias in distribution data
- Evaluate the power to detect trends in productivity as a performance measure

Foothill Yellow-legged Frog

- Determine a strategy to identify the trigger for breeding.
- Work with the habitat and 2-D modelers to evaluate the impact of alternative flow schedules on egg mass survival.
- Consider how we could estimate recruitment? Would PIT tags be an option?
- Consider how we could estimate survival of other life stages.
- Determine guidelines for how many egg masses should be tracked to reliably estimate the survival(current numbers are so low they can probably all be tracked)

Western Pond Turtle

- Determine best strategy for integrating existing design (reaches 10 and 11) with the GRTS panel design or determine if an alternative design is required. Should reaches 10 and 11 be maintained as permanent sites? Why or why not?
- Identify a useful performance measure for nesting habitat and develop a corresponding sampling design.
- Determine the necessary sample size to assess changes in abundance at the system scale. Use 2009 sampling to collect initial data from system in order to answer this question.
- Work with the fish habitat scientists to determine an appropriate strategy for assessing structural and thermal complexity at rehabilitation sites (relates to Assessments 1H, 3H, and 8H).
- Explore the use of adaptive sampling techniques to address the problem of population clusters.
- Determine the necessary sample size to assess changes in recruitment at the system scale. Use 2009 sampling to collect initial data from system in order to answer this question.

Appendix M. Future risk of detrimental riparian encroachment under the ROD flow regime

Sub-Hypothesis #1: The TRRP flow and sediment regimes are considerably smaller than pre-dam conditions, resulting in a high level of risk for future detrimental riparian encroachment to occur, particularly following a series of drier water years.

Flow regime

- Peak magnitude – Peak flow magnitudes at Lewiston reduced from ~100,000 ft^3/s pre-dam to 11,000 ft^3/s ROD releases (about 11% of pre-dam peak flow magnitude). Maximum peak flow releases from Trinity Dam could be increased up to 14,000 ft^3/s based on outlet works capacity, downstream bridge capacity, and proximity of downstream houses/property.
- Peak frequency – Pre-dam usually had multiple peak flows each year greater than 6,000 ft^3/s, ROD releases only have 1 per year greater than 6,000 ft^3/s in 60% of water years (Normal and wetter years) at Lewiston. Mainstem winter storm component missing, although sometimes partially provided in downstream reaches by tributary floods.
- Duration – Snowmelt peaks and duration roughly equal
- Summer base flow – Pre-dam base flow continued to drop through the summer as low as 100 ft^3/s, ROD base flow kept at constant 450 ft^3/s throughout summer.

Sediment regime

- Tributary and upstream fine sediment supply – Eliminated from upstream watershed, post-dam tributary supply much greater than transport capacity, post-ROD supply substantially less from Grass Valley Creek, equal or slightly less from other downstream tributaries
- Tributary and upstream coarse sediment supply – Eliminated from upstream watershed, equal or slightly less from tributaries downstream, eliminated from Grass Valley Creek
- Mainstem coarse sediment supply – much less than pre-dam, post-ROD augmentation rates and grain size intended to balance transport capacity under ROD high flow regime.

Risk of future riparian encroachment

Figure M.1 illustrates the risk implied in Sub-hypothesis #1, namely the risk of detrimental riparian encroachment during and following sequences of drier water years. Evidence presented in the TRFE indicates that three years is the period of time necessary for willow seedlings to root to the degree that ROD peak flows are no longer sufficient to scour and kill the growing plants. After that channel simplification will occur. Detailed annual monitoring and assessment of seedlings, initiation, and incipient recruitment is needed to assess annual risk, as any year could be the start of a series of dry years. Therefore, annual assessments are necessary to inform annual adjustment of the magnitude and duration of ROD peak flow releases.

Vertical scour/deposition of bar surfaces along the low flow channel due to high flow releases and tributary floods will be the primary riparian seedling mortality agent responsible for preventing detrimental riparian encroachment. Coarse sediment augmentation, channel rehabilitation, and large wood introduction will result in enhanced modes of riparian vegetation mortality. Reduction in fine sediment storage in the reach upstream of Grass Valley Creek due to ROD high flow releases will reduce the risk of riparian berm formation. Reduction in fine sediment supply from Grass Valley Creek and fine sediment storage downstream to Indian Creek due to ROD high flow releases will reduce the risk of riparian berm formation downstream to Indian Creek. However, the overall risk of detrimental riparian encroachment remains high.

Sub-Hypothesis #2: The TRRP flow and sediment regimes are considerably larger than the post-dam conditions that led to detrimental riparian encroachment. The combination of the ROD (variable) flow regime and the prescribed annual gravel augmentations reduces the risk of future detrimental riparian encroachment.

Flow regime

- Peak magnitude – Peak flow magnitudes at Lewiston increased from 6,000 ft^3/s under pre-ROD conditions to 11,000 ft^3/s under ROD releases (roughly 2-fold increase from pre-ROD peak flow magnitude).
- Peak frequency – The ROD flow regime institutes an annual flood peak each year; the pre-ROD flow regime experienced Safety of Dams (SOD) releases in some normal and wetter years, all less than 6,000 ft^3/s at Lewiston. Mainstem winter storm component missing, although sometimes partially provided in downstream reaches by tributary floods. Overall, frequency and magnitude of peak flows will increase under the ROD regime compared to pre-ROD conditions.
- Duration – Snowmelt peaks and duration roughly equal

Sediment regime

- Tributary and upstream fine sediment supply – Eliminated from upstream watershed, post-dam tributary supply much greater than transport capacity, post-ROD supply substantially less from Grass Valley Creek, equal or slightly less from other downstream tributaries
- Tributary and upstream coarse sediment supply – Eliminated from upstream watershed, equal or slightly less from tributaries downstream, eliminated from Grass Valley Creek
- Mainstem coarse sediment supply – much less than pre-dam, post-ROD augmentation rates and grain size intended to balance transport capacity under ROD high flow regime.

Risk of future riparian encroachment

According to Mackin (1948), stability in an alluvial channel "occurs when, over a period of time, the slope is adjusted to provide, with available discharge and the prevailing channel characteristics, the velocity required to transport sediment supplied from the drainage basin." Lane (1955) defines alluvial stability as "an unlined earth channel which carries water, the banks and bed of which are not scoured objectionably by the moving water, and in which objectionable deposits of sediment do not occur." Chien (1955) asserts that "…the equilibrium state of an alluvial channel is attained by adjusting the dimensions of the cross section and the slope of the channel to the natural conditions imposed on the channel by the drainage basin."

Completion and operation of Trinity and Lewiston dams drastically reduced the high flow regime and sediment regime, to the point where the channel was largely static except during SOD releases and tributary floods. Too much stability following dam closure resulted in detrimental riparian vegetation. A primary philosophy of the TRFE was to restore a dynamic stability in the form of a variable flow regime, coarse sediment management, and many of the attributes of a healthy river (a mobile bed being one such attribute).

Figure M.2 illustrates the historical and predicted indices of bed mobility, detrimental riparian vegetation, substrate composition, and annual peak flow. Annual volume in this context, while specified in the Flow Study, is a poor surrogate for frequency and magnitude of annual peak flows. Premises of Sub-Hypothesis #2 include an annual gravel augmentation program that results in a fining (compared to Pre- and Post-Dam/Pre-ROD periods) of the river bed substrate, and a variable flow regime that releases roughly 50% of the annual Trinity Lake inflow to the Trinity River. **Figure M.3** illustrates historical and predicted changes in riparian vegetation and aquatic habitat, with a potential future undesirable trajectory in riparian vegetation and aquatic habitat after a series of drier water years. There is a difference of opinion on the risk of this trajectory; some are concerned that the ROD high flow regime and sediment augmentation program does not provide any safety factor for series of dry water years, increasing the risk of detrimental riparian encroachment and aquatic habitat degradation.

Others see this as a low risk as channel narrowing is a natural process, and the channel will naturally evolve to an equilibrium width over time that is wider than the post-dam channel width. As the bed becomes finer (compared to both pre-dam and pre-ROD periods) through the augmentation of gravel, the incipient motion threshold will likewise decrease. In the meantime, the ROD flow regime will, on average, be greater than post-dam conditions. When the bed fines to the point where the majority of the size fractions are mobile under the ROD flow regime (see **Figure M.2**), a post-ROD era of bed mobility will begin. In this condition, the establishment of detrimental riparian vegetation will be hindered, until in response, a new regime of near-stream riparian vegetation adjusts to both the ROD flow and sediment regimes. The result will be a new dynamic equilibrium with a channel able to adjust both its width and slope (changes in sinuosity) to match both the ROD flow and post-ROD (AEAM) sediment regime, artificial as both will be (compared to the natural basin). In addition, there will be significant mortality agents, not specifically described or quantified in the Flow Study, to maturing riparian vegetation along the low water edge, including lateral scour from channel migration, inducement of local scour by the placement of large wood, sediment burial, vertical scour from increased coarse sediment supply, and others. Therefore, in the medium to long term, the combination of the ROD flow regime and the prescribed annual gravel augmentations reduces the risk of detrimental riparian encroachment, while enhancing geomorphic complexity.

Discussion

Figure M.2 and **M.3** illustrates the interaction of many processes key to the riparian management and aquatic habitat goals of the TRRP. The issues is framed in the context of risk, namely the risk of detrimental riparian vegetation and the resulting channel simplification, and the ultimate consequence of loss of critical juvenile salmonid fish habitat.

The question is how to define 'risk.' In **Figure M.2** risk is defined for both hypotheses, where **Figure M.1** illustrates the risk associated with the life cycle of fringe riparian vegetation, and the potential consequences of not assessing that risk on an annual basis.

Figure M.2 and **M.3** shows that the risk associated with Sub-Hypothesis #1 is directly proportional to the annual flow volume or frequency and magnitude of annual floods. The intent is to show that if the pre-dam flow regime returned to the river, the risk of detrimental riparian vegetation would, in the long term, be zero. With roughly 50% of the pre-dam flow volume available under the ROD flow regime, a significant risk of detrimental riparian vegetation remains, enough so to warrant annual assessment of its status.

The risk associated with Sub-hypothesis #2 is proportional to the difference between substrate composition (median size and size distribution) and annual flow volume or better, annual peak magnitude and frequency. The stability concept discussed in Sub-Hypothesis #2 section leads to the conclusion that given a mobile bed, that is a substrate able to be mobilized frequently by the ROD flow regime, the river will adjust to both of those factors.

Commonalities

Elements common to both of these Sub-hypotheses include:

- In response to the ROD flow regime, the channel (active – probably widen; low-flow—may narrow; bank-full—may widen considerably) will widen compared to pre-ROD conditions, where not confined geologically (valley walls), geomorphically (dredger tailings or pre-dam bed material), or by infrastructure (bank protection). The potential and rate of widening will be proportional to the stability of the banks, and the power of the flow above the incipient erosion threshold.
- The annual addition of prescribed volumes (10,000 ton/yr) and associated fractional sizes (½–4 inch diameter) of riverine coarse sediment will reduce the bed mobility threshold. The result will be more frequent episodes of bed-material transport under the variable ROD flow regime. In response, the river channel will have greater topographic, particularly vertical, variability, a more sinuous low-flow (<1,000 ft^3/s) channel, and greater frequency and magnitude of repeated geomorphic units. The addition of coarse sediment will enhance modes of riparian vegetation mortality.
- The removal of riparian berms and/or compacted tailings on the outsides of bends, lowering the floodplains on outsides of bends, and adding large wood into the active channel, will increase the potential for lateral channel migration, both magnitude and frequency, where not confined geologically, geomorphically, or by infrastructure. The rate of lateral migration will be proportional to the stability of the banks, and the power of the flow above the incipient erosion threshold of the banks.
- The addition of gravel sized (volume and fractional mixture) coarse sediment, combined with the ROD flow regime, will increase frequency and magnitude of bed mobility, resulting in greater topographic, particularly vertical, variability, a more sinuous low-flow (<1,000 ft^3/s) channel, and greater frequency and number of repeated geomorphic units.
- The augmentation of coarse sediment will result in multiple modes (mode types as well as magnitude) of riparian vegetation mortality of varying effectiveness.
- Fine sediment supply to the Trinity River from Grass Valley Creek will continue to be managed at Hamilton Ponds. Watershed restoration will eventually result in less fine sediment recruitment to the Trinity River. Fine sediment storage in the mainstem will decrease in response to the decreased watershed supply and ROD high flow (greater than 2,000 ft^3/s) regime.

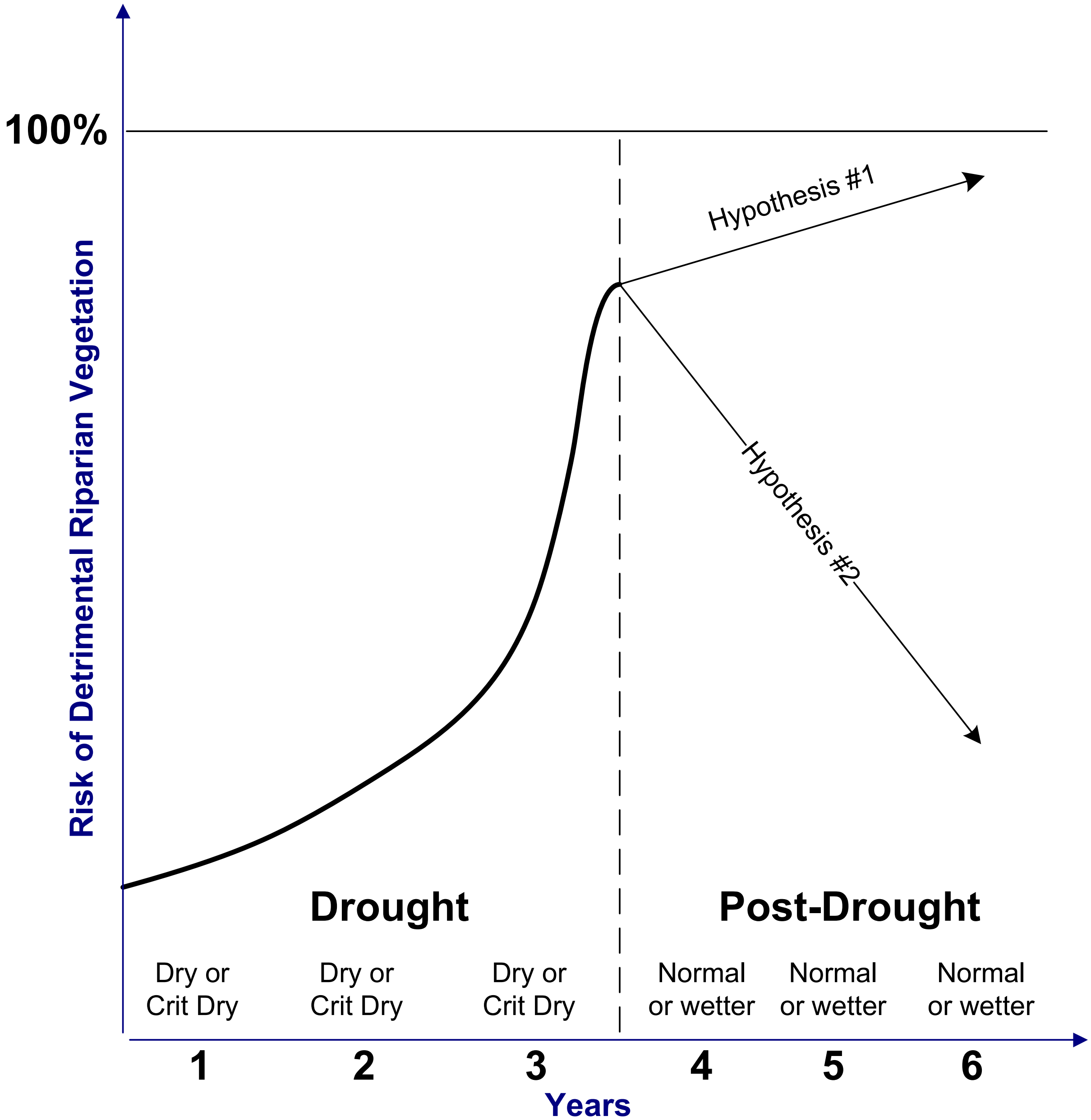

Figure M.4. Temporal based differentiation of risk associated with the competing Sub-hypotheses 1 and 2, described in the text.

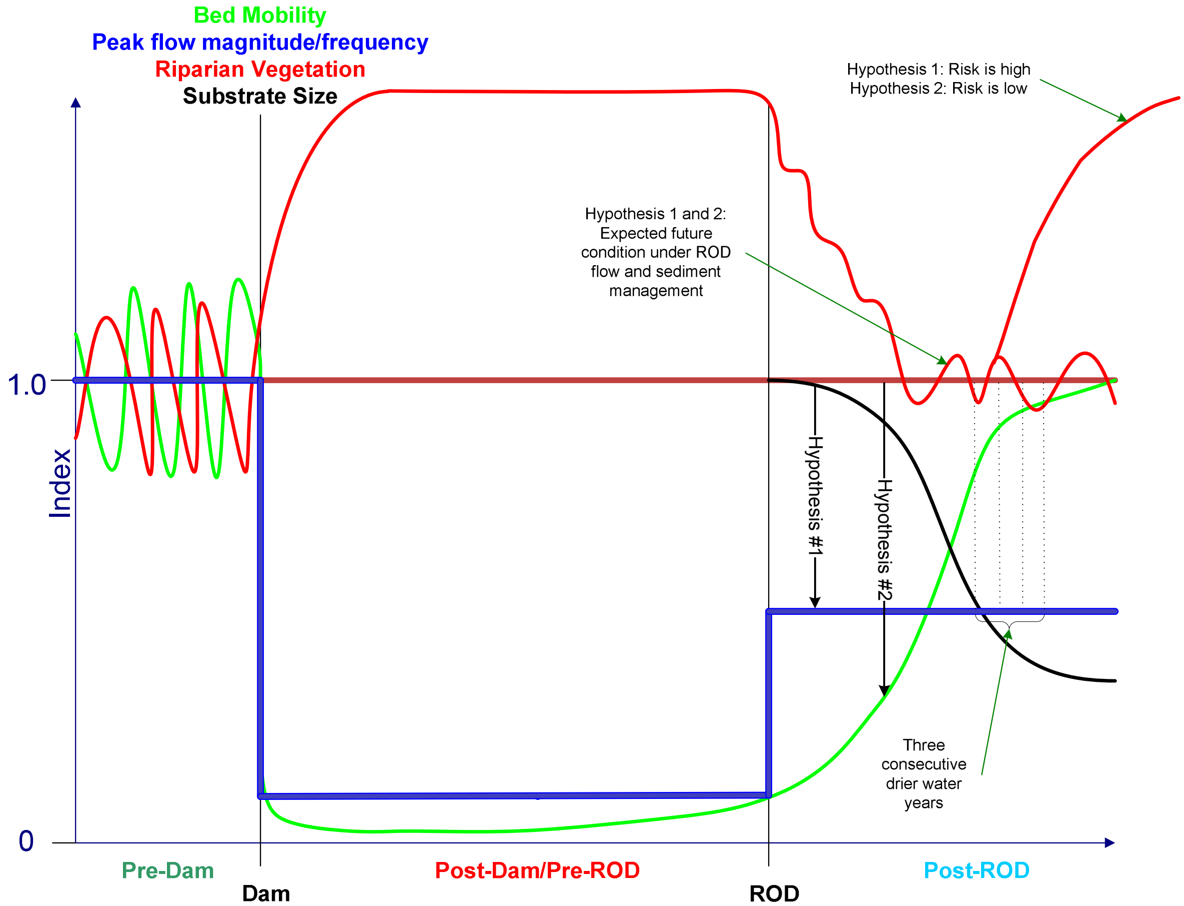

Figure M.5. Risk of detrimental riparian vegetation. Index of bed mobility, annual flow volume or peak, riparian vegetation, and substrate size is relative to Pre-dam conditions. Hypothesis 1 postulates increased risk of detrimental riparian vegetation after three drier water years, whereas hypothesis 2 considers the risk to be low due to higher bed mobility and smaller substrate size.

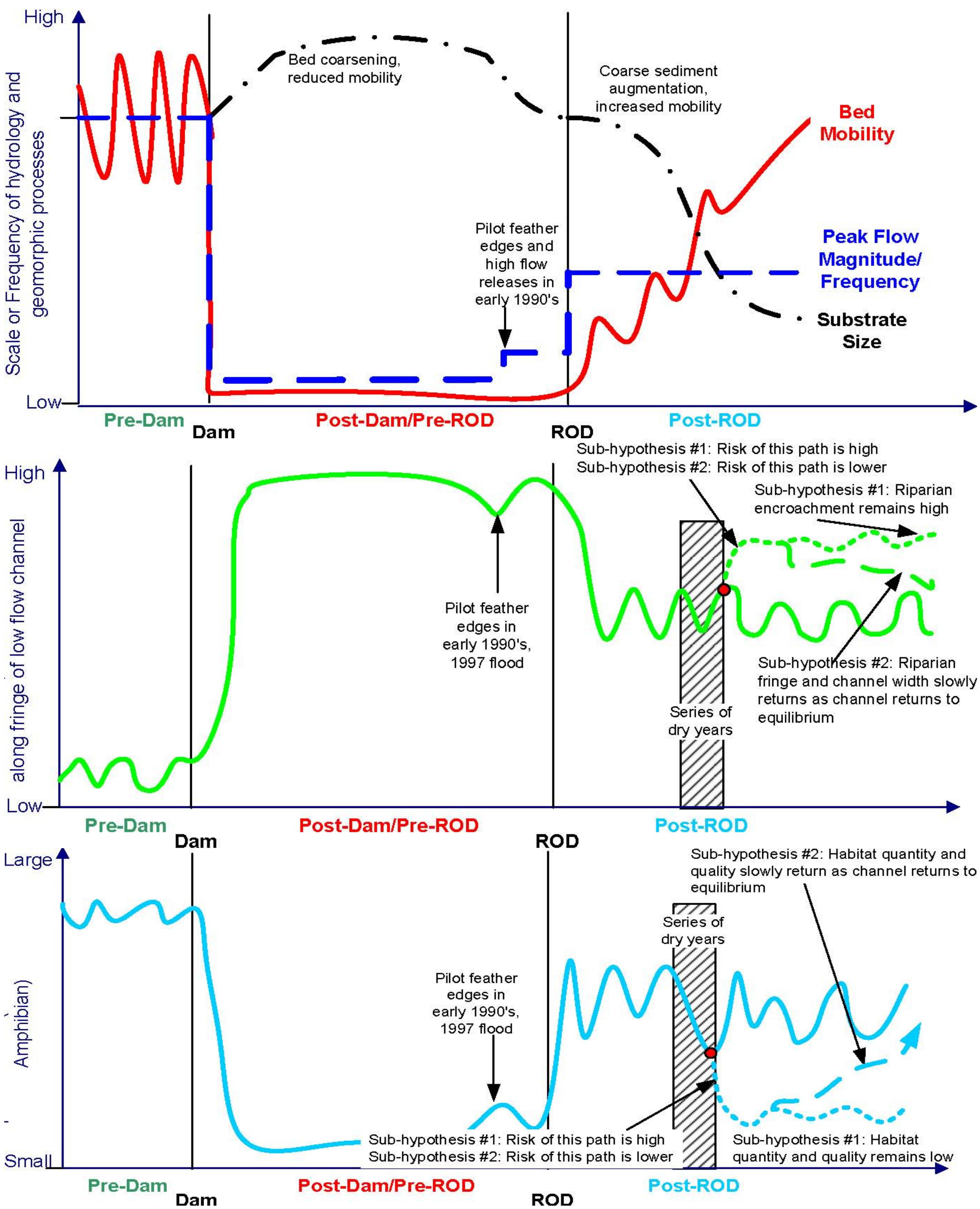

Figure M.3. Historic and predicted future detrimental riparian vegetation and aquatic habitat quantity/quality as a function of changes in high flow regime, sediment regime, bed mobility, and substrate size. Hypothesis 1 postulates increased risk of detrimental riparian vegetation after three drier water years, whereas hypothesis 2 considers the risk to be low due to higher bed mobility and smaller substrate size.

Appendix N. Spatial distribution and timing of channel rehabilitation projects in the Trinity River Program Area

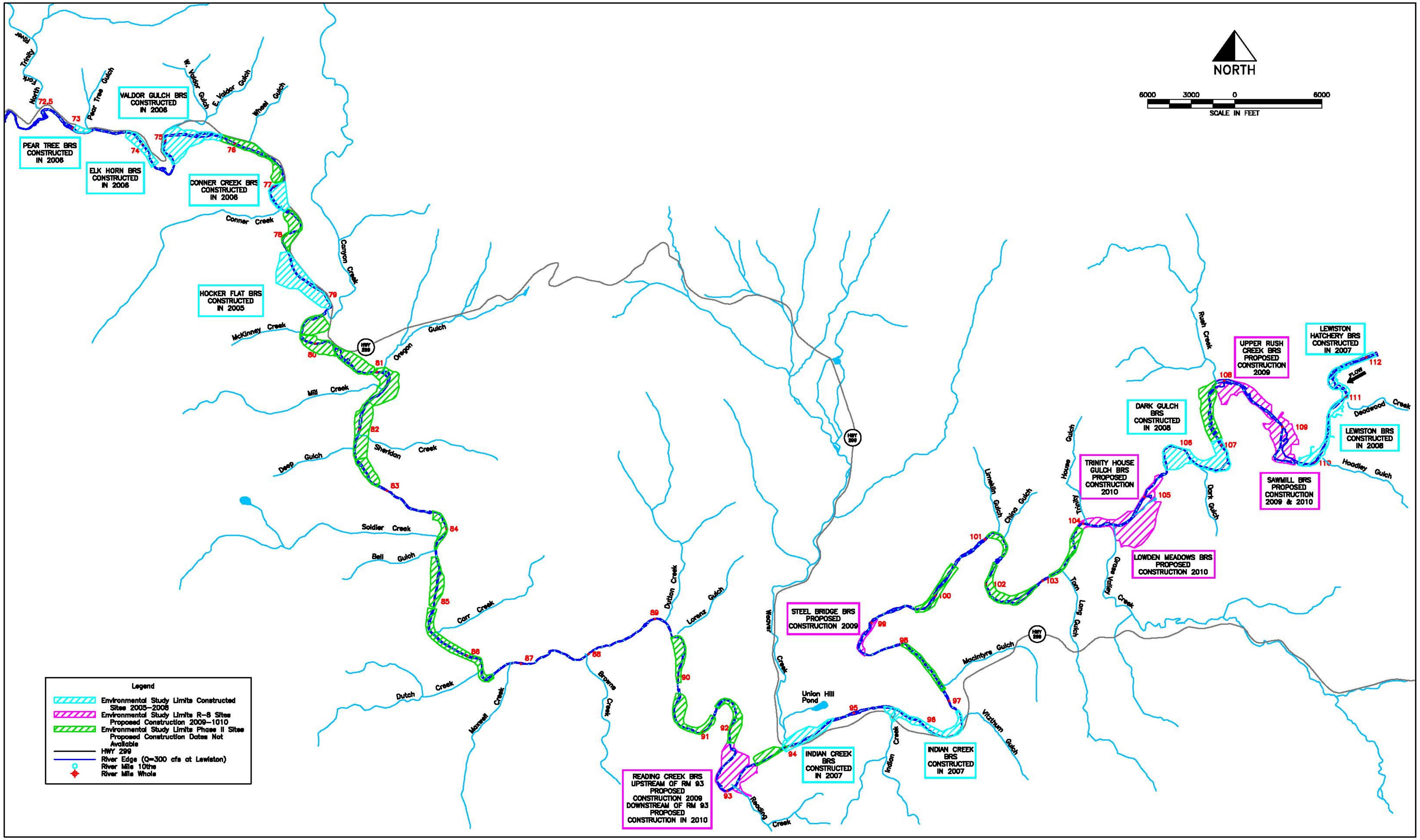

Figure N.1. Study area map, including location and timing of channel rehabilitation sites, environmental study limits and tributaries.

Appendix O. IAP Goals and Objectives (from August 29, 2006)

The purpose of the Trinity River Restoration Program (TRRP) Integrated Assessment Plan (IAP) is to describe the integrated ***Assessments*** (***Monitoring*** and ***Analyses***) of the TRRP for adaptively managing ***Implementation*** ***Actions*** and assessing progress towards ***Program Goals***.[38]

Means to achieve purpose

1. ***Hypothesis Testing*** (***Objective Specific Monitoring***) in the Adaptive Environmental Assessment & Management (***AEAM***) context to gain better understanding (***Assessment***) of system response to management actions.
2. Trend analysis (***Long-Term Monitoring***) to track progress towards program goals.

Target audience

The target audience for the IAP is the entirety of the TRRP organization.

Chapters 1-3 of the IAP should…

1. Be the TRRP plan for executing AEAM. It is a bridge that spans Record Of Decision (ROD) policy, Trinity River Flow Evaluation Final Report (TRFE) strategy, integrated assessments, and monitoring tasks;
2. Be concise (target 50 pages or less), with a 2-3 page executive summary;
3. Be straight forward, easily understood by the scientists – managers (TMC) – and program stakeholders (TAMWG);
4. Be a living plan. The IAP should be an evolving/improving document as the program implements AEAM. Programmatic and TRFE/ROD objectives (fundamental objectives) and most management targets would not change without TMC policy direction. Assessment methodologies could change based on demonstrated need;
5. Summarize program goals, Assessments, and ***Assessment Objectives***. The *Policy* framework for the program has at least three components:
    - Overall Program Goals (Tribal & Public Trust)
    - Program ***Policy*** (Record of Decision)
    - Program ***Strategy*** (TRFE)
6. Be the ***Science*** framework for the program. It is the plan for assessing the scientific and physical implementation of the program in the AEAM context. Chapters 1-3 will summarize the program goals and background, define the objectives of the individual assessments, describe the integration of all assessments, and set the stage for inviting (RFP process) multiple methodologies for accomplishing individual assessments;
7. Illustrate how the program will apply AEAM. The IAP should promote understanding of the AEAM process by illustration. The IAP will utilize examples (flow scheduling) of how the

[38] Italicized terms are defined in the IAP Glossary.

AEAM organization will be implemented, and how information will be used in the decision-making process. The IAP must specifically illustrate the concept of having two or more viable management objectives each year and how choices can be made. This is an opportunity to revisit AEAM and begin doing it better by helping all components of the TRRP organization to understand the AEAM process and become involved in discussion and choosing annual action plans. AEAM is being successfully implemented in some areas but a common understanding of the process among all parts of the TRRP organization is essential;

8. Identify priority performance measures. The IAP should summarize ***Performance Measures*** that drive science issues that originate within applicable legislation, the ROD and TRFE. Tables 8.5-8.9 of the TRFE list many of these measures as 'Management Targets';

9. Identify process for identifying, prioritizing, and testing hypotheses. The IAP will propose a process for identifying testable hypotheses, predicting outcomes, and assessing responses. This process must also include developing prioritization criteria for existing and new hypotheses. Unanimous agreement on specific hypotheses and assessments is not required. The IAP authors should attempt to get unanimous agreement on the process for identifying, prioritizing, and testing hypotheses. The process must illustrate opportunity for dissenting opinions in the form of alternative testable hypotheses as long as they adhere to the overall TRFE/ROD strategy and outlined goals and objectives. The IAP should provide a transparent process to resolve scientific disagreements/uncertainties (e.g., resolution roundtable) An update of TRFE Appendix O and the Conceptual Models & Hypotheses document could be attached as appendices;

10. Specify assessments and assessment objectives for: (1) evaluating long-term program success, and (2) testing specific, as well as annual, priority hypotheses. Chapters 1-3 of the IAP focus on Objectives, Performance Measures, Analyses, and External review. The IAP should identify mileposts for evaluating objectives (e.g., fish production, habitat creation, sediment budget) related to specific performance measures. For example, the TRFE articulates several objectives for assessing aquatic habitat response to management actions. Those assessment objectives will be central to the development of study designs and acquisition of monitoring and analytical data;

    The ingredients of each individual assessment include:

    a. Objectives
    b. Performance measures
    c. Analyses
    d. Monitoring plan designs
    e. Data requirements
    f. External review
    g. Deliverables

11. Prioritize integrated scientific assessments by priority performance measures. Prioritization is a function of analyses tied to management targets and programmatic goals, the number and type of data (monitoring) required for said analyses, and the cost of acquiring that data;

12. Articulate an Integrated Assessment Strategy that tests priority hypotheses using associated performance measures derived from the management targets specified in Chapter 8 (Tables 8.5-8.9) of the TRFE, other programmatic goals and purposes, or associated with alternative hypotheses developed within the AEAM process. This assessment strategy couples with a monitoring strategy, and includes analyses, ***Prediction*** (modeling), and reconnaissance-level studies;

13. Will provide an overview of methodologies for accomplishing the assessment objectives. Chapters 1-3 of the IAP will focus on the '*WHAT*' and '*WHY*', that is what and why assessments (and their associated objectives) are high priority. The IAP will only touch on the '*HOW*',

'*WHERE*', '*WHEN*', of each assessment. The RFP process will answer the '*WHO*'. The assessment objectives and associated analyses should drive assessment topics and methodologies. Chapters 1-3 will provide only enough detail to ensure the integration of various discipline assessments is clear to the program. Specific methodologies will be highlighted, but not detailed. The focus of the latter chapters will be the '*HOW*', '*WHERE*', '*WHEN*', proposed by the '*WHO*';

14. Address regulatory ***Compliance Monitoring***. Regulatory monitoring is a program requirement and should be included at an appropriate scale and scope in relevant assessments.

Chapters 1-3 of the IAP Should Not…

1. Provide detailed monitoring methodologies (let creative folks develop methods as part of a ***RFP***/Proposal/***ERP*** Review process);
2. Be 'set in stone'. It should be an evolving/improving document as we implement AEAM. However, the assessment objectives are rather firm. The methodologies for conducting assessments are much more flexible;
3. Be a 'silver bullet' for solving all budgetary prioritization difficulties. The IAP will recommend a set of integrated assessments, all of which are a 'priority', yet retain articulated flexibility in scale and scope;
4. Resolve all scientific disagreements/uncertainties. Rather, it should provide a transparent mechanism/process to resolve priority scientific disagreements/uncertainties.

Appendix P. Priority issues to be addressed within and across subsystems.

IAP Component	Priority Issues to Address (PITAs) from the Integrated Assessment Plan	Priority ranking within subsystem (H,M,L)	Prioritization rank across subsystems[39]	Specific question to be addressed	Linkage to IAP assessments (What assessment in Table 2.2 does the PITA support?)	Specific tasks to be undertaken to answer the question
Physical	Defining performance measures of channel complexity that best relate to fish habitat and aquatic habitat for FYLF and WPT	H	NR	What performance measures of geomorphic "complexity" should be used that best explains observed changes to fish habitat performance measures?	1P	For 2009, six channel rehab sites were chosen as a pilot to inform 2010 geomorphology-riparian-fish habitat assessment
Physical	Assessing whether spawning gravel quality is acceptable	H	NR	Is spawning gravel quality limiting fry production now, or will it limit fry production once rearing habitat is improved? Are spawners choosing spawning locations based on gravel quality in addition to depths/velocities/substrate?	16P	Pilot project being conducted in 2009 by GMA at 8 sites, habitat mapping and redd mapping being done at a pilot site to assess spawning HSC
Physical	What is the total coarse sediment supply (tributary+gravel augmentation)	H	10	What is the coarse sediment augmentation locations, rates, size classes, and morphology that best meets channel complexity/habitat	5P, 7P, 14P	Need to review D. Gaueman's analysis/report, then experts meet to discuss methods and results,

[39] These are preliminary Steering Committee (SC) rankings (as of Aug 20/2009) and there has not yet been input from IAP co-authors. Additionally some PITAS were not ranked by the SC across subsystems, as indicated by a NR (not ranked) descriptor in the table.

IAP Component	Priority Issues to Address (PITAs) from the Integrated Assessment Plan	Priority ranking within subsystem (H,M,L)	Prioritization rank across subsystems[39]	Specific question to be addressed	Linkage to IAP assessments (What assessment in Table 2.2 does the PITA support?)	Specific tasks to be undertaken to answer the question
	volume needed to meet channel complexity/habitat objectives			objectives		then recommend additional tasks to address question
Physical	Revisiting the DURATION of ROD releases, re-evaluate using Rush Creek coarse sediment delivery as the management objective for DURATION	H	9	Should the ROD objective currently used to develop annual peak flow Duration (Rush Creek delta) be revised, and if so, what should the new objective be?	14P	Initially we need to have a meeting with TRFE authors and contributors to discuss strengths & weaknesses of existing objective, and brainstorm possible alternatives, then assess
Physical	Evaluating LiDAR bathymetry with respect to meeting various data needs (topographic monitoring, 1-D and 2-D hydraulic modeling, etc)	H	NR	What is the topographic accuracy of the bathymetric LiDAR data, and how does that accuracy compare to needs by other modeling/monitoring efforts?	1P, 2P, 3P, 15P, 2H, 5H	Compare 2009 LiDAR bathymetry to controlled ground-based topographic surveys
Physical	Evaluate design criteria that improves longevity and habitat quality in constructed side channels and alcoves	H	NR	Are constructed design features "working", and if not, why not? What design criteria improves longevity/success of constructed features?	12P	Physical surveys, hydraulic modeling to understand hydraulic and geomorphic criteria that improves design performance

IAP Component	Priority Issues to Address (PITAs) from the Integrated Assessment Plan	Priority ranking within subsystem (H,M,L)	Prioritization rank across subsystems[39]	Specific question to be addressed	Linkage to IAP assessments (What assessment in Table 2.2 does the PITA support?)	Specific tasks to be undertaken to answer the question
Habitat	Evaluate the compatibility of habitat assessment method(s).	H	NR	What is the best method for assessing habitat?	1H,2H	Compare results from 2009 2D models at Reading/Lowden with flow-habitat measurements by SBHM crew
Habitat	Identify targets for how much habitat we need, and identify how much habitat we can potentially have based on geomorphic and hydrologic conditions.	H	5	How much habitat do we need to meet program goals? What is the maximum habitat potential in the upper 40 miles?	1H, 2H etc	Estimate number of fry needed to meet adult return goals, then estimate amount of habitat necessary to produce this number of fry. Evaluate the geomorphic/habitat potential of the Upper 40 miles?
Habitat	Develop and utilize an adaptive management capability for informing channel rehabilitation projects. <links to X-cutting 3>	H	8	How can we use the results of habitat assessments for adaptive management?	1H, 2H	Need to integrate monitoring data into the design process
Habitat	Evaluation of cool water pool in Trinity Reservoir	H	1	What facilities and operations optimize conservation of the cold water pool	Habitat availability, juvenile health/production, egg viability, etc.	Review historic docs, feasibility of alternative facilities to manage cold water pool
Habitat	Get a baseline estimate of available habitat. This is not a	H	NR	Which timeframe is the best comparison for assessing change to the river?	1H, 2H	GRTS systemic habitat map

IAP Component	Priority Issues to Address (PITAs) from the Integrated Assessment Plan	Priority ranking within subsystem (H,M,L)	Prioritization rank across subsystems[39]	Specific question to be addressed	Linkage to IAP assessments (What assessment in Table 2.2 does the PITA support?)	Specific tasks to be undertaken to answer the question
	PITA, but is assessment 2H.					
Habitat	Explore metrics of habitat availability during fry/presmolt rearing period (see Appendix C). (change Sec 3.2 text)	M	NR	What are the appropriate metrics?	2H	Review literature and existing data
Habitat	Evaluate the performance of LiDAR data for producing the topographic tin within a 2D habitat model	M		Can LIDAR be used to estimate habitat?	1H, 2H	Compare results from 2009 LiDAR with measured habitat at a specific site
Habitat	Develop metric to define thermal heterogeneity	L	NR	What are the appropriate metrics?	8H	Literature and thermal imagery review
Habitat	Determine what assessments are feasible at each scale, given the high natural variability of macro invertebrate populations.	L	NR	What invertebrate assessments could be done to determine food abundance or to answer other questions about habitat which would be useful and cost effective?	9H, 10H	Literature review
Fish (adult)	Integration of age-structured harvest estimates and age-structured spawning escapement estimates to get cohort estimates for fall	H	16	What is effect of TRRP habitat improvements on R/S (cohort strength) and harvest, after removing effects of ocean conditions, temperatures, in-river flows, etc.? The validity of using	22A	Use CWT and of Klamath-Trinity fish above harvest point, and perhaps contract Dave Hankin or Michael Moore. Would need to do

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	Chinook? (Most robust data set)			Trinity specific cohort data to evaluate rehabilitation effects needs to be investigated further.		similar technique for ocean harvest (e.g. 1 CWT = x ocean fish caught). Joe has done this kind of work before (15 years ago). Would need to use reference stocks from Rogue, and perhaps Klamath; Dave Hankin doing this work this summer. Build off of PFMC work.
Fish (adult)	Developing methods to estimate winter/spring steelhead run-sizes and age structure	L	NR	Evaluate how well tribs are producing steelhead, reflecting benefits of watershed actions. But trib monitoring of fine sediment output is more direct PM.	Builds off of 13A	Explore feasibility of monitoring and assessment methods.
Fish (adult)	The current PFMC and DFG harvest management plans for fall Chinook salmon do not recognize the Program's spawning escapement goals as a management target (Klamath Basin is managed as one	L	NR	Meet w PFMC to show rationale for amending Fish Management Plan (increasing Trinity FC and SC escapement goal) given increased habitat capacity that TRRP will create.	Section 3.4 harvest / escapement goals, and overall Program goal.	Analysis to assess if harvest is limiting production (not enough fish being allowed to return)

IAP Component	Priority Issues to Address (PITAs) from the Integrated Assessment Plan	Priority ranking within subsystem (H,M,L)	Prioritization rank across subsystems[39]	Specific question to be addressed	Linkage to IAP assessments (What assessment in Table 2.2 does the PITA support?)	Specific tasks to be undertaken to answer the question
	group, with 30-40% harvest rate).					
Fish (adult)	Can integration of age-structured harvest estimates and age-structured spawning escapement estimates provide a complete assessment of the stock productivity of Trinity Basin naturally produced and hatchery produced spring Chinook and coho?	M (do SP if FC works out)	NR	Same as Adults-1	22A	Use methods developed under Adults-1, and extend to SC and coho. Coho age structure is simpler (only 2 returning age classes) than Chinook.
Fish (adult)	Policy Issue to Be Resolved. The Trinity Management Council in June 2008 (Trinity Management Council meeting minutes June 16-17, 2008, Weaverville, CA) chose not to include numeric harvest goals in the goals for the TRRP. Furthermore, the Department of	policy issue, not up to us to rank	NR	What form of numeric goals are sufficient to ensure that Program will achieve lasting success and meet tribal trust responsibilities? Required data are being collected (e.g. escapement, harvest, habitat), should goals be established later.	Objective 4 and overall Program Goal	

IAP Component	Priority Issues to Address (PITAs) from the Integrated Assessment Plan	Priority ranking within subsystem (H,M,L)	Prioritization rank across subsystems[39]	Specific question to be addressed	Linkage to IAP assessments (What assessment in Table 2.2 does the PITA support?)	Specific tasks to be undertaken to answer the question
	Interior's Office of the Solicitor (March 12, 2008) supported this TMC decision. Subsequently, HVT and Yurok had G2G meeting on this issue with BoR. DOI is reassessing their position.					
Fish (juvenile)	We want to assess population performance measures like fry / spawner over both space (e.g. rehab vs. reference areas) and time. We need to analyze the statistical power of these measures, and # sites / # years required to detect biologically significant changes in them.	H	4	Described in PITA (column B)	Sections 3.3 and 4. Assessments 2J, 4J, 13A, 1A	Define effect sizes, complete power analyses, and simulate ability to detect effects.
Fish (juvenile)	Refine methods for assessing fry standing stock.	H	3	Which methodology yields the best results?	2J, 4J, 13A, 1A	Clearly define metrics for each question, and then examine alternative ways of estimating them (frame nets, snorkeling,

IAP Component	Priority Issues to Address (PITAs) from the Integrated Assessment Plan	Priority ranking within subsystem (H,M,L)	Prioritization rank across subsystems[39]	Specific question to be addressed	Linkage to IAP assessments (What assessment in Table 2.2 does the PITA support?)	Specific tasks to be undertaken to answer the question
						RSTs). Closely linked to Fish Production #1 and 3.
Fish (juvenile)	How to combine standing stock and emigrant trapping estimates.	M	NR	How are standing stock and RST fry estimates going to be utilized to address effects of habitat restoration on fry production?	2J, 4J,	Closely linked to Fish Production #1 and 2.
Fish (juvenile)	assess cost, precision and benefits of different performance measures to measure fish health/condition; converge to most cost effective measures for early detection of changes in fish health / condition	H	19	What is the most cost-effective metric (see col. B)?	2J, 4J,	Relates to Cross-Cutting PITA #2
Fish (juvenile)	How to identify hatchery and naturally produced juvenile Chinook (only 25% cwt) for development of a healthy smolt index.	M	NR	What is the health of hatchery and naturally raised smolts?	2J, 4J,	Develop protocol for doing this (e.g. stop assessment before hatchery fish arrive; analyze CWT fish separately)

IAP Component	Priority Issues to Address (PITAs) from the Integrated Assessment Plan	Priority ranking within subsystem (H,M,L)	Prioritization rank across subsystems[39]	Specific question to be addressed	Linkage to IAP assessments (What assessment in Table 2.2 does the PITA support?)	Specific tasks to be undertaken to answer the question
Fish (juvenile)	clarity on the use and application of SALMOD	M	NR	Is there a need for a fish production model for the Trinity (update w new data sets, do exploratory analyses of alternative actions and hypotheses)?	Cross-cutting as it would link temperature, fry and smolts. Was described in detail in IAP 0.95…	Have a workshop with independent experts to assess benefits and costs of different kinds of modeling efforts. Include both modelers and empiricists.
Fish (juvenile)	quantitative targets for juvenile production need to be evaluated; LINK TO HABITAT TARGETS PITA	M	NR	What is target # outmigrants that constitutes "success"?	1H, 2H, 13A, Overall escapement goals by species	Work through a number of methods of bracketing goal for outmigrants (e.g. from adult goal, from habitat capacity goal).
Fish (juvenile)	Development of a cold-water pool management plan	M	NR	See Habitat PITAs		
Fish (juvenile)	Determine whether we need additional genetic studies on other salmonid species	L	NR			
Fish (juvenile)	presence of a hybrid zone found near TRH	L	NR			
Fish (juvenile)	Integration of the Program with TRH	Policy Issue	NR			

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	management should be considered as a policy issue by the TMC.					
Riparian	Desired riparian vegetation conditions and quantitative vegetation targets, linked to a suitable ecological model describing how desired conditions should be achieved and maintained.	H/M	6	What are the desired plant species, vegetation patterns, structure, composition and spatial extent of the future riparian corridor (organism and value driven)?	2h, 1h, 1p, 1r, 4w, 12p, 14p, 3r, 5p, 3h, 4h, 6p, 11w, 5r, 13w, 10w, 9p, 1w, 2r, 8h, 12h, 2w, 13h, 6w, 2p, 9h, 10h, 9w, 12w, 5h, 3p, 10p, 15p, 4r, 5w, 3w, 7w, 15w	Take the initial thoughts about a desired condition developed during the workshop, list them and if possible assign units, then have a workshop or use working group to refine the list of desired conditions/functions with units and integrate into current monitoring scheme (if not already)
Riparian	How to define the risk of encroachment	H/L	7	What are the units of encroachment? Is encroachment risk a probability or index? What is the temporal sensitivity of risk (was the TRFE 3 year window correct?)?	2h, 1h, 1p, 1r, 12p, 3r, 3h, 4h, 6p, 5r, 8h, 13h, 2p, 3w, 7w, 9w, 11w, 2r, 4r	Several different ideas have been proposed for defining /quantifying encroachment risk- use historic data to evaluate which method best illustrates encroachment risk.
Riparian	Exploring whether less intensive	H/H	14	Can a simpler, faster sampling method along	1r, 4r, 4r, 1w, 9w,	Use current sampling data to assess whether

IAP Component	Priority Issues to Address (PITAs) from the Integrated Assessment Plan	Priority ranking within subsystem (H,M,L)	Prioritization rank across subsystems[39]	Specific question to be addressed	Linkage to IAP assessments (What assessment in Table 2.2 does the PITA support?)	Specific tasks to be undertaken to answer the question
	measures of plant density (e.g., frequency and cover) can provide the necessary information required to manage riparian vegetation encroachment thresholds			cross-sections at GRTS sites capture plant establishment patterns with enough strength to guide management decisions and assess encroachment risk?	12w,	frequency or smaller sample sizes will provide sufficient power or if more transects with less effort would provide better power
Riparian	Determining whether it's necessary to have more accurate site-scale assessments of the physical processes responsible for preventing riparian vegetation from reaching encroachment thresholds.	H	15	Do we need to have geomorphic experiments at all sites for all years to establish cause-and-effect between riparian and geomorphology?	6p, 3r, 4r	Conduct pilot using band transects only to make assessment, then a paired one with geomorphic experiments and see how assessment would change or not
Riparian	Evaluate alternatives ways to map patches of vegetation that cannot be detected on aerial photographs (i.e., patches <5 years old) to reduce bias by the mapper.	H	NR	Are there other methods of mapping that can accurately portray the patch location and extent of seedlings, establishing plants etc that do not rely on aerial photos, or can eliminate estimating polygon locations- when the mapped patches cannot be	2h, 1h, 3h, 4h, 1r, 2r, 4r, 3w, 7w, 9w, 11w,	Look at different methods being used currently in the industry or by others (i.e., fish habitat mapping). Use a similar methods of mapping at one site, compare results, and

IAP Component	Priority Issues to Address (PITAs) from the Integrated Assessment Plan	Priority ranking within subsystem (H,M,L)	Prioritization rank across subsystems[39]	Specific question to be addressed	Linkage to IAP assessments (What assessment in Table 2.2 does the PITA support?)	Specific tasks to be undertaken to answer the question
				seen on air photos?		assess whether results provide comparable, repeatable measures and whther the results can be used in the way envisioned in the IAP
Wildlife	Power analyses on current point count data have been completed to determine the duration and intensity of monitoring needed to detect varied levels of change in target riparian species abundance with expected levels of confidence. Similar power analyses are now needed for monitoring productivity through demographic data collected at banding stations.	AS = H; Demo = M	18	What is the effort needed to detect a change in abundance or age ratios of riparian birds at 3 spatial scales and from 3 to 20 years?	4W, 1W, 3W, 2W, 5W	Power analyses using point count data and examined at various scales: rehab site, 40 miles, reference reaches
Wildlife	Population size for target species needs to be estimated to help establish target	H	20	Estimate the numbers of individuals within the 40 mi for target species of riparian	4W, 1W, 3W	Population baseline estimates by species for area of riparian

IAP Component	Priority Issues to Address (PITAs) from the Integrated Assessment Plan	Priority ranking within subsystem (H,M,L)	Prioritization rank across subsystems[39]	Specific question to be addressed	Linkage to IAP assessments (What assessment in Table 2.2 does the PITA support?)	Specific tasks to be undertaken to answer the question
	population levels for up to 15 years after initial implementation.			birds		habitat
Wildlife	Protocols used to monitor annual productivity of riverine birds need to be evaluated (power analyses) to determine if current methods allow determination of age with sufficient certainty and sample sized to detect changes in age ratios for these species.	L	NR	What is the effort needed to detect a change in abundance or age ratios of riverine birds at 2 spatial scales and from 5 to 20 years?	6W, 7W	Power analyses using river float survey data and examined at various 40 mile and reference reaches scales
Wildlife	Population size for target species need to be estimated to help establish target population levels for up to 15 years after initial implementation.	H	21	Estimate the numbers of individuals within the 40 mi for target species of riparian birds	6W, 7W	Population baseline estimates for riverine bird species
Wildlife	Power analyses on current and 1990's	H	17	Monitoring effort needed.	10W, 11W	Compile historic data, conduct power

IAP Component	Priority Issues to Address (PITAs) from the Integrated Assessment Plan	Priority ranking within subsystem (H,M,L)	Prioritization rank across subsystems[39]	Specific question to be addressed	Linkage to IAP assessments (What assessment in Table 2.2 does the PITA support?)	Specific tasks to be undertaken to answer the question
	historical FYLF data are necessary to determine the duration and intensity of monitoring needed to detect varied levels of change in populations with expected levels of confidence.					analysis (mostly on egg masses)
Wildlife	Determining whether dam releases/spring hydrograph could be synchronized with FYLF breeding chronology to improve reproductive success	H	11	Can gauging stations above the dam be used to adjust dam releases to the more natural hydrograph?	9W, 10W, 11W	Compile above dam inflow records, discuss at flow meetings
Wildlife	Power analyses on current and 1990's historical turtle data are necessary to determine the duration and intensity of monitoring needed to detect varied levels of change in population	H	NR	Monitoring effort needed.	13W, 14W	Conduct power analysis

IAP Component	Priority Issues to Address (PITAs) from the Integrated Assessment Plan	Priority ranking within subsystem (H,M,L)	Prioritization rank across subsystems[39]	Specific question to be addressed	Linkage to IAP assessments (What assessment in Table 2.2 does the PITA support?)	Specific tasks to be undertaken to answer the question
	demographics and density with expected levels of confidence.					
Wildlife	Identify the causes and effects of reduced body size of post-dam WPTs on population to assist with adaptive management recommendations for this and other species.	H	NR	Is reduced size related to a lack of thermal diversity, timing of hydrograph, prey availability, other?	14W	(1) Measure thermal diversity; (2) Behavioral data - [telemetry]; (3) prey availability vs. use
Wildlife	The mechanisms by which invasive wildlife species might impact native biota need to be identified	H	NR	This is a potential issue for all Trinity species. Should we be proactive in monitoring the distribution of potentially detrimental invasives?	wildlife (15W), fish (7J, 6J), vegetation (1R), macroinvertebrates (9H, 10H, 11H)	Develop protocol for inventory current native and invasive species, especially aquatics. Risk assessment for various species.
Cross-Cutting	Integrated sampling design to support all components (finalization of GRTS; GRTS or not; individual sampling plans; assessment overlay, co-location,	H	2	How to best provide a reliable sampling design that enables scientifically defensible system-wide inferences, and interdisciplinary analysis of cause-effect relationships?	See Appendix L of IAP 0.99. Primary: 1H, 2H, 4J FC and SC, 1P, 1R, 2J, 12P, 3R, 3H, 4H, 1J, 16P, 9P, 3H, 4H... Secondary: 13A,	Continue work done in Chapter 4 to finalize details of GRTS and non-GRTS approaches in collaboration with workgroups.

IAP Component	Priority Issues to Address (PITAs) from the Integrated Assessment Plan	Priority ranking within subsystem (H,M,L)	Prioritization rank across subsystems[39]	Specific question to be addressed	Linkage to IAP assessments (What assessment in Table 2.2 does the PITA support?)	Specific tasks to be undertaken to answer the question
	and nesting; expansion to system-wide target populations; review of pilot study data)				1A, 17A, 14P, 5P, 6P, 16A, 13W, 10W, 3A, 7P, 8P, 18A, 19A, 2P...	
Cross-Cutting	Cost-precision-decision tradeoffs (including power analyses) for low, medium, high intensity approaches to primary performance measures	H	12	Given the information inputs to each annual and long term decision, what are the most cost-effective sampling designs & monitoring protocols?	See Appendix L of IAP 0.99. Similar to those listed above, but considers monitoring protocol in addition to sampling design	Do power analyses for critical inputs to decision, evaluating alternative monitoring protocols and sampling intensities (low, medium, high cost) to assess cost-precision tradeoffs.
Cross-Cutting	Develop AEAM decision rules that reflect revised, more specific objectives, and multi-objective decision rules	H	13	Given the information inputs to each annual AEAM decision, and the set of objectives for each ecosystem component, what are the formal decision rules which determine if/when actions should be revised?	All assessments which are listed as "Needed to revise specific actions" or "Both" under assessment type (i.e. 2H, 1H, 7H, 1P, 1R, 12P, 14P, 3R, 5P, 6P, 5R, 10W, 9P, 1W, 8H, 12H, 2W, 7P, 8P, 2P, 10H, 12W, 5J, 3P, 4P, 10P, 11P, 4R, 11H, 3W, 7W, 15W)	Work collaboratively with topic leads to develop decision rules for changing flow, sediment, riparian, and channel rehab actions (See Figure 1.4 in IAP)