

Development and Application of the EDT Database and Model for the Sandy River Basin

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Prepared by
City of Portland Bureau of Water Works
with assistance from
Mobrand Biometrics, Inc.

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1.0 INTRODUCTION

In 1999, six partner organizations signed the Sandy River Basin Agreement (SRBA) pledging to work together to restore aquatic habitat and salmonid populations. The partners included the City of Portland, Portland General Electric, USDA Forest Service, National Marine Fisheries Service (now known as NOAA Fisheries), USDI Fish and Wildlife Service, and the Oregon Department of Fish and Wildlife. The agreement initiated a collaborative process involving a larger set of local, state, federal, and non-governmental organizations. An SRBA Policy Committee and a Technical Team were formed, consisting of representatives from many key partner organizations.

The SRBA Policy Committee agreed in June 2000 to use the Ecosystem Diagnosis Treatment (EDT) model developed by Mobrand Biometrics Inc. as a tool for evaluating the productive capability of the basin's fisheries. The Technical Team began working with the model in August 2000. The resulting analyses have since proved useful in describing habitat conditions and evaluating the potential to increase fish populations.

This report documents how the Technical Team (TT) organized and analyzed key technical information for the model. It describes how the original data were entered, verified, and used to run the model. For simplicity, the report is designed as a step-by-step explanation of the activities completed to date for the Sandy River Basin, with the emphasis on process. More detailed technical information is provided in the appendices.

2.0 EDT OVERVIEW

EDT is both a scientific model and an analytical tool. The methodology has been developed over a number of years, with considerable input from state, local, tribal, and private interests in the Pacific Northwest involved with watershed restoration and salmon recovery.¹ The model incorporates stream habitat features, biological performance data, and other environmental information to construct a working hypothesis of a basin or watershed. It also is capable of bringing together information derived from empirical observations, local experts, and other models and analyses. As a result, the EDT model provides a framework for understanding complex ecological systems in order to support fish and wildlife planning and to design effective enhancement strategies.

EDT has three basic components:

- (1) A conceptual framework (a way of organizing information to describe a watershed ecosystem in order to apply scientific principles to the understanding of the ecosystem),
- (2) A six-step process that is based on the analysis of current and historical conditions, and
- (3) A set of tools (both a database and a population model) that enables scientists to organize and analyze large amounts of biological and environmental data.

¹ The Northwest Power and Conservation Council have placed the EDT Model and data entry tools on the WEB. The model is now available for public use at www.mobrand.com/edt.

Model outputs are presented in terms of:

- 1) Fish productivity (the density independent reproductive rate or success of the population),
- 2) Capacity (density dependent survival of the diagnostic species), and
- 3) Diversity (number of different life histories exhibited by the population).

Estimates of these parameters can be developed for specific fish populations, by reach, by subbasin, or for an entire basin. These same three parameters are included in the list of parameters that the National Oceanic and Atmospheric Administration (NOAA) Fisheries considers important to defining the viability of salmonid populations (McElhany et al. 2000).

EDT draws on an environmental database of 46 habitat attributes and a set of mathematical algorithms to compute productivity, capacity, and diversity parameters for the targeted salmonid populations. A detailed matrix of EDT habitat attributes is provided as Appendix A (See file: EDT Information Structure)². The biological ratings of the habitat attributes are derived from observed environmental conditions, including recent stream surveys using standard assessment methodologies. Gaps in observed data were filled using available scientific literature and judgments by habitat and fish biology experts familiar with the basin. The “level of proof” for the data entered for the Sandy River EDT analysis can be found in Section 4.2.3. Biological rules were used to convert habitat quality and quantity to estimates of fish performance. A copy of all rules used in the Sandy EDT Analysis, as well as a rule viewer, can be downloaded from www.Mobrand.com.

A complete description of the EDT method, modeling tools, and algorithms is presented in *Ecosystem Diagnosis and Treatment (EDT) Applied Ecosystem Analysis – A Primer* (Lestelle et al. 1996).

3.0 SANDY RIVER BASIN EDT APPROACH

This section of the report outlines the participants and the methods used to complete the EDT analysis for the Sandy River Basin.

3.1 Sandy River Basin Agreement Technical Team

Representatives from various agencies and governmental entities, including the City of Portland, have been meeting since late 1998 to discuss fish and habitat needs in the Sandy River Basin. The Sandy River Basin Agreement Technical Team (TT) was established in 1999 as a more formal collaboration on the development of a basin wide strategy for improving fish populations in the Sandy River Basin. The TT consists of fish, wildlife, and regulatory staff from local, state, and federal agencies and organizations.

² All appendices can be found on the accompanying CD.

Table 1 presents a complete list of past and current TT participants and Appendix B has a brief summation of all TT meetings since its inception.

Table 1. TT Participants.

Affiliation	Name
Bureau of Land Management – Salem District	John Barber Dave Roberts*
Clackamas County	Karen Streeter
U.S. Forest Service Mt. Hood National Forest	Duane Bishop Joe Moreau Todd Parker Dan Shively* Ivars Steinblums
National Oceanic and Atmospheric Administration – Fisheries	Michelle Day Melissa Jundt Ben Meyer* Bryan Nordland Dan Tonnes*
Oregon Department of Environmental Quality	Greg Geist*
Oregon Department of Fish and Wildlife	Jim Brick Dick Caldwell Art Martin Jim Muck Greg Robart Jeremy Sikes
Portland General Electric	Doug Cramer John Esler
Portland Water Bureau	Steve Kucas*
The Nature Conservancy	Jonathan Soll*
U.S. Fish and Wildlife Service	Ron Garst Ann Gray* Timmie Mandish Joe Zisa*

* current members (as of August 2004)

3.2 Technical Team Meetings

The TT held its first meeting in March 1999 and has met approximately monthly through mid-2003, investing numerous hours in developing the necessary database and the EDT model inputs. TT members, assisted by Mobrand staff, provided all data inputs and data quality review required to perform the EDT analysis. The TT was responsible for understanding the model underpinnings, selecting species for analyses, entering stream habitat and environmental data into the model, and interpreting model outputs. Mobrand was responsible for performing quality control analysis of data inputs and outputs, conducting model runs, documenting the process, and writing reports.

Over the course of 2 years, Mobrand staff held frequent workshops with the TT. The first workshop was held in Portland from August 16 through 17, 2000. The goal of the workshops was to ensure that the TT members shared a clear understanding of how the model works, including its strengths and weaknesses, and to accomplish a series of tasks. The tasks included data entry, habitat rating, and model output interpretation.

In the initial workshops, Mobrand staff provided a detailed overview of model input assumptions, the biological rules that translate habitat conditions to fish performance, and the algorithms used to calculate modeling parameters such as productivity, capacity, and diversity. At the September and October 2000 workshops, the TT discussed how each member was rating habitat so that it was performed in a similar manner in all streams. Mobrand Biometrics developed ACCESS-compatible software to facilitate EDT data entry. As the analyses progressed, the focus of the workshops changed from understanding the modeling process to reviewing data inputs as part of a quality control process. At each workshop, the TT reviewed the data inputs produced by its members and responded to data concerns expressed by Mobrand staff. Any data anomalies identified by Mobrand were reviewed by the TT at the workshops and, if necessary, were changed on the basis of TT feedback. Such changes to model inputs were implemented only with TT approval.

In January 2001, the TT began reviewing results of the initial EDT model runs.

4.0 APPLICATION OF EDT METHODOLOGY TO THE SANDY RIVER BASIN

The data required for running the EDT model fall into two categories: biological and environmental. EDT model outputs include: (1) estimates of fish performance expressed by the population parameters of productivity, capacity, and diversity; and (2) the environmental data analyses described in more detail in Section 5 of this report.

4.1 Biological Data

The EDT model requires a wide range of biological data, including stock-specific information on fish fecundity, sex-specific age distributions, relative hatchery/wild fitness, hatchery program information, spawning sites and times, terminal harvest rates,

and basic life history patterns. Specific parameters and information collected and entered by the TT into the model are described in the following subsections.

4.1.1 Indicator Species

Coho Salmon, Spring and Fall Chinook Salmon, and Steelhead

The TT initially chose four species for EDT modeling and analysis: coho, spring and fall chinook, and late winter steelhead. These species were selected because they are native to the Sandy River Basin, are important economically and culturally, and exhibit species-specific habitat preferences. These species are also currently ESA-listed or are proposed for state or federal listing. The use of these species enabled the TT to model habitat conditions in all anadromous fish-bearing streams in the basin.

Coastal Cutthroat Trout

Coastal cutthroat trout were also considered as one of the indicator species for the Sandy River. Biological rules were developed for the species and preliminary EDT model runs were completed in 2003. However, the model run results were not very useful as explained in Section 5.1 and the results have not yet been shared with the rest of the SRBA Technical Team. Since Moberg Biometrics thought the model results had limited value, coastal cutthroat trout were not selected as one of the indicator species for the Sandy River. The results of the cutthroat trout analysis are presented in section 6 of this report.

4.1.2 Population Names

A unique name was used in the model and analysis to identify the population and approximate area used by the five indicator species of interest. For example, the TT used the model to analyze Bull Run spring Chinook and Lower Sandy fall Chinook.

4.1.3 Spawning Distribution

The TT developed a complete list of the reaches in which each natural population was known or assumed to spawn, either currently or historically. For streams where data were not available to determine species use, the TT assumed that Chinook (spring and fall) would not utilize streams with a minimum width less than 15 feet or a gradient higher than 8 percent. For steelhead, the team assumed that this species did not use streams with minimum widths of less than 8 feet or a gradient higher than 12 percent. For coho, a spawning distribution developed by the Oregon Department of Fish and Wildlife (ODFW) was used.

After initial model runs were completed in 2001, the TT met again to review the results and re-examine spawning distribution in the basin. Based on this review, several spawning reaches were excluded for some species and added for others. In general, the changes were made to reaches that had stream widths or gradients that fell near the dividing criteria identified above. For example, a stream may have been given a width of

8-feet indicating use by steelhead, but field surveys showed that steelhead were not present in this reach. In this case, the reach was removed from the analysis.

In mid-2003, several TT members thought the spawning distribution for several species should be modified again. Dan Shively (Mt. Hood National Forest) felt that winter steelhead in Still Creek could not utilize habitat upstream of river mile 10.2. Dan Tonnes (NOAA Fisheries) felt that the current distribution of fall Chinook should only include streams just up to Marmot Dam. Although these conclusions differed from the general assumptions described above, the TT agreed to incorporate them. Both of these changes were made in the database and the fall 2003 model runs reflect them.

4.1.4 Adult Run and Spawn Timing

The weeks in which spawning typically begins and ends for each species were based on literature values for each species and input from the ODFW Sandy River Fish Management Plan (ODFW 1997). Spawning times used in modeling are presented in Table 2.

Table 2. Spawning Times Used in the EDT Analysis by Species.

Species	Start Date	End Date
Coho	November 5	January 28
Spring Chinook	August 6	October 7
Fall Chinook	October 1	November 25
Late Winter Steelhead	March 19	June 3
Coastal Cutthroat	March 1	June 1

4.1.5 Life History Patterns

In EDT modeling, a life history pattern consists of a distinct combination of juvenile and adult age distributions for different components of the same population. More specifically, it consists of a set of proportions (summing to 1.0) describing the prevalence of alternative patterns. The life-history data used in this analysis were taken directly from the ODFW Sandy River Fish Management Plan (ODFW 1997) and from the literature for cutthroat trout. The life-history assumptions used in the model can be found at www.Mobrand.com/edt.

4.1.6 Sex-Specific Age Distribution

Age-specific sex ratios and age-specific fecundity values were taken from the ODFW Sandy River Fish Management Plan for Chinook, steelhead and coho (ODFW 1997). Generic literature values for each parameter were used for cutthroat trout.

4.1.7 Harvest Rates by Species

Because the focus of the Sandy River Basin EDT analysis was to determine habitat production potential, harvest rates were not incorporated into the initial modeling effort. Consequently, the analyses discussed in this report are based on the assumption that harvest impacts do not occur to the five selected fish populations. Since harvest does occur both outside and within the basin, the results tend to over predict adult numbers returning to the spawning grounds.

4.1.8 Hatchery Operations Data

Baseline hatchery data were compiled for the basin and summarized as follows:

- Hatchery location
- Species reared
- Fish size and weight at release
- Total number of fish released by species
- Release locations (tributary and river mile)
- Donor stock (local, adjacent drainage, distant drainage)
- Release date(s)

Hatchery data were used in the model to determine the degree of competition of hatchery fish with naturally produced fish. However, the initial 2001 model run did not include hatchery releases because the EDT analysis focused on determining habitat production potential.

In 2002, the hatchery information was used to explore competition effects from hatchery fish on spring Chinook in the lower Bull Run River. The hatchery assumptions used in the 2002 analysis can be found in Appendix C (See file: Sandy River Hatchery Assumptions 522 2002). All model runs completed in 2003 and 2004 did not include a hatchery component because the TT agreed that the EDT analysis should focus on stream habitat and actions to improve this habitat.

4.1.9 Smolt-to-Adult Return Rates

Currently, no data are available on smolt-to-adult return (SAR) rates for Sandy River Chinook, steelhead, or coho stocks or cutthroat trout (sea-run form). Therefore, the SAR rates used in the EDT model are based on literature and the professional judgments of the TT members and staff from Mobrاند Biometrics. This parameter has a significant affect on the estimated population recovery, so the basis for the species- specific SAR assumptions is provided below.

Fall Chinook

Because data regarding SAR rates were not available for wild Sandy River Chinook populations, coded-wire-tag data collected for Lewis River wild fall Chinook were used to develop the SAR rates for Sandy River ocean-type, life-history patterns (Cramer

1997). Cramer used cohort analysis to estimate fall Chinook survival rates to age 2 for brood years 1977 to 1991, as shown in Figure 1. The average age-2 survival rate observed in the Lewis River over this time period was approximately 2.4 percent. After accounting for losses in the ocean, an SAR of 1.0% was estimated for the Lewis River fall Chinook. The 1.0 percent SAR assumption was used for all model runs conducted for Sandy River fall Chinook.

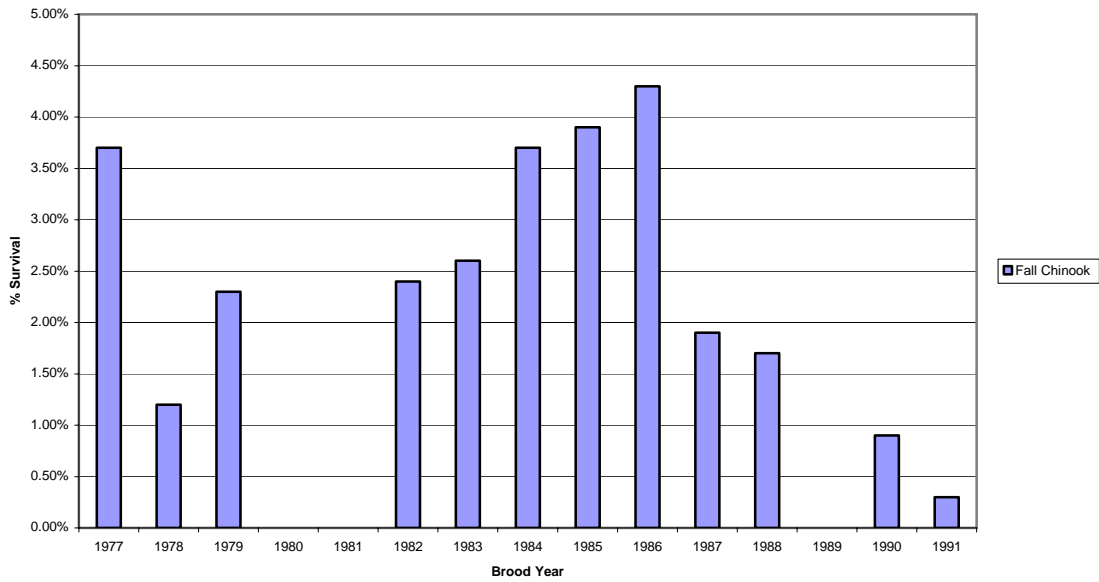


Figure 1. Lewis River Wild Fall Chinook Juvenile-to-Age-2 Survival Data, 1977-1991.

Spring Chinook

As with fall Chinook, SAR data for wild Sandy River spring Chinook were not available to help determine a reasonable SAR for this population. Moreover, the TT could not find coded-wire-tag data for wild Willamette River spring Chinook to use as a surrogate. The TT decided to use the analysis developed by the Northwest Power Planning Council (NWPPC) as part of its Columbia River Multi-Species Framework Project (NWPPC 2000) to determine spring Chinook survival once fish migrated out of the Sandy River Basin. The analysis was therefore performed using the NWPPC’s habitat ratings and survival benchmark values for the lower Columbia River, estuary, and ocean. The habitat ratings for the lower Columbia River and estuary incorporate mortality associated with degraded physical habitat conditions, as well as tern and marine mammal predation. The result was an estimated SAR of 1.5-2 percent for spring Chinook smolts.

Steelhead

To model steelhead populations, the SAR data shown in Figure 2 for the Keogh, Kalama, and Snow rivers were used to establish the benchmark SAR (12 percent) and to determine current (1990s) SARs for each population. Based on these data and best professional

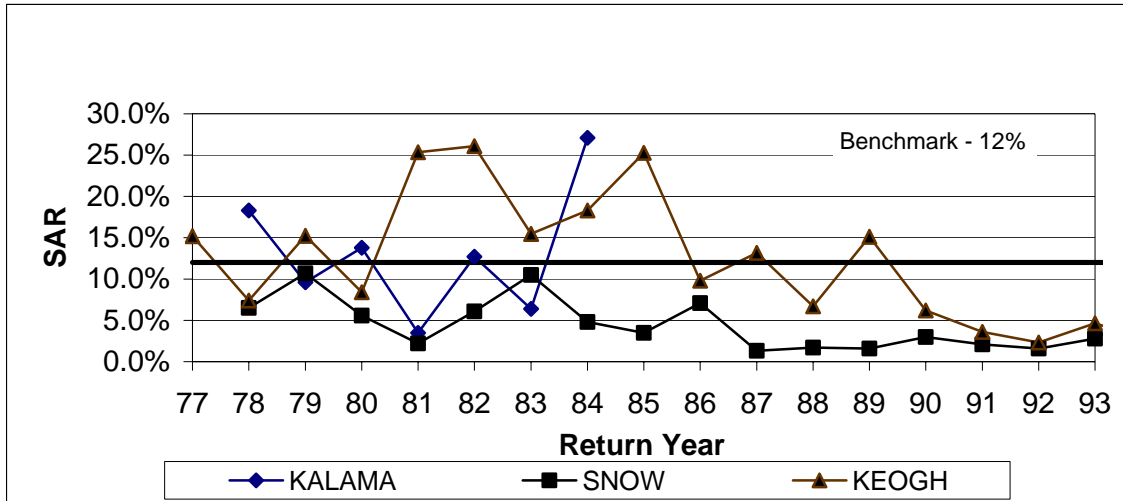


Figure 2. Steelhead SARs for the Kalama, Snow, and Keogh Rivers from 1977 through 1993.

judgment from conversations with Washington Department of Fish and Wildlife (WDFW) staff, Mobrand staff estimated that steelhead SARs for the last 7 to 10 years were approximately 3 percent. The 3 percent SAR was used for all model runs through 2002. Starting in 2003, steelhead SAR was increased to achieve values from 5-6 percent. This change was made in order to be consistent with the assumptions being used by the Lower Columbia River Technical Recovery Team for late winter steelhead.

Steelhead SARs can vary dramatically, depending on the time frame examined. For example, in the 1980s, steelhead SARs for these rivers was as high as 27 percent (see Kalama, 1984, in Figure 2). The large variation in steelhead SARs over time should be kept in mind when interpreting the adequacy or accuracy of EDT model estimates of steelhead production.

Coho

Coho SAR data used in the analysis were based on data presented in Seiler (2001). The author estimated, based on data for coastal and lower Columbia River coho populations, that the SAR for this species averaged approximately 4 percent.

Coastal Cutthroat Trout

An explicit SAR value was not used to model cutthroat trout. Instead, the cutthroat trout model was used to estimate total cutthroat trout production for each geographic area based on the biological rules. This approach was taken because life-history data were not available to determine the percent of the population that would take the sea-run form versus resident form. SAR values would only apply to the sea-run form.

4.2 Environmental Data

The process of assembling environmental data for the analysis consisted of four basic steps:

1. Identification of the geographic scope.
2. Defining the stream reaches.
3. Rating the stream habitat.
4. Reviewing the stream habitat ratings.

The methods used for completing these four steps are presented below.

4.2.1 Identification of the Geographic Scope

The first step in the environmental data entry process was to identify the geographic scope of the EDT analysis. The TT decided that only stream reaches historically accessible to anadromous fish species would be modeled. Stream reaches above impassable waterfalls or other natural barriers were not modeled as part of this effort. However, stream reaches above man-made barriers, such as dams and culverts, were included in the analysis, when appropriate.

Team members were assigned specific watersheds of the Sandy River Basin for which they would be responsible for entering stream habitat data into the EDT model. In general, smaller watersheds were assigned based on each member's knowledge of the particular area, and on their respective agency's landholdings or management responsibilities. The habitat area assignments are summarized below.

- U.S. Forest Service (USFS): those streams flowing through national forest lands, which are located primarily in the upper Sandy River Basin
- ODFW: tributary and mainstem habitat in the lower Sandy River Basin
- Portland Water Bureau: stream habitat in the Bull Run River and Little Sandy River subbasins
- Clackamas County: the majority of tributaries in Clackamas County
- Bureau of Land Management: those stream reaches in the upper Sandy River Basin not located on national forest lands

Mobrand staff were responsible for rating habitat in the mainstem Sandy River upstream from its confluence with the Bull Run River.

4.2.2 Defining the Stream Reaches

In this step, fish-bearing streams were divided into reaches reflecting the hydrography of the basin. The reaches were defined on the basis of habitat surveys, topographic maps, locations of man-made barriers, gradients, stream sizes and confinement, and confluences with other streams. In 2001, the TT entered habitat data for 119 reaches for the Sandy

Basin. Currently, there are 136 reaches in the Sandy River Basin EDT database. A list of all modeled reaches is included in Appendix D (See file: Sandy River Stream Reach Editor 904 2003)

Mobrand staff were responsible for coding the hydrography of the basin, i.e., indicating the direction of water flow and the spatial relationship of tributaries so that it could be processed by the EDT model. This type of reach structure was needed to ensure that the confluences of all fish-bearing streams were identified, as well as to provide coding by which the model could determine upstream from downstream, and thus possible migration routes for juveniles and adults. Whenever possible, the TT also identified obstructions (e.g., dam, culvert, and cascade) that might significantly restrict adult or juvenile passage or cause mortality to adults or juveniles.

4.2.3 Rating the Stream Habitat

From August 2000 through January 2001, the TT entered habitat ratings into the EDT model. Forty-six habitat attributes were rated for each stream reach. The 46 attributes are listed in Appendix A and can be roughly grouped into these categories:

- Hydrology
- Water temperature
- Channel/streambed
- Biological community richness
- Riparian conditions
- Physical habitat (pools, riffles, glides)
- Water quality
- Miscellaneous (e.g., pathogens, hatchery outplants)

Before proceeding with the data entry phase, TT members met in the field and office with Mobrand staff to review the approach for rating each of the 46 attributes. This step in the analysis was designed to standardize the approach and rating theory among TT members, emphasizing that habitat descriptions needed to be based on actual measured observations whenever possible. In the absence of such data, the analysis would then rely on the professional judgment and experience of the individual entering the data or on conclusions drawn from data collected in other stream reaches. Therefore, it was important that each attribute rating be associated with both a rationale and a level-of-proof assessment. The latter would be used to flag potential errors for future revision, and the former would indicate exactly how an erroneous evaluation might be corrected (e.g., by additional data collection).

Each TT member entered the habitat ratings directly into the EDT model using the EDT Habitat Questionnaire, which is an ACCESS-based program that Mobrand Biometrics wrote for data entry. The questionnaire was eventually modified and is now referred to as the Stream Reach Editor. The editor is provided in Appendix D (See File: Sandy River Stream Reach Editor 904 2003). TT members were trained in entering habitat attributes, defining stream reaches, and flow routing. Mobrand staff worked closely with the TT,

reviewing the habitat attribute definitions and describing the correct process for each attribute, to ensure consistency in habitat ratings by each team member.

The questionnaire enabled the users to enter data along three axes. The first axis is spatial, reflecting the reach structure developed for the basin or subbasin. The second axis is temporal: some information will refer to the normative, historical (circa 1850) watershed; some to the contemporary, non-normative watershed, and some to a specific season (by month). The third axis captures the justification or level of proof for an item of information.

When the Technical Team members entered the data for the Sandy River EDT analysis, they also rated the “level of proof” behind each attribute rating. The TT entered information for 6,126 attributes. Twenty percent of those ratings were based on empirical (measured) observations. Approximately 32% of the ratings were expansions of empirical observations, i.e. data collected in one reach of a stream was used to rate habitat in another similar reach. Expert knowledge of the Sandy Watershed streams was used to generate about 27% of the attribute ratings. Finally, 21% of the attribute ratings were speculative or hypothetical with little site-specific empirical support. These last two categories were usually applied to historic conditions, where biologists “speculated” that habitat conditions in the Sandy River would have been similar to other cascade streams.

All of the reach information for Sandy River Basin streams comprises the database for the watershed. The original database was created in the fall of 2000. Since then, the TT has changed it based on new stream reach information as it became available.

4.2.4 Reviewing the Stream Habitat Ratings

Stream habitat data and ratings entered into the model were reviewed for quality control purposes in two ways:

1. Mobrand staff acted as independent reviewers of the data set. Mobrand staff reviewed each stream’s ratings for inconsistencies based on their knowledge of the basin, relationships among habitat attributes, and consideration of how similar reaches were rated within the basin. Questionable inputs were returned to the TT for review and correction, if needed.
2. After all habitat data and ratings were entered into the EDT model, results for all streams were sent to the TT members for review and comment. The TT met several times to review data inputs and make changes.

The end product of the TT review was an agreement that the data set was the best possible given the information available at that time. The TT then authorized Mobrand to begin initial modeling of fish performance for the basin. The original database was created in the fall of 2000. Since then, the TT has updated the database based on new stream reach habitat information. The changes, or at least the new assumptions used in modeling, are documented in the EDT habitat database (www.Mobrand.com/edt).

5.0 KEY ENVIRONMENTAL PROBLEMS –EDT ANALYSIS TYPES

Once the biological and environmental data were entered into the EDT model, Mobrand staff ran the model to produce the following analyses:

- Population
- Reach
- Restoration
- Preservation
- Attribute Splice

These analyses were designed to assist the TT in systematically diagnosing the key environmental problems in the basin. The various analyses were run from 2001 to 2004. A description of each type of analysis, when it was run, and the methodology used is presented below. Specific purposes and results of the analyses are described in section 6.

5.1 Population Analysis

The Population Analysis results in estimates of current and historical fish performance. Data were presented for the attributes listed below.

- 1) Productivity (number of recruits (adults and juveniles) per spawner).
- 2) Carrying capacity (number of adults and juveniles the habitat is capable of supporting).
- 3) Life-history diversity (number of different life histories exhibited by the population).
- 4) Equilibrium abundance (the average number adults and juveniles produced from the basin).

Model runs were originally completed for spring and fall Chinook and late winter steelhead. Coho modeling was run after the TT analyzed the results for steelhead and Chinook. Model runs were also completed for coastal cutthroat trout. The cutthroat trout results were not very useful because the smaller tributaries typically used by cutthroat were not entered into the database due to a lack of habitat information. The model run results for cutthroat are described later in this report.

The TT also used the results of the Population Analysis as a quality control check of model inputs. EDT estimates of abundance were reviewed and then compared with observed population data in key streams or areas in the basin. Specifically, the EDT abundance estimates were compared to empirical data sets for the lower Bull Run River and Still Creek.

The City of Portland estimated juvenile steelhead production for two reaches in the lower Bull Run River from 1998-2000. The steelhead smolt estimates developed for this reach

were 263, 1,207, and 1,194 for migration years 1998, 1999 and 2000 respectively. The EDT Model estimated that smolt production for the entire lower Bull Run River (4 reaches) ranged from 800-1700, dependent on the survival assumptions modeled.

Still Creek juvenile steelhead trap counts ranged from 311 to ~10,500 during the period 1994 to 2002. The average for this same period was 3,997 (smolts and juveniles). EDT estimated average juvenile steelhead production from this stream at 4,750.

The TT gained confidence with the outputs of the EDT model after reviewing the results from these two comparisons.

5.2 Reach Analysis

The Reach Analysis compares current to historical habitat conditions on a reach-by-reach basis for the target species. This analysis is used to identify those stream reaches in the basin having the greatest effect on fish performance by species. When the Reach Analysis was done, the results were expressed in reach-by-reach summary sheets for each focus species. The greater the effect the reach had on fish production, the greater the benefits that might accrue to the target species if the reach was restored. Reach Analysis results were presented in a format that showed the effect of individual habitat attributes on fish performance. An example Reach Analysis is provided in section 7.3 of this report. The TT used the information provided by the Reach Analysis to identify habitat improvement opportunities on a reach-by-reach basis.

5.3 Restoration Analysis

The Restoration Analysis offered a way to examine the effect that restoring historical habitat conditions in each stream reach would have on fish performance in the basin. The analysis was performed by substituting historical habitat values for the current condition, one reach at a time. The EDT model was then rerun, and the changes in fish productivity, diversity, and abundance were determined. Reaches were prioritized based on the combined score for all three parameters (productivity, capacity, and diversity). The higher the score, the higher the reach was ranked. The TT used this analysis to determine which areas (or streams) of the basin should be prioritized for habitat improvement.

5.4 Preservation Analysis

A Preservation (or maintenance) Analysis was a means of determining which reaches were the most important to protect in order to secure the fish population against further loss. The TT used the results to identify stream reaches and lands that should be acquired for protection.

The Preservation Analysis was conducted by decreasing habitat quality in each reach by changing (degrading) the values for key environmental attributes, such as fine sediment, stream temperature, and bed scour, to a set level. The decreases in attribute values resulted in a corresponding reduction in habitat quality sufficient to eliminate most, but not all, fish production from the reach. Preservation Analysis results were presented as a

percentage change in total watershed fish abundance, capacity, productivity, and diversity.

The Preservation Analysis conducted for the Sandy River Basin did not incorporate the cumulative effects that would occur downstream as a result of a change in habitat quality in a given reach. For example, if stream temperature was decreased in Reach 2 (upstream), no change in temperature was assumed for Reach 1 (located downstream).

5.5 Attribute Splice

The Attribute Splice was used to summarize the total effect a single attribute had on total fish performance in a designated set of reaches³. The analysis was conducted by simply setting the current condition attribute value to that of the historical condition attribute value for all reaches of interest, and the re-running the model. The analysis is performed one attribute at a time, and the results displayed graphically. The TT used the Attribute Splice analysis as a means to quickly summarize habitat problems, or limiting factors to fish production, for the SRBA Policy Committee.

6.0 MODEL RUNS – RESULTS OF ANALYSES

The Sandy River Basin EDT Model has been run a number of times since 2001. Each model run provided an opportunity to incorporate the most up-to-date habitat and species information and to use the results to evaluate data quality. The TT was directly involved in all updates of the model. The key model runs for basin wide analysis are described in this section. Additional model runs were focused on developing a habitat conservation plan for Portland's Bull Run water supply. Those results are not included in this report.

6.1 April 2001 Model Run to Assess Data Quality

The first EDT model run was conducted in April 2001. The types of analyses completed for the first run were as follows:

- Population Analysis
- Reach Analysis
- Restoration Analysis
- Preservation Analysis

The April 2001 model run results were summarized in the Sandy River EDT Working Notebook, which is a 3-ring notebook binder (Mobrand Biometrics, Inc. 2001). The model results defined the present day and historical Chinook and steelhead anadromous fish production in the Sandy River Basin. The TT used the results of this initial model

³ In the attribute splice analysis, the 46 attributes are combined into groupings of similar attributes such as flow, habitat diversity etc. This step is required to allow easier interpretation of model results.

run to ground-truth modeling assumptions about fish distribution in the basin by species, abundance estimates, and smolt-to-adult survival rates.

As mentioned in section 5.1 Population Analysis, the TT used the first model run fish abundance projections to determine if observed stream population data agreed with the model results. In addition, the TT reviewed, on a reach-by-reach basis, all environmental ratings entered into the model. At the end of this process, the TT agreed that although the accuracy of some environmental ratings was uncertain, the data used for modeling was the best available at the time. The results of this model run were used to identify draft restoration actions throughout the basin, and described later in Section 7.0.

6.2 March 2002 Model Run to Incorporate Updated Information

Additional model changes made by the TT in 2002 included the following:

- Habitat types were redefined. Specifically, percent glides were entered into the database. This habitat type was not a part of the EDT Model in 2001, but was added by the model designers in 2002.
- Coho and new reaches were added to the analysis. The TT requested that coho production in the Sandy River Basin be evaluated. In order to complete this task, additional small tributaries were added to the model's reach structure.
- Steelhead rules were updated based on Washington Department of Fish and Wildlife (WDFW) review. The EDT model designers, working in collaboration with WDFW staff, updated the steelhead rules based on smolt and adult trapping data for the Wind and Kalama Rivers. The major change in the rule was the increase in suitable juvenile steelhead rearing habitat in boulder-dominated streams.

The model was then run to assess the impacts of the changes. The types of analyses completed for the second model run were the following:

- Population Analysis
The model generated new adult and smolt abundance numbers for the Sandy River Basin reaches under current and historic conditions (Appendix E (multiple files)). The model was also used to evaluate two packages of off-site (non Bull Run River) restoration measures to compare with the production potential of the Bull Run Watershed (Appendix F (multiple files)).
- Attribute Splice
The model was used to determine the primary environmental factors that were affecting fish populations in the lower Bull Run River and the lower Sandy River (reaches 1 and 2). This information was later incorporated into the City's proposal for addressing the City's impacts in the Sandy River Basin.

The Population Analysis results of the March 2002 EDT model runs can be found in Appendix E (multiple files). The EDT database of all stream information was also

distributed by compact disc (Final Updated Sandy River Questionnaire (March 19, 2002)) to all TT members and interested parties⁴. The Attribute Splice information was summarized by Mobrand Biometrics and is included as Appendix G (See file: Sandy 1 and 2 Attribute Splice 1015 2002, also Bull Run Attribute Splice 2002 (by species)).

6.3 2003 Model Runs

6.3.1 Chinook, Coho and Steelhead Model Runs

After the first model run in April 2001, the results were presented to the SRBA Policy Group. The TT was able to highlight the stream reaches that were either in good condition or those that were degraded and could benefit from restoration work. The Policy Group then directed the TT to identify specific habitat restoration projects throughout the Sandy River Basin from the EDT information. The TT then spent 6 months, from July through December of 2001 developing those actions. These activities are described later in this report.

After the draft restoration actions were developed for the Sandy River Basin, the EDT model was run several times (May, June, August, September, and October of 2003) for different purposes. In May of 2003, the TT worked on correlating the flow inputs for the lower Bull Run River with the estimates of weighted usable area (WUA) from previous instream flow work on the Bull Run (R2 Resource Consultants 1998).

In June of 2003, the model was run to identify the Chinook salmon benefits of the off-site (non Bull Run) Sandy River actions (See section 7.0 for discussion of action development). The City later used these results to craft their October 2003 proposal, which focused on their off-site measures to improve habitat conditions for spring Chinook salmon. Figure 3 is an example of EDT model outputs that indicates which non-Bull Run actions would produce the most Chinook salmon.

In the fall of 2003, the model was run several time using the new fish distribution suggestions from Dan Shively (U.S. Forest Service) and Dan Tonnes (NOAA Fisheries) as described earlier in this report. In addition, stream habitat upstream of some natural waterfalls in the upper Bull Run River was added to model steelhead production from these areas. At that time, TT members also scrutinized the model's assumption regarding fish response in relation to the food production habitat variables. They found that the literature-based algorithms were reasonable for describing food production⁵.

New fish abundance numbers were calculated for various scenarios, which were combinations of Bull Run and off-site actions. These scenarios were run because the City had proposed a set of conservation measures that the SRBA partners were reviewing for adequacy. The 2003 EDT model results had updated estimates for current and

⁴ As the information in this questionnaire is outdated, it is not included in this report. The most recent version of the habitat database can be downloaded from www.mobrand.com/edt.

⁵ A subset of the TT members contacted Ron Ptolemy, author of the alkalinity paper used to develop the EDT food rule, in October and November of 2003 to discuss his work. Mr. Ptolemy agreed the assumptions used were reasonable, but that if there were a bias in model outputs, it was that the model might be overestimating steelhead production in low alkalinity streams.

historic fish abundance. The Population Analysis numbers are provided in Table 3. The data show the estimated number of adult fish returning to the spawning grounds. The results indicated that current basin adult production for all species combined is about 20 percent of historic.

Top 25 Actions That Increase Chinook Abundance (Sandy River)

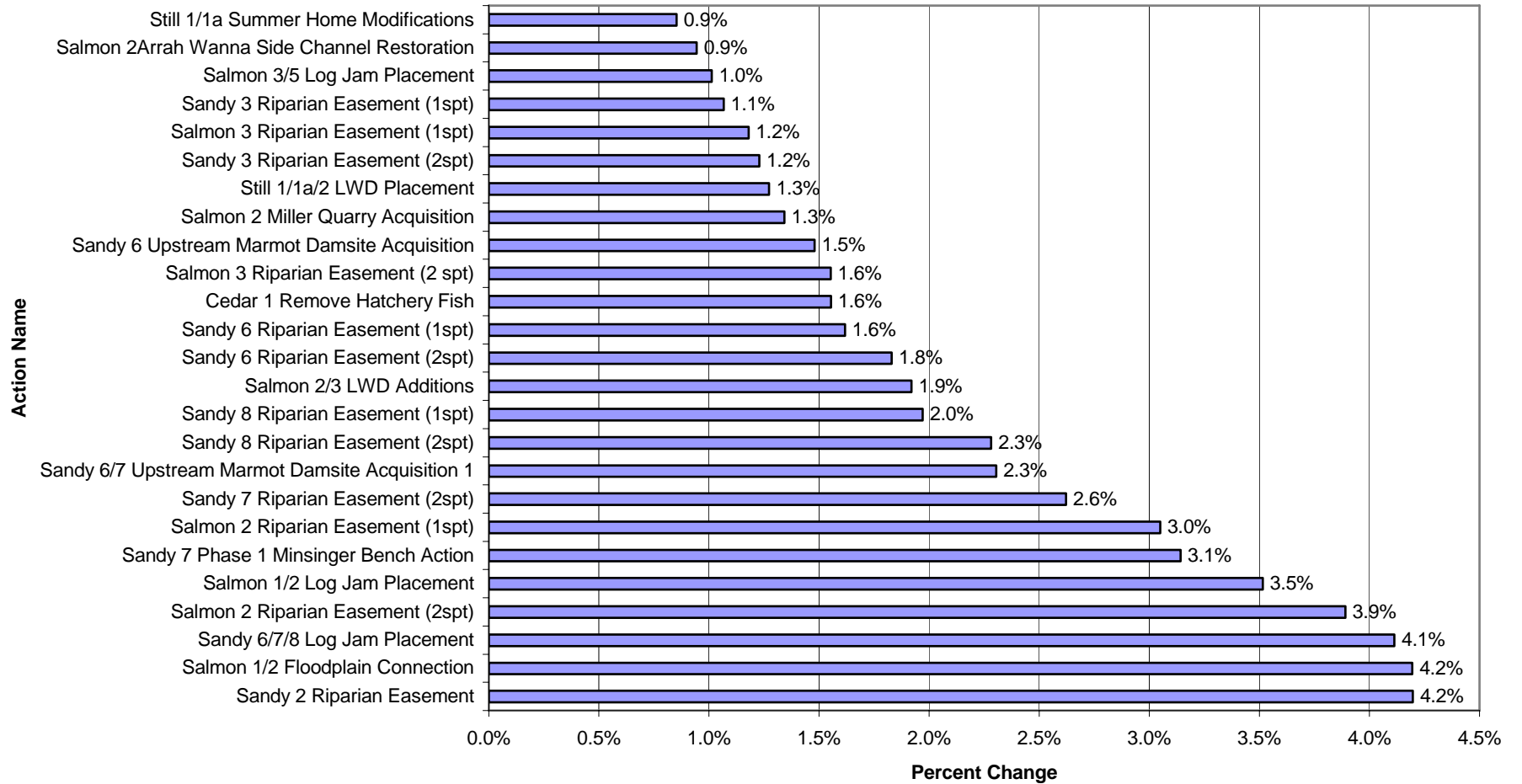


Figure 3. Example of Top 25 Habitat Improvement Actions that Increase Chinook Abundance in the Sandy River.

Table 3. EDT Model Estimates of Adult Abundance for Current and Historic (September 2003 Model Run).

Geographic Groupings	Steelhead		Fall Chinook		Spring Chinook		Coho	
	Current Adults	Historic Adults	Current Adults	Historic Adults	Current Adults	Historic Adults	Current Adults	Historic Adults
Lower Sandy River	254	568	2,553	11,163	0	0	88	3,687
Beaver	65	240	0	0	0	0	31	663
Lower Sandy Tributaries	142	566	228	1,097	54	378	0	386
Lower Bull Run	60	220	74	928	0	994	0	334
Upper Bull Run	0	856	0	997	0	1,983	0	893
Little Sandy	37	344	104	670	57	791	1	48
Middle Sandy River	351	745	1,474	4,702	718	2,507	802	5,569
Cedar Creek	38	531	168	320	77	244	58	935
Middle Sandy Tributaries	112	221	0	0	0	0	21	95
Salmon River	673	1,344	0	2,784	936	3,234	215	1,433
Upper Sandy River	538	994	0	2,293	718	2,203	547	2,306
Upper Sandy Tributaries	586	1,017	0	322	206	561	127	475
Zigzag River	801	1,590	0	1,850	659	2,112	90	575
Totals	3,657	9,236	4,601	27,126	3,425	15,007	1,980	17,399
SAR's	6.4%	7.3%	0.9%	1.1%	2.4%	3.7%	3.2%	5.4%

Grand Total Current 13,663
 Grand Total Historic 68,768
 % Historic 20%

Memos describing the results for the fall 2003 EDT model runs can be found in Appendix H (See file: August 2003 Sandy River Model Results Memo) and Appendix I (See file: September 2003 Sandy River Model Results Memo).

6.3.2 Coastal Cutthroat Trout

At the start of the Sandy River EDT analysis, biological rules were only available for Chinook, coho and steelhead. Thus, it was not possible to conduct analyses on either the resident or anadromous form of coastal cutthroat trout. Because of the interest expressed by the TT and other parties in the Columbia River, a process was undertaken to develop draft cutthroat trout rules for use in the Sandy River Basin.

The USFWS, Tacoma Power, City of Portland, the Washington Department of Fish and Wildlife, and Mobrاند Biometrics provided funding and assistance in developing the rules. Actual rule development was done in a series of workshops held in Portland, Oregon, with members of the TT, Mobrاند Biometrics staff and other researchers in 2002. The inputs received from these workshops were incorporated into a set of draft rules, which were used to model cutthroat trout in December of 2003.

The results of the cutthroat trout analysis are shown in Table 4 by geographic area.

The data presented in Table 4 indicate that some geographic areas do not support cutthroat trout production. This is a direct result of a lack of spawning habitat available in the geographic areas as defined by the TT.

Table 4. EDT Model Estimates of Coastal Cutthroat Trout Abundance for Current and Historic (December 2003 Model Runs).

Geographic Area	Current #	Historic #
Beaver Creek	403	1,906
Cedar Creek	2,281	5,395
Little Sandy	0	0
Lower Bull Run	0	0
Lower Sandy	0	0
Lower Sandy Tributaries	749	1,421
Middle Sandy Tributaries	612	904
Middle Sandy	0	0
Salmon River	1,726	2,725
Upper Bull Run	141	538
Upper Sandy	0	0
Upper Sandy Tributaries	1,211	2,044
ZigZag River	626	923

However, it is likely there are many stream reaches in these geographic areas that do support cutthroat trout. Coastal cutthroat trout use small tributaries as their primary spawning area. Because habitat data were not available for many of these small streams, they were not included in the EDT habitat database. This resulted in a situation where some geographic areas did not have spawning habitat suitable for cutthroat trout. Without spawning habitat, the EDT model is unable to calculate an abundance value. Thus, the fish numbers presented in Table 4 were deemed not very useful in estimating cutthroat trout production in the basin, or examining the effects proposed actions would have on this species.

EDT model results for coastal cutthroat trout (December 2003), as well as the rules used to generate them, are provided in Appendix J.

6.4 2004 Model Runs

There have been several EDT model runs in 2004. In February, two types of analyses were completed: Restoration Analysis and Preservation Analysis. Both analyses were performed using the web version of the EDT Model.

The web version of the EDT model uses the most recent set of biological rules developed for the Columbia River basin, as well as new assumptions for habitat conditions in the lower Columbia River. EDT model results produced from the web do not vary significantly from those developed in ACCESS, as both use similar rules and data sets. The fish numbers produced from each will however vary due to the randomness of the trajectory generator used to move fish to and from the spawning grounds. Generally, the change in fish production due to trajectory differences will be less than 5%. As the ACCESS version of the EDT model is no longer being supported, all future EDT runs for

the Sandy River or other Columbia River basins will be performed on the web so that results are comparable.

The 2004 analysis was conducted at both the reach and geographic area scale level. The raw data files for this analysis can be found in multiple files in Appendix K. The files in this appendix are sorted by species for reader convenience. The results and interpretation of the analysis are presented in a separate report (CH2M Hill 2004).

In May 2004, the City and the Services (NOAA Fisheries and USFWS) developed three alternatives for evaluation with the EDT model. The alternatives are groups of off-site (non-Bull Run) habitat actions. These alternatives were run through the model to compare the projections of fish numbers. These results will continue to inform the City's Habitat Conservation Plan proposal and will be presented in separate supporting documents to the HCP.

7.0 DEVELOPMENT OF BASINWIDE DRAFT RESTORATION ACTION MATRIX

After the EDT model was first run in the spring of 2001, it was difficult to say which specific reaches should be emphasized in regards to restoration work. This was because the source of the environmental degradation could occur significantly upstream of the degraded reach (e.g., high water temperatures in the lower Sandy River mainstem reaches). Since the specific stream reaches could not be identified to focus restoration work, the TT was directed by the SRBA Policy Group to develop restoration actions for the entire Sandy River Watershed. The TT went through a rigorous 6-month process in the fall of 2001 to identify draft actions that could correct the habitat problems identified in earlier EDT model runs. The TT used the following six-step process for identifying actions:

- Develop an overall strategy for action identification
- Assign streams/subbasins to TT members
- Identify the problem ecological attributes within the reaches
- Identify potential actions for treating identified ecological problems
- Describe the action in regard to location, scale, effectiveness, and cost
- Enter information in an Action Identification Form

Each step in the process is briefly described in the following sections.

7.1 Develop an Overall Strategy for Action Identification

TT members agreed to develop actions that fell within three broad strategy groups.

- Protection – actions that would maintain high- quality habitat in the most productive subbasins (e.g., land purchases, riparian easements).
- Enhancement – actions that would enhance fish performance in highly productive subbasins (e.g., culvert removal, withdrawal elimination).
- Restoration – actions that would restore fish to those subbasins where production has been eliminated (e.g., Little Sandy Dam Removal).

7.2 Assign Streams/Subbasins to Team Members

As was the case with the entry of biological and environmental data, TT members were assigned specific streams and watersheds for which to develop actions. Staff involved in identifying actions represented the Water Bureau, Oregon Department of Fish and Wildlife, NOAA Fisheries, U. S. Fish and Wildlife Service, Mt. Hood National Forest, Clackamas County, and the Sandy River Basin Watershed Council.

7.3 Identify Problem Ecological Attributes within the Reaches

Technical Team members used the EDT results presented in matrix-type tables (Sandy River EDT Working Notebook), data in the Habitat Questionnaire (Sandy River Basin EDT database), aerial photos, and current stream surveys to identify specific habitat problems. The reach tables were organized by species in the Sandy River EDT Working Notebook (Mobrand Biometrics, Inc. 2001). These tables summarize habitat problems by salmonid life stage, by month, and by attribute. Examples of these types of tables can be found in Appendix K (See miscellaneous files by species) and in Figure 4 below.

For Figure 4, the larger the black dot, the larger the effect this attribute has on fish performance. Each black dot represents an opportunity to restore habitat conditions in the basin, thereby enhancing salmon performance. The TT mainly focused on the environmental problems identified for the number 1 or 2 rated life history phase for each species of interest. By this process, the TT was able to develop target restoration actions to address the most severe environmental problem limiting fish production on a reach-by-reach basis.

7.4 Identify Potential Actions for Treating Identified Ecological Problems

After identifying the key attributes affecting fish performance, TT members began developing a set of actions to treat the problems. Some TT members undertook field trips to particular reaches both to develop actions and to verify on-site the data used to complete the habitat database. All actions developed by the TT were meant to directly or indirectly result in either some degree of change to one or more conditions of stream systems or the rate of change associated with new land developments. Consequently, the actions developed by the TT did not include planning activities, studies, or monitoring and evaluation. Actions covered a range of types including the following:

7.5 Describe the Action in Terms of Location, Scale, Effectiveness, and Cost

For each action proposed, TT members provided information about location (identified reaches or areas), scale (intensity), effectiveness (improvement in habitat rating for each attribute), and cost. At this stage of the analysis, such information was preliminary and somewhat subjective, but it was still useful to inform policy discussions.

7.6 Enter Information in the Action Identification Form

The information gathered in the first five steps was used to fill in the Action Identification Form as shown in Table 5. Instructions for completing this form are provided in Appendix L. (See file: Instructions For Completing Sandy Action ID Form)

The purpose of this form was to organize the various actions so that (1) they were easy to disseminate to other team members, (2) they could be grouped into specific restoration strategies (e.g., sediment reduction), and (3) their status could be tracked over time. Although this form was originally constructed using a word processing program (Microsoft Word), it was later converted to an ACCESS database format to simplify data entry.

In March 2002, the TT completed the matrix of draft restoration actions for the Sandy River Basin. They identified 159 actions, which had a total cost of about \$150,000,000. Over time the list of actions was edited to reflect changes in the environmental database. The most recent matrix of actions is included as Appendix M (See file: Sandy River Action List and Scenario Builder 2004). Since its development in March 2002, parties in the basin have implemented several of the actions identified by the TT.

8.0 SUMMARY

This report summarizes the process used to compile habitat data for the entire Sandy River Basin, to diagnose the key environmental problems limiting salmonid population success, and to identify restoration actions that could be taken to both protect and restore key habitat elements. The SRBA Technical Team from the fall of 2001 to spring 2004 completed all of the modeling activities. The process involved a diverse set of partners and resulted in a basin wide model that had never before been created for the Sandy River Basin. The SRBA partners hope this model and database will enable ongoing collaborative assessment and allow the partners to track progress toward basin restoration.

Table 5. Action Identification Form.

Person Identifying Action:			Phone:
Action (project name):			
Type of Action (Circle appropriate type; describe "Other" in space provided)	Capital Expenditure Project Water quantity related Water quality related Riparian/channel/habitat restoration Fish passage/access Biological process related Acquisition Other Describe "Other" here _____	Program Education Technical assistance Tax advantage Cost-share Easement Other	
Action Status (Highlight choice in Bold)	Currently being completed or implemented (effects not seen yet) Scheduled for implementation (funded) Proposed (not funded) Preliminary consideration/initial planning stages		
Goal of Action (e.g., moderate rate of storm water runoff)			
Action Description (Briefly describe nature of action, including scale, scope, and time frame)			
Action Effectiveness: (Expected change in Level 2 environmental attributes or fish survival)			
Affected Streams (Include river miles [RM] where action occurs—approx. if not certain):	Stream(s): RM:		
Land Ownership (at action; circle)	Public		Private
Technical feasibility Methods well known – very feasible Methods partly known – some uncertainty Methods experimental – high uncertainty Community support Broad support – well accepted Uncertain support – acceptance unknown Broad support unlikely – known conflicts	Certainty of outcome Certain of achieving all aspects of goal Uncertain of achieving some aspects of goal Uncertain of achieving all aspects of goal <u>Describe nature of uncertainty if possible:</u>	Cost (estimated range) <25,000 >25,000 and <100,000 >100,000 and <250,000 >250,000 and <500,000 >500,000 and <1,000,000 >1,000,000 and <2,000,000 >2,000,000 and <5,000,000 >5,000,000 and <15,000,000 >15,000,000 OR Known estimate \$ _____	

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