MidCoast Watersheds Council

Sixth Field Watershed Assessment

Alsea
Ocean Tributaries
Salmon
Siletz
Yachats
Yaquina

July 2001

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MidCoast Sixth Field Watershed Assessment Final Report

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* Figures ending in letters (like AQ-18AL) are printed separately for each major basin and are located in the Basin Inserts. The last two letters correspond to the basin: AL=Alsea, OT=Ocean Tributaries, SA=Salmon, SI=Siletz, YA=Yachats, and YQ=Yaquina.

2 Executive summary

The study area for this assessment is composed of the Alsea, Salmon, Siletz, Yachats, and Yaquina River watersheds and those watersheds that drain directly to the ocean between Cascade Head and Cape Creek at Heceta Head (Ocean Tributaries). Wherever possible, 1:24,000 uniform scale geographic information system (GIS) data that covered the entire study area were used in this assessment. Goals of this study include, (1) a summary of current conditions for each 6th field watershed; and (2) recommendations for monitoring and management actions for prioritized 6th field watersheds.

Coastal Oregon is a dynamic landscape. During the past 10,000 years the Pacific salmon have adapted to this rapidly changing environment. However, during the past 150 years dramatic new patterns have emerged. Old growth forests have been replaced with younger, even aged stands. Stream networks have been simplified by channelization, down cutting and damming. The frequency and magnitude of materials arriving in the stream network *via* landslides and debris flows has increased. Cool, clear, oxygenated waters have been replaced by warmer, sediment laden, and oxygen-poor waters.

There are seven types (species and runs) of anadromous salmonids found in the MidCoast region and early residents of the region benefited from an abundance of salmon. Some of the earliest accounts include descriptions of how abundant salmon were harvested with pitchforks in the late 1800’s and early 1900’s (Boateng & Associates Inc. 1999). Canneries thrived in early coastal towns. As late as 1947, vast quantities of salmon were harvested in and around Lincoln County, which boasted of a catch that included a staggering 1.3 million pounds of chinook and “varying quantities” of coho (Boateng & Associates Inc. 1999). Concomitant with changes in the coastal landscape were changes in salmon abundance so that now many salmon populations are seriously depressed and a few are threatened with extinction.

A requisite step in watershed management is to take stock of the resources and the factors that affect those resources. In formulating an adaptive management strategy for recovery of wild salmonids, Botkin *et al* set two priorities: (1) statistically valid estimates of the number of fish present in each basin, and (2) a detailed and integrated mapping of landscape patterns within each basin (Botkin *et al* 1993). Watershed assessment is one way to map landscape patterns, and watershed assessments often incorporate data on fish distribution and abundance.

The goal of this watershed assessment was to prioritize 6th field watersheds within the MidCoast Region, and in the process we mapped landscape patterns of many types. We used existing information to map landscape patterns, focusing on patterns and processes that are important in creation and maintenance of anadromous salmonid habitat.

Our charge in conducting this assessment was to use existing GIS data to the extent possible, and to create new GIS layers from data that had been collected by others, where feasible and useful for the assessment. Because of the large size of the study area, we did not collect field data for this assessment. We focused on data that had consistent, comprehensive coverage across the study area, to provide a valid basis for comparing the 217 6th field watersheds to each other.

Our first step in the assessment was to review a series of GIS layers provided to us on the MCWC CD-ROM. We then spent several months contacting data providers to update important data sets and acquire new ones. In some circumstances, we cautiously combined important data sets to develop a regional perspective on valued resources. In other circumstances where data were lacking, we developed surrogate or stand-in data layers to aid us in this watershed assessment and to assist in the action planning efforts of the MidCoast Watershed Council.

Our approach was to identify important watershed properties and resources and prepare descriptions of each, one factor at a time. Then, with input from the MCWC Tech Team, we used GIS to combine many of these factors into multi-factor analyses of the study area. These multi-factor analyses were designed to answer specific, complex questions about the watersheds. For example, we developed an analysis to answer the question, “Which 6th field watersheds have, on average, the highest functioning levels for coho winter habitat?” The answers to questions like these require syntheses of many different data sources, so we refer to these as “multi-factor analyses.” The results are provided in this report.

This assessment prioritized 6th field watersheds to provide the MidCoast Watersheds Council a broad-scale basis for prioritizing watershed actions. Since watershed management actions are often taken at the stream reach level, the obvious next step for the Council is to take the results of this assessment and the data we compiled, and use these products to prioritize project sites at the stream reach scale. To “jump start” this process, we developed and provide in this report several examples of multi-factor analyses designed to answer questions at a scale below that of 6th field watersheds. Examples of our analyses that answer two questions are “Where are potential locations for floodplain restoration?” and “Where are suitable locations for placement of large woody debris?” These analyses are intended to provide guidance to the MidCoast Council during the next phase of its watershed assessment and action planning activity.

Availability of GIS data about watershed resources is increasing rapidly. New data layers became available both during this study and after completion of our analysis. Many of the data sources we used are updated annually by the groups or agencies that produce them. We recommend that the MidCoast Watershed Council update the data layers used in this assessment frequently, and acquire and use new information as it becomes available, to ensure that data used to make watershed management decisions are as recent and relevant as possible.

2.1 Brief description of watershed conditions

The study area for this assessment consists of the following major Oregon coastal river basins: Salmon River, Siletz River, Yaquina River, Alsea River, Yachats River, and Ocean Tributaries from the Salmon River south to Cape Creek at Heceta Head. The total study area is about 375,000 ha or 1,450 sq mi in size and includes 217 6th field watersheds and 18 5th field watersheds.

The MidCoast Region lies within the Coast Range Ecoregion as defined by US EPA (Pater 1998) and is characterized by wet winters and relatively dry summers. High amounts of rainfall and rugged terrain heavily influence the types of organisms and the ecological processes that occur in the region. The area was once covered with a patchwork of forest stands of varying ages --- younger forests or open areas in disturbed areas, and more mature coniferous forests in other areas. In 1995, much of the region was dominated by broadleaved forests (about 17%), mixed forests of young conifers and broadleaved trees (18%), and young coniferous forests (22%). About 9% of the study area was covered in 1995 by coniferous forest of large or very large sized trees. The large conifer forests were concentrated in the southern portion of the study area.

The vast majority of the study area (90.6%) is zoned for Forest Use. Predominant landowners are private industrial timber companies (39.9% of the study area), USFS (28.6%), private non-industrial landowners (17.0%), and BLM (10.5%).

The northern portion of the study area has the highest stream densities and the largest area of igneous (volcanic) geologic formations. Igneous formations predominate in the Salmon basin, middle and upper Siletz basin (Middle Siletz, Upper Siletz, and Schooner/Drift Creek 5th field watersheds), the southernmost Ocean Tributaries (south of Yachats), and the upper Alsea basin (North and South Fork Alsea 5th field watersheds).

Both landslide risk and soil erosion risk are high throughout the study area. Over 1/3 of the land area in many watersheds is at high risk for landslides (based on a landslide risk model), while 45.8% of the study area has soils with severe risk of soil erosion. Major concentrations of hydric soils are found in the estuaries of the study area's major rivers (Yaquina, Siletz, Salmon and Alsea), and in the Beaver Creek (Ocean Tributary) watershed. Hydric soils are also quite extensive in the valleys of the major rivers and major tributaries, and behind the foredune along the coast. The wetlands behind the foredune are particularly susceptible to development pressure; these wetlands may contain unique plant communities in the deflation plain habitats (Weidemann *et al* 1974).

Seven biotypes of anadromous fish are found in the study area: coho, fall chinook, spring chinook, winter steelhead, summer steelhead, chum, and searun cutthroat. Coho, fall chinook, and winter steelhead are widely distributed in the study area, while the distributions of the other biotypes are more restricted. Snorkel surveys made in 1998 and 1999 showed that coho rearing densities in the study area generally averaged under 0.5 coho/sq m. Eight 6th field watersheds had average rearing densities over 0.75 coho/sq m. Of these eight watersheds, four were in the Yaquina basin, two in the Alsea basin, and two in the Ocean Tributaries basin. These eight watersheds excluded those 6th field watersheds with high densities but less than 10 pools snorkeled.

We analyzed about 1,606 km of aquatic habitat survey data for this assessment, including data from the Oregon Department of Fish and Wildlife, the U.S. Forest Service, and the

Lincoln Soil and Water Conservation District. Here we present only a few highlights of the analysis.

Pool area (as percent of stream area) was highest in the southern portion of the watershed. Twenty one 6th field watersheds averaged over 60% pools; of these, eleven were in the Alsea basin, four in the Siletz, three in the Yaquina, two in the Ocean Tributaries basin, and one in the Yachats basin. Pool frequency was highest in the 18 6th field watersheds with five or less channel widths per pool; of these, 10 were in the Alsea basin, six in the Siletz basin, and two in the Yachats basin.

Stream channel shading was generally satisfactory; most 6th field watersheds averaged over 60% shade for surveyed streams. Frequency of large woody debris was highest in the southeast corner of the study area (North Fork Alsea 5th field watershed) and in the Ocean Tributaries basins between Depoe Bay and Newport. Frequency of key wood pieces was generally highest in the southern portion of the study area.

Sixth field watersheds that had 303(d) listings for water quality impairment were located in the North Fork Alsea River, central Alsea mainstem, central Big Elk Creek (Yaquina), lower Siletz, and Little Salmon River. Most 303(d) listings were due to elevated stream temperatures. Stream flow restoration is a high priority for 6th field watersheds in the Schooner/Drift Creek subbasin, and in the lower Yachats basin. No GIS data on roads suitable for comparison and ranking of 6th field watersheds were available, but some urbanized coastal watersheds appear likely to be at high risk of peak flow enhancement due to impervious road surfaces.

Modeled shallow landslide risk was highest in the central Siletz basin, the Alsea basin, and the southernmost Ocean Tributaries basin (Cummins-Tenmile). Highly erodible soils were predominant throughout the study area but were particularly concentrated in the upper Siletz basin, Alsea basin, and southernmost Ocean Tributaries basin. Active streambank erosion (from aquatic habitat survey data) was highest in the 6th fields where underlying geologic formations were predominantly sedimentary, and lowest in the areas of igneous formations. We combined data on soil erosion risk and shallow landslide risk for a multi-factor analysis of landslide/erosion risk. The combined risk was highest in the central Siletz basin, Alsea basin, and southernmost Ocean Tributaries basin.

We conducted three multi-factor analyses of anadromous salmonid habitat. The first combined data on stream gradient and stream confinement (derived from Digital Elevation Models), hydric soils, pool frequency, large woody debris frequency, and side channel habitat for a multi-factor analysis of coho winter habitat. Of the ten 6th field watersheds ranked highest for coho winter habitat in this analysis, five were in the Alsea basin, two in the Siletz basin, two in the Ocean Tributaries, and one in the Yaquina basin.

The second multi-factor analysis of salmonid habitat addressed factors influencing coho summer habitat. Factors used in this analysis were stream gradient and stream confinement (derived from Digital Elevation Models), pool frequency, large woody debris frequency, stream channel shading, length of riffle habitats, length of bedrock substrate, and juvenile coho density. Of the ten 6th field watersheds ranked highest for coho summer habitat in this analysis, four were in the Alsea basin, three in the Ocean Tributaries basins, two in the Yaquina basin, and one in the Siletz basin.

The third multi-factor analysis of salmonid habitat addressed factors influencing winter steelhead habitat. Factors in this analysis were stream gradient and stream confinement (derived from Digital Elevation Models), length of riffle habitat, and length of riffle habitat dominated by gravel-to-boulder-sized substrate. Of the ten 6th field watersheds ranked highest for winter steelhead habitat in this analysis, three were in the Alsea basin, three in the Siletz basin, two in the Ocean Tributaries basins, and two in the Yachats basin.

To assist MCWC in the next phase of action planning, we conducted two multi-factor analyses of potential watershed restoration sites. The first combined data on juvenile coho density (from snorkel surveys) with aquatic habitat survey data on LWD, to locate suitable areas for large woody debris placement. The second analysis combined data on flat areas near streams (possible floodplains) with non-development zoning to locate potential floodplain restoration sites. We provide stream reach mapping of the sites located using these multi-factor analyses.

3 Goals and purpose

According to the Oregon Watershed Enhancement Board (OWEB), Oregon Watershed Assessment Manual, a Watershed Assessment is a process for evaluating how well a watershed is working (Watershed Professionals Network 1999). "An assessment can't give us site-specific prescriptions for fixing problems, but it can, and should, tell us what we need to know to develop action plans and monitoring strategies for protecting and improving fish habitat and water quality" (Watershed Professionals Network 1999).

The purpose of this study was to conduct a GIS-based assessment of watershed conditions, summarized at the 6th field watershed level, within the MidCoast Region of Oregon, with focus on habitat for anadromous fishes. We were charged with using existing GIS data, and with creating new GIS layers from data that had been collected by others, where this was feasible and useful for this assessment. Because of the large size of the study area (18 fifth field watersheds, 375,000 ha or 1,450 sq mi), we did not collect field data for this assessment.

The study area is composed of the Alsea, Salmon, Siletz, Yachats, and Yaquina River watersheds and those watersheds that drain directly to the ocean between Cascade Head and Cape Creek at Heceta Head (Ocean Tributaries). Wherever possible, 1:24,000 uniform scale geographic information system (GIS) data that covered the entire study area were used in this assessment. Goals of this study include, (1) a summary of current conditions for each 6th field watershed; and (2) recommendations for monitoring and management actions for prioritized 6th field watersheds.

This study followed the guidance of the OWEB manual (Watershed Professionals Network 1999). However, there are several important differences between this assessment and the procedures outlined in the OWEB manual:

(1) The current assessment is designed to be a GIS-based assessment; therefore, considerable effort was put into acquiring, critically reviewing, and updating GIS data layers.

(2) The unit of prioritization in this assessment is the 6th field watershed. This contrasts with the procedure outlined in the OWEB manual, which is designed to assess a single watershed that is "approximately 60,000 acres in size" (i.e., a 5th Field Watershed).

3.1 Strategy

We have made extensive use of existing data. Wherever possible, we have used quantitative data that were collected using known protocols. During this process, we have documented important data gaps. In several cases, we made use of the tremendous analytical power of GIS to develop surrogate, or stand-in approximations (modeled) for the missing data. Most notably, we used the 10 m digital elevation model (DEM) data to develop study area-wide, uniform scale GIS layers that depicted streams, stream gradient, stream confinement, and stream channel types. Wherever possible, we made comparisons between our surrogate data sets and other data sets (e.g., available data sets that had only partial coverage of the study area); however, surrogate data sets were not field checked. Results of the data set comparisons are presented in this report. As we state in our recommendations section, we advised MidCoast Watersheds Council (MCWC) members to use surrogate data layers as a framework for future field observations. In this way, the GIS layers can be validated and the procedures used to model watershed characteristics can be refined.

Our strategy entailed working closely with members of the MCWC. Rather than performing our watershed assessment and then delivering a final report to the group, we involved MCWC council members in the synthesis of watershed data. First, we examined one variable at a time (single-factor analyses) to produce study-area wide summaries for each watershed characteristic. To increase interaction with MCWC members, we attended quarterly meetings and met with the Technical Team and Action Planning subcommittee as needed. In addition, we established a series of web pages where examples of GIS summaries could be posted and reviewed by interested watershed council members. As MCWC became familiar with the nature and limitations of the single-factor analyses, they provided us with direction in the form of a series of GIS-based questions/ analyses that would guide them in their prioritization and management actions. Pursuing these questions and working closely with MCWC, we developed a second series of analyses. These analyses were multi-variable (multi-factor) GIS summaries designed to answer specific important questions during the MCWC action planning process.

The current OWEB watershed assessment process seeks to summarize conditions within a single 5th field watershed. The logical next step is to use these conditions to prioritize subwatersheds or stream reaches for management actions. A wide range of factors -- sociological, economical, political, or ecological -- can be used in such prioritizations. In this study, we used GIS to rank 6th field watersheds using ecological processes as the primary constraints. However, throughout the process we have incorporated the views of council members with various training, backgrounds, and perspectives. We used their input to sort through coarse regional-scale priorities. We recognized that the watershed council would have, as its next step, a desire to select specific sites within each prioritized 6th field watershed. During this study many data sets were developed that can be used below the 6th field level (i.e., at a finer spatial scale). Therefore, wherever possible we summarized the data at the 6th field level but maintained the fine-scale spatial resolution and links to the underlying data. The next phase of prioritization will go beyond the currently available guidance documents (OWEB Manual) to ultimately select specific sites for specific management actions. Like any good project, this assessment ended with many data layers that can be seasoned with local knowledge and then used to select the “best” choices for restoration or monitoring sites.

4 How to use this report

This report is organized into several types of sections: a main report containing methods and general results from the entire study area; results specific to individual basin planning teams; and recommendations. We have organized the report so that sections prepared for individual basin planning teams appear as separate chapters, referred to as the Basin Inserts. **The basin insert sections are not intended to be stand-alone chapters and should not be separated from the other sections of this report.**

Identical versions of this report are available as “hard” (printed) and electronic copies. The electronic copy consists of several separate PDF files: the **Main Report**, six **Basin Inserts**, and **Appendix A (Supplemental Methods**). PDF files are Adobe Acrobat Portable Document Format files, which can be easily viewed and printed from any computer using the free Adobe Acrobat Reader, available free on the World Wide Web at *http://www.adobe.com/products/acrobat/readstep.html*. The PDF files, along with all figures contained in the report, can be downloaded from the MidCoast Watersheds Council website at *http://www.midcoastwatershedcouncil.org*.

Throughout this report, we include data layer names so that future GIS users can reference specific data layers for summaries that they may be interested in producing. File names ending with SHP are ARCView shape files. File names ending with XLS are Excel spreadsheet files. File names ending with ZIP are zip files containing multiple related files; these files must be “unzipped” before they can be used. ArcView shapefiles consist of multiple files. We used a ZIP utility to make a single file from these groups of files. Sources of data files are also indicated as follows, data layers are marked with a superscript “M” if they were taken from the MCWC CD-ROM or marked with a superscript “W” if they are available from the worldwide web. If data layers are mentioned with no superscript, then they are provided with this report as part of this assessment. Web-based information sources are referenced in the text. Reports and other published sources of information are listed in the Literature Cited section.

4.1 List of acronyms and abbreviations

AHI	Aquatic Habitat Inventory
BLM	Bureau of Land Management
CD-ROM	Compact Disc, Read Only Memory
CLAMS	Coastal Landscape Analysis and Modeling Study
DEM	Digital elevation model (GIS representation of topography)
DLCD	Department of Land Conservation and Development
DLG	Digital Line Graph
DEQ	Department of Environmental Quality
DOQ	Digital Ortho Quad
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information Systems
HUC	Hydrologic Unit Code
K	1,000 (used in scale descriptions, e.g. 1:100K = 1:100,000 scale)
MCWC	MidCoast Watershed Council
NRCS	Natural Resource Conservation Service (formerly SCS)
NMFS	National Marine Fisheries Service
OCSRI	Oregon's Coastal Salmon Restoration Initiative
ODFW	Oregon Department of Fish and Wildlife
ODF	Oregon Department of Forestry
ODOT	Oregon Department of Transportation
OSU	Oregon State University
OWEB	Oregon Watershed Enhancement Board
OWRD	Oregon Water Resources Board
PRISM	Parameter-Elevation Regressions on Independent Slopes Model
REO	Regional Ecosystems Office
SMORPH	A landslide risk model used in this assessment
SNF	Siuslaw National Forest
STORET	EPA’s STOrage and RETrieval database
USFS	U.S. Forest Service
USGS	U.S. Geologic Survey

4.2 Data

4.2.1 Use restrictions

Some of the data used in this report were given to us with the condition that they would not be distributed. Specifically, we agreed not to distribute data concerning rare, threatened and endangered species that we acquired from the Natural Heritage Program. These data will be kept in the MCWC office. In addition, we obtained the Coastal Landscape Modeling and Analysis Study (CLAMS) land cover data from researchers at Oregon State University. These data cannot be distributed by MCWC. Persons wishing to use the CLAMS data should contact the CLAMS directly. CLAMS researchers are in no way responsible for our use of or conclusions drawn from our use of their data.

4.2.2 Our use of existing data

Wherever possible we used uniform scale data that covered the entire study area. In some instances, data were only available for portions of a 6th field watershed or stream network (e.g., Rapid Bioassessment and AHI data). In these cases, we used our judgment to determine if enough data were available to summarize the condition of a 6th field watershed. In cases where there were not enough data to rank a watershed, we left the 6th field unranked. In other cases where there was only partial coverage, we indicated such on the map and in the report.

Since important information on instream condition was generally not available for the entire study area from one source (i.e., data often came from multiple agencies and were gathered using multiple protocols), we found it necessary to **carefully** combine and summarize data that were available from the various sources. Generally, environmental variables are measured so that the condition of the environment can be known or that environmental change can be determined. Measurements are made using protocols (and experimental designs) so that differences observed in the data are due to changes in the environmental variable not due to differences in the way that something was measured.

For several data sources (e.g., AHI surveys), we compiled and reviewed data from three sources. In several cases, variables that we were interested in were collected using different protocols or summarized differently. Rather than not include these important observations in our report, we combined these data and indicated such in this report. We used all available information and our knowledge of the study areas to produce these summaries. We recommend that extreme caution be used in interpreting this information because we have no way of knowing how accurate these summaries are. The only way that accuracy can be assessed is through additional fieldwork.

Finally, in a review of data available for anadromous fish populations in western Oregon and northern California, Botkin et al. (Botkin *et al* 1993) reviewed data from many sources. They ranked the "potential usefulness" of various data sources as being either potentially useful or not. All potentially useful data sets included a description of methods and sampling schemes. Similarly, Garono (1999) reviewed available GIS data for their completeness and suitability for this project. Readers interested in data quality are directed to these two reports.

4.2.3 Accuracy & uncertainty

The relationships between the various salmonid species and the watersheds they inhabit are extremely complex. Generally, we assume that "given enough research and the right models, or other analytical approaches, exact numbers can be determined for population size, components of population dynamics, and the responses of populations to given harvest levels... This assumption is nearly always erroneous" (Botkin *et al* 1993). Botkin et al. have identified three sources of environmental uncertainty: (1) incomplete information regarding the current state of a resource; (2) incomplete information on details of cause and effect relationships; and, (3) intrinsic unpredictability in nature. Since most population estimates are based on a relatively small sample, appropriate sampling methods and interpretation of results allow one to estimate the amount of uncertainty associated with each sample and to develop an understanding of causal relationships.

Both **accuracy** and **precision** are important considerations in making any measurement; generally, as accuracy and precision go up, so do the costs. Accuracy tells us how well our measurements reflect the condition of a variable (e.g., how many salmon there actually are in the watershed in which we are interested). Precision tells us how repeatable our measurement is time after time. You can have measurements that are precise and not accurate, ones that are accurate and not precise, and ones that are neither accurate nor precise. Statistics are used to assess accuracy and precision.

Making management decisions based on observations or measurements that do not accurately describe watershed conditions may produce unexpected results.

5 Setting

5.1 Location

The study area for this assessment consists of the following major Oregon coast river basins: Salmon River, Siletz River, Yaquina River, Alsea River, Yachats River, and Ocean Tributaries from the Salmon River south to Cape Creek at Heceta Head. The total study area is about 375,000 ha or 1,450 sq mi in size and includes 217 6th field watersheds and 18 5th field watersheds.

Although the MCWC area of interest extended only to Cape Creek, our analyses generally included three additional 6th field watersheds at the southernmost tip of the study area, south of Cape Creek (the Bailey, Berry, and Dahlin watersheds). We included these three watersheds because they were contained in all of the hydrology coverages provided to us by MCWC on the MCWC GIS CD-ROM, and these hydrology coverages formed our base layers for this assessment. We discussed this issue with MCWC early in the assessment and our inclusion of these 6th field watersheds was accepted. However, in response to a late request by MCWC, the maps we produced excluded these southernmost three 6th field watersheds, which are within the area covered by the Siuslaw Watershed Council. Nonetheless, the exclusion of the Mercer, Berry and Dahlin 6th field watersheds from maps does not mean they were excluded from analyses, and their inclusion may have slightly affected rankings of other 6th field watersheds.

5.1.1 Cities and landscape features

Cities, major rivers, boundaries of 5th and 6th field watersheds, lakes and reservoirs, and report sections (major basins) are shown in **Figure SET-1**. Detailed maps of each basin also show major roads and stream names. These figures, like other basin-specific maps, are named according to the major basin. For example, **Figure SET-2AL** depicts the **AL**sea basin, **Figure SET-2OT** depicts the **O**cean **T**ributaries basin, **Figure SET-2SA** depicts the Salmon basin**, Figure SET-2SI** depicts the Siletz Basin, **Figure SET-2YA** depicts the Yachats Basin, and **Figure SET-2YQ** depicts the Yaquina Basin. Watershed codes are shown in separate figures for each major basin (**SET-3AL, SET-3OT**, etc.). These figures can be printed or copied on transparencies and used as overlays, to help interpret other individual basin maps.

5.1.2 The human population

People value and use different resources from MidCoast watersheds. It is becoming increasingly more difficult to accommodate the variety of uses of the MidCoast's natural resources. The study area lies within five counties. There are at least nine cities located within or near the study area. **Table 5.1** summarizes human population change in the study area from 1990-1998 (the 2000 census information was not yet available).

Data obtained from the Center For Population Research & Census *(http://www.upa.pdx.edu/CPRC/*) indicate that there has been a 7.6 to 16.7 percent increase in the populations of the five counties in the study area. The two predominantly coastal counties (Lincoln and Tillamook) have experienced about a 10% population increase. The MidCoast's coastal cities have grown faster than the state in general (13.4% for the same period) and faster than many of Oregon's other cities (Corvallis, 9.8%; Portland, 13.9%; Salem, 14.9%).

Table 5.1. Population change, 1990-1998

City	**1990 Population**	**1998 Population**	**% Change**
Depoe Bay*	870	1,100	20.9%
Lincoln City*	5,903	6,855	13.9%
Newport*	8,437	10,240	17.6%
Siletz	992	1,200	17.3%
Toledo	3,174	3,590	11.6%
Waldport*	1,595	1,845	13.6%
Yachats*	533	685	22.2%
County			
Benton	70,811	76,600	7.6%
Lincoln	38,889	43,200	10.0%
Lane	282,912	313,000	9.6%
Polk	49,541	59,500	16.7%
Tillamook	21,570	24,000	10.1%

*= coastal community

5.1.3 Sixth field watersheds

Watersheds come in all shapes and sizes. Regardless of size, all watersheds define drainages. That is, precipitation falling anywhere within a watershed must eventually flow into a stream or river. The stream or river leaves the watershed at a specific point. Watersheds of different sizes are nested within one another. Large watersheds, such as the one that drains the Columbia River Basin, are made up of smaller watersheds, such as the Willamette River Basin. Ridge tops delineate watersheds. In order to facilitate comparison among watersheds, larger watersheds have been identified and delineated by governmental agencies (e.g., US Geologic Survey). These watersheds are designated by unique identifier numbers called Hydrologic Unit Codes (HUC).

Frequently watersheds are referred to as 5th field or 6th field watersheds. The terms “fifth” and “sixth” field refer to the size of watersheds, with fifth field being the larger of the two. Fifth field watersheds, the size of watershed for which the OWEB manual was developed (Watershed Professionals Network 1999), range in size from 40,000 to 120,000 acres and average about 60,000 acres (24,300 ha). Fourth field watersheds include several fifth field watersheds; there are two 4th field HUCs that drain the MidCoast study area, 17100204 (Siletz-Yaquina) and 17100205 (Alsea).

Watersheds are convenient ecological units because they represent bounded areas that share similar properties like flora and fauna, climatic patterns, and disturbance regimes (see Appendix B: Ecological Processes). At the time that this assessment was performed, there were several slightly different versions of 6th field watershed GIS coverages for Oregon. In agreement with the MidCoast Tech Team, we agreed to use the 6th field coverage that was supplied to us on the MCWC CD-ROM as our unit of comparison and prioritization. These 6th field watersheds are shown in all figures, and the identifying codes used in all analyses are shown in **Figures SET-3AL** through **SET-3YQ**.

5.2 Hydrology (streams, lakes and rivers)

The primary goal of the watershed assessment is to rank 6th field watersheds so that actions can be planned “for protecting and improving fish habitat and water quality” (Watershed Professionals Network 1999). Of course, in order to determine what factors affect in-stream fish habitat and water quality, you must know where the streams are. Geographic information systems (GIS) are powerful tools for visualizing the spatial relationship between watershed components such as streams and streamside vegetation. However, consideration must be given to the nature of the data that go into any GIS mapping project or analysis. Spatial scale is only one of the factors that must be weighed when interpreting GIS output (Garono 1999).

5.2.1 1:100 K streams

We obtained the 1:100,000 streams^M layer (**mc_rivs**) from the MidCoast Watershed Council (MCWC) CD-ROM. This data layer is of uniform spatial scale and covers the entire study area; however, it is at a spatial scale that is inappropriate for this watershed assessment (i.e., it is not at 1:24K). We are providing this summary for comparison with the other available streams layers, 1:24,000 USGS Streams, USFS Densified Streams^W, and DEM-Derived Streams.

There are 3,016.9 km (1,874.6 mi) of streams mapped in the 1:100 K streams layer for the study area. Using this figure, we calculated that the stream density for the entire region (3,016.9 km / 375,341.0 ha) is equal to 0.008 km of stream per ha (1.29 mi/ mi^2).

5.2.2 1:24 K DLG streams

The ideal stream data layer for this analysis is the 1:24 K US Geological Survey (USGS) streams layer developed from the 7.5 minute USGS topographic maps (**USGSstreams.zip**, shapefile name **clip_usgshydro.shp**). Field crews commonly use USGS topographic maps as base maps and it is useful to present data at the same spatial scale at which the data were originally mapped. However, the USGS GIS streams coverages were not available for the entire study area. We did, however, acquire a partial coverage of these data layers where they were available (772 mi^2, 199,947 ha, or roughly 53% of the study area). There are 3,439.7 km of streams mapped on the 1:24 K DLG streams layer; this is slightly more than was mapped for the entire study area at 1:100K. Therefore, one would expect the level of detail to be about double that shown on the 1:100 K streams layer. As with the 1:100 K streams layer, stream density can be calculated, at least for those areas that have coverage. We calculated that the overall stream density was 3,439.7 km / 199,947 ha = 0.02 km stream per ha (2.77 mi/mi^2). This is about twice the density of the 1:100 K streams layer. Knowledge of map scale of data is important when interpreting or evaluating any sort of summary.

5.2.3 USFS Densified Streams Layer

In 1999-2000, a joint effort of USFS, BLM and other agencies produced a new streams layer, which covers the entire study area. This “densified streams layer” (available from Diane Rainsford, Siuslaw National Forest, Corvallis, OR) provides a high level of detail, including many small headwaters tributaries and intermittent channels that are not found in other streams layers. The total length of streams in the densified layer is about 15,241 km, over 4 times the length of the 1:100K streams layer. The densified layer is at a scale of 1:24 K or better (it is a mixed spatial scale data layer) and provides a level of detail that will be very useful for Basin Planning Teams and field crews.

During the analysis phase of this assessment, we were unable to use the USFS densified layer for many of our analyses because it did not yet have gradient and confinement attributes for most of the study area. Also, the USFS densified layer incorporated data created by different agencies (e.g., BLM and USFS) using somewhat different methods for their respective areas. Agency staff report that analysis of these different areas did not show major inconsistencies (Diane Rainsford, personal communication), but inconsistent methodologies can create problems for analytical use of such data in GIS. Perhaps more importantly, we were interested in defining gradient and confinement at a finer resolution than the reaches for which these characteristics are defined in the densified streams layer (reaches in that layer average about 200m in length). Therefore, we derived a streams layer for the study area from the 10m DEMs (Digital Elevation Model) (see **DEM-derived streams** below).

After completion of the analysis phase of this assessment, the gradient and confinement data in the USFS densified streams layer were completed for the study area. However, during the assessment we had access to gradient and confinement data for only a portion of the study area. The gradient and confinement data in the densified layer that were available during our analysis were used to compare with our derived stream gradient and stream confinement descriptions in lieu of spatially explicit field observations.

5.2.4 DEM-derived streams

This watershed assessment was conducted at a 1:24 K spatial scale using existing GIS data wherever possible. From the proceeding section, we recognize that the not only is spatial scale important, but it is also important that the data be of uniform scale. Since a goal of this watershed assessment is to prioritize 6th field watersheds, it is best to have uniform datasets that extend across the entire study area so that valid comparisons can be made. In this way, differences observed are known to be a result of the variable of interest and not the way in which the variable was measured or recorded.

Although we acquired a 1:24 K streams layer based on the USGS topographic maps (the USGS DLGs), that layer did not cover the entire study area. Until recently, a digital streams layer did not exist for the study area that was at an appropriate spatial scale. As discussed above, the densified streams layer containing important information on stream channel confinement, stream gradient and fish distribution has been developed by USFS (Siuslaw National Forest) in cooperation with BLM. This layer is at a scale of 1:24 K or better and provides a level of detail that will be very useful for Basin Planning Teams and field crews. However, the USFS densified layer could not be used for many of our analyses because at the time of our analysis it lacked important gradient and confinement data (see **USFS Densified Streams Layer** above).

With input from the MCWC Tech Team, we used an ARCView extension (*txdo0409.apr*) developed by David Maidment's group at the University of Texas (Austin) to develop a uniform scale stream layer from the 10 m digital elevation models (dem-derived-streams). The ARCView extension is available on the WWRI web site (*http://www.ce.utexas.edu/prof maidment/*) or on the Hydro98 CD-ROM (available from Environmental Systems Research Institute, Inc. (ESRI)).

When developing a new streams layer from the DEMs, the user must define the level of detail for the new streams layer. We were interested in approximating the 1:24 K streams layer for the entire study area. Therefore, we used an iterative process to develop several stream layers. Then we compared our DEM-derived streams with portions of the study area for which we had a 1:24K streams layer (a detailed description of this process is given in Appendix A: Supplemental methods). We selected a DEM-derived streams layer that most resembled the existing 1:24K streams layer. As it turned out, a Stream Initiation Threshold of 1,400 cells (about 34 acres) produced a stream layer that best approximated the USGS 1:24K stream network (**derivedstreams.zip**; shapefile name **st1400-c.shp**). This stream initiation threshold, the area necessary to produce a stream or drainage channel, resulted in a 6,293.8 km (3,910.8 mi) long stream network for the entire study area.

The overall stream density for the study area is 6,293.8 km / 375,341.0 ha = 0.017 km stream ha^{-1} (2.7 mi stream mi^{-2}). This value for overall stream density is very close to what we calculated using the partial coverage of 1:24 K USGS streams layer. On a 6th field by 6th field basis, stream densities ranged from a high of 0.044 km stream ha^{-1} to 0.008 km stream ha^{-1}. Most of the 6th field watersheds (n=173) had stream densities between 0.02 and 0.025 km stream ha^{-1} (**Figure SET- 9**).

5.3 Roads

Knowledge of the type and location of roads is important for a watershed assessment. For example, roads located in floodplains and roads that cross streams can directly affect hydrologic patterns by constraining stream channels. Indirectly, road building replaces permeable soils with impervious surface so that instead of slowly infiltrating soils, water runs along road surfaces and enters the stream network over a short period of time. In extreme cases, roads have actually functioned as extensions of the stream network during storm events (Wemple 1994). The Watershed Assessment Manual (Watershed Professionals Network 1999) suggests that when impervious surfaces of roads cover 4 to 8% of a watershed's area, there is a moderate to high risk of alteration to hydrologic peak flows. Of course, as water moves over a road surface it can transport pollutants and sediments to the stream network. A study by an independent group of scientists reported that roads could be a chronic source of sediments to streams (Independent Multidisciplinary Science Team 1999).

In order to determine the risk of sediment (and pollutant) delivery and stream channel constraint that roads pose to each watershed, it is necessary to map and categorize roads throughout the basin. This would include classification of roads into paved and unpaved categories, and determination of road width. If road densities were to be calculated, a uniform-scale map of roads is necessary. Although detailed roads information was not available for the entire MidCoast study area, we used available information to calculate road densities.

5.3.1 1:100K roads

A uniform-scale roads data layer was provided on the MCWC CD-ROM (**minrds6**^{M}). This layer was clipped to the boundaries of the study area using ARCView. There are 4,865.5 km (3,023.3 mi) of roads mapped in the study area. The road density for the entire study area, using this layer, is 0.013 km of roads per ha.

Although the 100K roads data layer was of uniform spatial scale and covered the entire study area, it was not at an appropriate scale for this study. In addition, it does not contain many smaller roads and therefore underestimates the total length of roads in the study area. Therefore, a better roads coverage is needed for the study area.

5.3.2 USGS DLGs

We obtained the 1:24,000 roads layer from the USGS Website (**usgs_24K_roads.zip**, shapefile name **cl_mcwc_roads.shp**). This was the appropriate scale for our analysis. Unfortunately, the data were only available for 772 mi^2 (approximately 53% of the study area). There were, however, 4,451.5 km (2,766.0 mi) of roads mapped for this area. This is almost equal to the length of roads in the 100K layer mapped for the whole study area! Considering only the area covered by the USGS roads coverage, and again assuming a average road width of 35 ft, the area of the watershed occupied by road surface is 2,766 mi X 0.0066 mi = 18.3 mi^2. Then assuming that the roads coverage was similar, at this spatial scale, for the rest of the watershed, there would be approximately 36 mi^2 of road surface pavement in the entire study area. This works out to be 36 mi^2 / 1,449.2 mi^2 = 0.025 or about 2.5 percent, still well below the 4-8% threshold described above.

Incidentally, the road density (km of roads per ha) worked out to be 0.025 km of roads per ha, or almost double that calculated from the 100K roads layer.

If the 1:100K roads layer is probably missing about half of the roads found in the 1:24K DLGs, an interesting question is what proportion of the "actual" roads are captured in the 1:24K DLGs. A brief analysis of a few watersheds in the Rock Creek (Siletz) drainage indicated that the 1:24K DLGs may also be missing a high percentage (perhaps 1/3) of the roads present (Garono and Brophy 1999).

5.3.3 Siuslaw National Forest roads

The USFS has produced a 1:24K GIS roads layer for portions of the study area, mainly covering areas of USFS ownership within the Siuslaw National Forest, but also with coverage of surrounding areas. The layer is available at the Siuslaw National Forest GIS data website (*http://www.fs.fed.us/r6/siuslaw/gis_data.htm*). According to the website, this layer has line and route features. The route system calibrated and linked to a series of Oracle tables that contain additional information about the forest service system roads.

Since the Siuslaw National Forest roads layer does not cover the entire study area, we could not use it for 6th field watershed rankings, such as analyses of road density, road-stream intersections, or other related analyses. However, the layer may be useful for future analyses within specific areas of interest.

5.3.4 BLM Roads

In fall 2000, after the completion of the analysis phase of this assessment, a new roads layer became available from the Bureau of Land Management. This layer is available at the BLM Ground Transportation Project website at *http://www.or.blm.gov/gis/projects/gtrn_project.htm.* The BLM roads layer covers the entire study area. According to the project website, the spatial data was captured at a scale of 1:24,000 or larger, and originates from "a variety of data sources." Spatial line sources for the Oregon data included "1:4,800 captured roads on BLM land in western Oregon, digital line graph (DLG) data from the US Geological Survey, cartographic feature files from the US Forest Service, and updated coverages from some individual National Forests."

The BLM roads layer was received too late for this assessment. However, we did review the layer when it became available, and can comment on potential uses of this layer. The scale is very good in some areas (i.e., many small roads are shown, even some trails on BLM land) and there is much less detail in other areas. This inconsistent scale is the result of the variety of data sources used to create the layer. Because of the inconsistent scale, the BLM roads layer will be suitable for certain kinds of tasks but not suitable for some kinds of analysis.

For instance, comparison of road densities across 6th field watersheds is a type of analysis that requires consistent scale data. Since scale in the new BLM roads layer varies depending on land ownership, this layer wouldn't be suitable for 6th field prioritization based on road density. On the other hand, the BLM layer will be very useful for the next phase of Action Planning, because it contains data from three previously separate sources: BLM, Siuslaw National Forest, and DLGs. For example, a local watershed group could use the BLM layer to determine where roads may confine stream channels, where roads are found on high slopes, and where roads intersect streams (likely culvert locations).

5.3.5 Extrapolated road frequency

All of the roads layers mentioned so far were supplied as GIS data layers. These data layers are computer representations of where the roads are thought to be in the watershed. We recognize that many roads, including many of the logging roads, are not represented in the available data layers. We were interested to learn how well the existing roads coverages represented actual roads in the watershed. Of course, the best way to do this would be to survey all the roads in the watershed. Since this was beyond the scope of this assessment, we discussed some possible approaches with the MCWC Tech Team and decided to do a pilot study using interpretation of the digital orthophotos (DOQs) available for the watershed. If course, it was assumed that we could see and correctly identify all the roads from the DOQ, and that the roads had not changed since the photographs were taken.

The method we developed, in discussion with the Tech Team, was to sample a large number of random locations (“cells”) within the study area (using the DOQs) to determine what proportion of these sampled cells had roads. We would then extrapolate from this sampling to gain some perspective on road frequency (presence/absence) within the study area.

Initially, we created a grid that uniquely identified each hectare in the study area. There were 375,000 hectares in the study area. We then randomly selected approximately 1% of all hectares (about 3,750 cells) and overlaid the grid on the DOQs in ARCView. We also overlaid the 1:24K streams and any available roads layers to help us correctly identify roads on the DOQs. Next, we visually examined the photographs in ARCView to see if there were roads present within the randomly selected grid cells. We avoided areas for which we did not have DOQs. **This resulted in road frequency (number of ha with roads present) rather than road densities.** For comparison, we used the same grid to sample the 100K and 24K roads layers so that results could be directly compared. The results below show the average road frequency for the entire study area, based on this random sampling of the DOQs, USGS DLGs, and the 100K layer.

Table 5.2. Comparison of road frequency and road density data.

Source	**Road Frequency (No. of ha with roads present)**	**Road Density (km / ha)**
DOQ	56.4%	NA
1:24 K USGS	32.7%	0.025
1:100 K MCWC	17.4%	0.013

These results suggest that the 1:100 K roads layer underestimates the "actual" number of roads by 3.2 times and that the 1:24 K roads layer underestimates roads by 1.7 times. These results also demonstrate that road densities are a function of the scale of the data that go into their calculation. Therefore, before road density values can be interpreted or compared, one must know the scale of the data used to derive them.

Our discussions with the MCWC Tech Team also directed us to investigate the relationship between road frequency and land ownership class. For this analysis, we used the road sample grid described above and the ownership (**own_osu**^{M}) layers. Ownership class (see **Land Ownership** below) was used as the identifying variable from this layer. ARCView was used to 'Select by Theme' those cells from the sample grid that were completely contained within the ownership class of interest. This resulted in all grid cells being selected for an individual ownership class. The 'query' tool in the Table view of ARCView was used to select grid cells with a value of 'y" (roads present) from the already selected set. This resulted in the number of grid cells within a single ownership category that had roads. This number was expressed as a percentage of the total number of grid cells. The percentage of hectares containing roads for each ownership class was then multiplied by the area occupied by that ownership class in each of the 6th field watershed to give an area-weighted road frequency. Area-weighted road frequencies were then summed for each 6th field (**Table 5.3**).

Table 5.3. Road frequency by land ownership class

Ownership class	**No. Observations**	**Road Frequency (% of Ha with Roads)**
USFS	850	56.4%
BLM	220	55.0%
PNI (private non-industrial)	492	60.6%
PI (private industrial)	1094	48.0%
State	114	57.0%
Misc	too few	N/A

Results from this analysis indicate that Private Industrial (PI) timberlands have the lowest road frequency and Private Non-industrial (PNI) lands have the highest. **Caution should be exercised in interpreting these results**, because only 1% of the study area was sampled, and urban areas were not excluded from the analysis (most urban areas are classed as "private non-industrial"). Other factors besides the actual presence or absence of roads may also have affected the results shown in Table 5.3. For example, differences between ownership classes in factors like the visibility of roads (e.g., the proportion of roads obscured by vegetation) could result in unexpected results. However, this analysis was not intended to be a definitive study, but simply to test a methodology and report the actual results. Further tests of this methodology could produce different results, and further tests are recommended. We recommend this analysis be extended to include more sampled areas, and to exclude urban areas.

We used the average road frequency for each ownership class to calculate an extrapolated road frequency for each 6th field watershed (**Figure SET-13**). The extrapolated road frequency is calculated by weighting the road frequency data by ownership class to reflect the areal proportion of each ownership class within each 6th field. We found that the ownership-weighted road frequencies calculated for each 6th field watershed ranged from 38.5 % ha with roads to 60.6 % ha with roads (average was 49.9 % ha with roads). This means that, on the average, half of hectares of any given watershed contain a road. Most of the 6th field watersheds belonged to this category. Sixth field watersheds with high area-weighted, extrapolated road frequencies were found in the Siletz and Alsea River basins, especially along the western portions of the study area (**Figure SET-13**).

5.3.6 Roadless areas

The Regional Ecosystems Office, an organization that facilitates cooperation between local, state and federal agencies in support of the President's Forest Plan for the Pacific Northwest, provides a GIS coverage showing Roadless Areas at *http://www.reo.gov/reo/data/reodata.htm*. However, the only roadless areas shown in this coverage are those that were inventoried during the Roadless Area Review and Evaluation (RARE II), conducted prior to 1993 (FEMAT 1993). The RARE II inventoried roadless areas are located within the Drift Creek (Alsea) 5th field watershed, in the Drift, Trout, Lyndon, Boulder, and Cougar Creek 6th field watersheds.

Other roadless areas exist within the study area. The 1993 FEMAT report ((FEMAT 1993) states that there are over 3 million acres of inventoried roadless areas in the range of the Northern Spotted Owl (which includes western Oregon and Washington, as well as northwestern California). Of these, over half are within identified Key Watersheds (see **Key Watersheds** below).

Other roadless areas besides the inventoried ones may also exist within the study area. The number of roadless areas present will depend on how roadless areas are defined. Until a detailed, consistent and comprehensive roads coverage is available, it will be difficult to determine whether a particular area has roads, except by analysis of aerial photographs. Use of aerial photos to determine road presence/absence requires development of a consistent protocol. For example, the protocol must address the question of whether or not to include logging roads in the definition of roads.

The Siuslaw National Forest website (*http://www.fs.fed.us/r6/siuslaw/gis_data.htm*) does not specifically list roadless areas. However, the SNF website does list special Management Areas designated in the Siuslaw National Forest Plan. The Management Areas which intersect the MidCoast study area are shown in **Table 5.4** below. These Management Areas include several prominent wilderness areas within the study area such as the Drift Creek Wilderness, Rock Creek Wilderness (Ocean Tributaries Basin), Cummins Creek Wilderness.

Table 5.4. Siuslaw National Forest Plan Management Areas

Management Area name	Designation	Area (ha)
CUMMINS CREEK WILDERNESS	Congressionally Reserved	3,678
ROCK CREEK WILDERNESS	Congressionally Reserved	2,969
CASCADE HEAD SRA*	Congressionally Reserved	2,912
CUMMINS_GWYNN CREEKS RNA	Administratively withdrawn	2,636
CHEF*	Administratively withdrawn	2,466
DRIFT CREEK WILDERNESS	Congressionally Reserved	2,342
CAPE PERPETUA SIA	Administratively withdrawn	1,029
DRIFT CREEK ADJACENT	Administratively withdrawn	698
MARYS PEAK SIA	Administratively withdrawn	341
FLYNN CREEK RNA	Administratively withdrawn	266
BUTTERFLY	Administratively withdrawn	101
ROCK CREEK EAGLE	Administratively withdrawn	50
HEBO DRIFT CREEK EAGLE	Administratively withdrawn	45
LOWER ALSEA EAGLE	Administratively withdrawn	42
DRIFT CREEK EAGLE	Administratively withdrawn	39
GRANT CREEK EAGLE	Administratively withdrawn	29
BIG CREEK EAGLE	Administratively withdrawn	27

* Management Area extends outside MidCoast study area

5.4 Land cover

Land cover generally refers to the type of vegetation occupying a particular area within a watershed. Land cover is an important ecological characteristic to consider in a watershed assessment, because land cover affects watershed characteristics like potential for large wood delivery to a stream network, erosion or landslide potential, wildlife habitat potential, susceptibility to rain-on-snow events, and riparian shade.

Land cover data can be captured in many ways. For example, on a plot-by-plot basis field teams could survey the dominant vegetation type, record plant density and then attribute those characteristics to a particular plot along a stream reach. This is often the approach taken in forest stand surveys. Other land cover data are collected by agricultural resource agencies that track crops planted on a field-by-field basis. For the MidCoast Watershed Assessment, we were interested in not only forest or cropped areas, but all of the vegetation types found within the entire study area. An ideal way to capture this sort of information is through remote sensing. Remote sensing involves collecting data, such as a photograph or a more sophisticated digital image, from either an airplane or a satellite. In either case, the photograph or imagery must be interpreted and ground-checked to assess its accuracy. The advantage of this sort of approach is that a computer representation of the vegetation covering the entire study area can be produced and brought into a GIS for analysis.

There were two sources of land cover data readily available for our study, the digital orthoquads^{M} (DOQs) and the CLAMS^{W} landcover data. Since the CLAMS data were in a format that could be readily analyzed, we selected that data set for our vegetation base layer. The DOQs were used in several analyses as an ancillary data set to double check our results. MidCoast DOQs are available on multiple CDs at the MCWC office (see **Digital orthophoto quads** below).

5.4.1 CLAMS95 analysis

Coastal Landscape Modeling and Analysis Study (CLAMS: *http://www.fsl.orst.edu/clams/*) is a multi-disciplinary research effort sponsored cooperatively through Oregon State University (College of Forestry), the US Forest Service's Pacific Northwest Research Station, and the Oregon Department of Forestry. As a part of their project, researchers at CLAMS developed a land cover data layer, based on satellite imagery, for the entire Coast Range of Oregon. The initial satellite imagery was acquired in 1988 and classified into 14 categories to produce a GIS layer of land cover. This layer was updated in 1995 by re-classifying the 1988 to account for succession and changes due to timber harvest and other disturbances. The 1995 data layer was not created through classification of new imagery. For more information see the CLAMS web site.

5.4.2 Entire watershed

Fourteen land cover classes (CLAMS95^{W}) were determined by researchers at CLAMS based on their interpretation of satellite scenes and their knowledge of successional patterns in the MidCoast Region study area (**Table 5.5, Figure SET-10**). We used ARCView to generate a summary of the already classified land cover classes by 6th field watershed. Results indicated that broadleaf trees dominate, covering about 16.7% of the total MidCoast study area. The large and very large conifer classes cover less than 10% of the study area. Vegetation classes dominated by broadleaf trees, but containing some large and small conifers, cover over a third of the area, suggesting that there is a strong potential for regeneration of large conifers. About 40% of the study area is covered with smaller (and presumably younger) forest classes including both mixed and pure conifer types.

We used the presence of large conifers to rank 6th field watersheds. In order to find the locations of large conifers in the watershed, we used the “very large conifer” cover class from the CLAMS95^{W} layer. We found that a few of the 6th field watersheds in the southern portion of the study area have between 2 and 5 percent of their area classified as very large conifers (**Figure SET-11**). However, most of the 6th field watersheds in the study area have well under 1 percent of their area classified as very large conifers.

When the CLAMS classes “large conifer” and “very large conifer” are combined, the results are more encouraging. Many of the watersheds in the southern part of the study area have between 14 and 37 percent of their area classified as large or very large conifers. Several of the watersheds had between 24 and 36 percent of their area occupied by these two cover classes.

When using these results, it’s important to remember that the land cover classes depicted in the CLAMS95^{W} data layer are more than five years old and conditions within the watershed probably have changed during the past few years. We recommend that a current land cover data set be obtained for the MidCoast Region.

Sixth field watersheds with significant proportions of large conifers may have well-shaded riparian areas, and could potentially be good areas for large woody debris recruitment to streams.

Table 5.5. Twelve categories of land cover, and total area and relative proportion occupied by each category, for the MidCoast study area.

Class No.	Cover Class	Description	Area Covered (ha)	% of Total Study Area
1	Shadow	Background (portions of the data file that do not contain image information)	910	0.24
3	Open	Open (0-40% vegetation cover)	16,000	4.28
4	Semi-Closed	Semi-Closed (41-70% vegetation cover)	39,900	10.71
6	Broadleaf	Broadleaf (>=70% broadleaf cover)	61,900	16.69
7	Mixed, Small Conifers	Mixed broadleaf/conifer: <70% broadleaf cover, small conifers (<=25cm DBH)	44,500	11.94
8	Mixed, Medium Conifers	Mixed: <70% broadleaf cover, medium conifers (26-50cm DBH)	24,200	6.48
9	Mixed, Large Conifers	Mixed:<70% broadleaf cover, large conifers (51-75cm DBH)	51,000	13.68
10	Mixed, Very Large Conifers	Mixed:<70% broadleaf cover, very large conifers (>75cm DBH)	17,200	4.61

Table 5.5. Twelve categories of land cover, and total area and relative proportion occupied by each category, for the MidCoast study area.

Class No.	Cover Class	Description	Area Covered (ha)	% of Total Study Area
11	Conifer, Small	Conifer: >70% conifer cover; conifers small (<=25cm DBH)	41,600	11.16
12	Conifer, Medium	Conifer: >70% conifer cover; conifers medium (26-50cm DBH)	39,500	10.59
13	Conifer, Large	Conifer: >70% conifer cover; conifers large (51-75cm DBH)	31,200	8.38
14	Conifer, Very Large	Conifer: >70% conifer cover; conifers very large (>75cm DBH)	3,149	0.84

5.4.3 Riparian areas

Riparian vegetation serves several important watershed functions. Riparian vegetation can provide shade to keep stream temperatures cool, can reduce rates of erosion and help to stabilize stream banks, and can provide large woody debris to the stream channel. Riparian vegetation is inventoried by resource agency survey teams, and this information appears in aquatic habitat inventory data. However, aquatic habitat inventory data are limited in coverage and generated differently when compared to remotely sensed data such as the CLAMS95^{W} data. On the other hand, remotely sensed data also have their limitations, particularly in terms of the resolution and spatial accuracy of the data. Our interaction with the MCWC Technical Team indicated that for this assessment, we should use percent shade from ODFW aquatic habitat surveys as one component of the riparian cover assessment and for multi-factor analyses. Furthermore, we were instructed to use the CLAMS95 data for an overview of the type of vegetation that occurs along stream corridors in the study area but not in multi-factor analyses.

For the CLAMS95 analysis of riparian vegetation, we first created a 100 ft buffer (100 ft on each side of the stream) around the DEM-derived streams. We then used ARCView to clip the vegetation from the CLAMS95 data layer using this buffer. Since the pixels in the CLAMS95 layer were 25 m on a side, we generally captured 3 pixels or so on either side of the stream channel. This is the minimum size of a buffer that can be used with the CLAMS95 layer.

We found that the buffered stream corridor contained 142.1 mi^2 of land cover, or approximately 10 percent of the study area. Another way to think of this is that about 10 percent of the watershed is within 100 ft of a stream. Evaluation of the stream corridor vegetation depends on what you're interested in. For example, conifers and deciduous trees will both provide shade to help keep stream temperatures cool, and even an unmowed field can slow down soil erosion. However, large woody debris derived from conifer trees is generally considered to have the best characteristics for stream habitat and stream structure. Therefore, watershed assessments are generally concerned with the presence of large conifers in riparian areas. As was the case with the land cover for the entire study area, we found that the broadleaf cover class was also the most common in the stream corridors and the very large conifer class ranked among the least common (**Table 5.6**). Some of the mixed cover classes (i.e., conifer and deciduous) ranked among the highest, suggesting that there may be potential for the regeneration of large conifers in the stream corridors.

Table 5.6. Ranked list of vegetation cover classes for vegetation within 100 ft of a stream. Rank 1 has largest area, Rank 12 has smallest area.

Class	Cover Type	Rank
6	Broadleaf	1
9	Mixed, Large Conifers	2
7	Mixed, Small Conifers	3
4	Semi-Closed	4
8	Mixed, Medium Conifers	5
10	Mixed, Very Large Conifers	6
11	Conifer, Small	7
13	Conifer, Large	8
12	Conifer, Medium	9
3	Open	10
14	Conifer, Very Large	11
1	Shadow	12

We mapped the proportion of each 6th field watershed's riparian areas that have cover consisting of large or very large conifers (**Figure SET-12**).

5.5 Elevation (DEMS)

We obtained provisional 10m digital elevation model[W] (DEM) data from CLAMS researchers at the Oregon State University. Digital elevation models, a GIS data layer, depict the elevation within a 10 X 10 m GRID that covers the entire study area. We used these data to derive a stream network, stream gradients, and stream confinement. In addition, elevation data were used in the Rain-on-Snow and Channel Typing summaries. Digital elevation models are a very important data source and at the time of this analysis, only provisional data were available.

5.5.1 DEM processing steps

We obtained provisional DEMs individually for each 7.5 min USGS topographic quadrangle in the study area. The DEMs were combined (a process called mosaicking) into one large GIS layer that covered the entire study area before we could use them. We mosaicked the DEMS using the ERDAS Imagine software program. During mosaicking, we matched up the edges of the individual DEM files so that elevations matched between files. Final versions of the 10 m DEMs have become available since data acquisition for this assessment was completed; therefore, we recommend that the new DEMS be acquired as soon as possible.

5.6 Digital orthophoto quads

Digital orthophoto quads^{M} (DOQ) are available in the MCWC office on a series of CD-ROMs. Digital orthoquads are black and white aerial photographs, taken in the mid 1990s, which have been corrected for the horizontal displacement that occurs when using aerial photography in a GIS and have been spatially referenced. The DOQs are an excellent information source and we used them extensively for this assessment (see roads assessment). The DOQs are updated every few years by the government. Because the data are spatially referenced photographs, the DOQs give a bird's eye view of most of the study area, as it looked in the mid 1990's, and they can be called up in ARCView and used as a base map. One limitation of the DOQs is that they must be (photo) interpreted to glean information on important watershed features. That is, a GIS specialist must scroll through the photo using GIS and delineate features of interest (i.e., roads, streams, forest stands, etc.). This can be a very time consuming process and, depending on the features of interest, there may be better ways to capture this information in GIS. We recommend that the MCWC continue to update their DOQs as they become available.

5.6.1 USGS DOQs

We acquired Digital Orthoquads^{M} (DOQs) with 1 m spatial resolution from the MidCoast Watersheds Council on 5 CDs. Coverage on these 5 CDs is not complete for the study area; missing quads are Lincoln City (including Siletz Bay), Warnicke Creek, Laurel Mountain, Depoe Bay, Valsetz, Fanno Ridge, Newport North, Toledo North, Eddyville, Nortons, Summit, Glenbrook, Horton, and Triangle Lake. Earth Design Consultants, Inc. and Gree Point Consulting filled some of the gaps by acquiring USGS digital quarter-quads (also at 1 m spatial resolution) for the Rock Creek Watershed Assessment (Garono and Brophy 1999b), including all four quarter-quads for Eddyville, Nortons, Valsetz and Summit. Three out of four quarter-quads are available from USGS for Depoe Bay (NW, SE), and all four quarter-quads are available for Glenbrook. However, USGS quarter-quads are not available for any of the other quads missing from the MCWC DOQ CDs.

5.6.2 SNF DOQs

We reviewed a set of DOQs^{W} acquired from the Siuslaw National Forest. Coverage included USGS quadrangles with some Siuslaw NF ownership. Spatial resolution was 4 m, less than the DOQs supplied by MCWC, so the Siuslaw National Forest DOQs were not used in the current assessment.

5.7 Lithology

Many watershed processes are influenced by bedrock lithology. The geologic formations that underlie each watershed determine how groundwater moves (therefore, temperature); how stream channels form; how soils form, weather, and erode; and many other watershed characteristics that directly and indirectly influence salmonid habitat.

The MCWC GIS contained a layer showing bedrock lithology for the MidCoast area (**geo62500^{M}**). We used ARCView to intersect this layer with the 6th fields layer, and analyzed for igneous *versus* sedimentary formations, to create the lithology layer for this assessment, **geo62500_m6.shp**. The layer is derived from USGS maps and shows 39 separate geologic formations within the study area. Using the metadata provided with the original layer, we divided the 39 formations into three main groups: 1) igneous formations; 2) sedimentary formations; and 3) quaternary alluvial and colluvial deposits.

Igneous formations in the MidCoast are predominantly basalts. The bulk of these (Heceta Head to Cape Perpetua and Yachats, and inland to Klikitat Ridge and north to Eckman Creek; and on Cape Foulweather, the Siletz Volcanics, and Cascade Head) are former volcanic islands accreted onto the edge of the continent. Yaqina Head and Seal Rock are much younger basalt, spilled over from the Columbia Plateau basalt flows. Most of the basalt appears in flows, but some is in breccias (re-cemented piles of broken rock). Table Mountain (Alsea Basin) is nepheline syenite, a rare intrusive igneous rock (Wayne Hoffman, personal communication).

Sedimentary formations are predominantly sandstones, siltstones, and mudstones, which often formed under the ocean during the Miocene and Oligocene and later became exposed on land due to continental uplift. Quaternary formations were deposited during the Pleistocene and Holocene epochs -- more recently, geologically speaking, than the igneous and sedimentary formations. Quaternary deposits are quite limited in area compared to the igneous and sedimentary formations. These deposits were laid down by water or earth movement in river valleys, estuaries, beaches and areas of ancient landslide activity.

5.7.1 Results: Study area summary

The **geo62500_m6** layer maps geologic formations over about 99 percent of the study area (371,800 ha out of 375,337 total ha). We summarized area of each type of formation within the six major basins (**Table 5.7**). Sedimentary formations occupy the largest area (252,107 ha or about 67%). About a quarter of the study area is occupied by igneous formations and the remaining 8 percent consisting of quaternary formations. The Yaquina Basin has the highest percent area in sedimentary formations (93%), while the Alsea Basin is close behind (82%) and has the largest absolute area of sedimentary formations (98,704 ha or about 381 sq mi). The Siletz Basin has the highest absolute area of igneous formations (36,786 ha or about 142 sq mi), but the Salmon River Basin has the highest percent area of igneous formations (about 43%). The Ocean Tributaries basins have the highest area and proportion of Quaternary formations (11,139 ha or about 43 sq mi).

Table 5.7. General lithology of MidCoast study area

	Area and percent of total area, by formation type						
Major basin	**Sedimentary**		**Igneous**		**Quaternary**		
	ha	**%**	**ha**	**%**	**ha**	**%**	**Total ha**
Alsea	98,704	81.6	17,696	14.6	4,594	3.8	120,993
Ocean Tribs	25,767	41.8	24,704	40.1	11,139	18.1	61,610
Salmon	10,112	52.3	8,282	42.9	927	4.8	19,321
Siletz	49,812	52.5	36,786	38.8	8,292	8.7	94,890
Yachats	8,141	72.5	2,621	23.3	471	4.2	11,232
Yaquina	59,572	93.4	443	0.7	3,739	5.9	63,753
Grand Total	**252,107**	**67.8**	**90,531**	**24.4**	**29,162**	**7.8**	**371,800**

We mapped lithology by major bedrock types (sedimentary, igneous, and quaternary) for each major basin. These maps are contained in the individual basin inserts (**Figure SET-8AL, SET-8OT**, etc.).

5.7.2 Recommended uses

Information on lithology helps interpret the results of other analyses in this watershed assessment. For example, when analyzing the length of streams with gravel substrate in a watershed, it might be useful to consider the total area of igneous *versus* sedimentary formations within that watershed. Gravels, cobbles and boulders formed from igneous rock tend to be quite durable, compared to those formed from sedimentary formations, which may break down within periods of tens to hundreds of years (Siuslaw National Forest 1997). A base map of general lithology (**geo62500_m6.shp**) can help predict and interpret stream channel morphology data and predict where dramatic changes in stream morphology may occur. For example, igneous intrusions such as dikes and sills can create natural barriers to anadromous migration as headward erosion of streams is impeded (Boateng & Associates Inc. 1999). Groundwater flow in areas of quaternary formations may not follow surface features (Siuslaw National Forest 1997), which may help interpret stream water temperature measurements.

5.8 Soils

5.8.1 Hydric soils

We followed several steps to create the hydric soils summary layer. We obtained soil survey GIS coverages for all counties in the study area except Tillamook from NRCS (on the internet) and OSU Soil Science Department ftp sites (contact OSU Crop and Soil Science Department), and merged these coverages to create a single soils coverage for the entire study area (**soils_m6.zip**, shapefile name **soils_m6.shp**). We then intersected this soils layer with the 6th fields layer. We developed tables of hydric components from downloaded Map Unit Interpretations Record Tables (from NRCS and OSU). We queried the merged soils coverage for hydric components, creating a new field (**all_hydcode** in **soils_m6.shp**), with value "hyd" for hydric, and "non" for non-hydric. (Before querying the coverage, we had to edit the Map Unit Interpretations Record Tables and/or GIS attribute tables to compensate for inconsistent mapping unit names.) Finally, we summarized the total area and proportion of NRCS mapped hydric soils in each 6th field (**Figure SET-6**).

The definition of hydric soils is established by the National Technical Committee on Hydric Soils; a description of the methods and criteria for hydric soils is found on the MidCoast GIS (hydrintro.htm). Lincoln County and Polk County Soil Survey GIS coverages and Map Unit Interpretations Record Tables (tables of soil mapping unit characteristics) were obtained from the OSU Crop and Soil Science ftp site (contact OSU Crop and Soil Science Department) and the NRCS website on the internet**.**

5.8.1.1 Results: Study area summary

The proportion of 6th watershed area occupied by hydric soils ranged from 0 to 29 percent, with the average for the study area being about 4 percent (**Figure SET-6**). Major concentrations of hydric soils are found in the estuaries of the study area's major rivers (Yaquina, Siletz, Salmon and Alsea), and in the Beaver Creek (Ocean Tributary) watershed. Hydric soils are also quite extensive in the valleys of many major rivers (for example, the South Fork Siletz River, Upper Yaquina, and Drift Creek [Alsea]), and in the valleys of many other streams in the study area. Strips of hydric soil are found behind the foredune along the coast, particularly between Yachats and South Beach (for example, in the Blodgett and Vingie Creek 6th field watersheds) and between Depoe Bay and Siletz Bay (Fogarty Creek 6th field watershed). By selecting and displaying only the soil mapping units classified as hydric, we mapped hydric soils for each major basin in the individual basin inserts (**Figures SET-7AL, SET-7OT**, etc.). The area of hydric soils in each 6th field watershed was used as a part of the coho winter habitat multi-factor analysis (see **Functioning coho winter habitat** below).

5.8.2 Erodible soils

Under some circumstances, soils can move across the landscape and into the stream network where suspended sediments can dramatically affect the quality of salmonid habitat. Circumstances that foster soil erosion include any actions that remove vegetation (which acts to stabilize soils), or any actions that lead to an increased frequency of mass wasting events. Detailed information on soils provided here can be used to plan actions to minimize the effect on soils prone to erosion.

As described under **Hydric soils** above, we obtained soils information for each county in the study area, except Tillamook County, as GIS layers from and the OSU Soil Science Department. These GIS layers did not contain information on soil characteristics, but simply showed a code for the soil type (mapping unit) and a polygon showing the location of the mapped unit. There were more than 350 soil units in the study area. Like we did for the hydric soils analysis, we obtain information on soil erosion risk by downloading Map Unit Interpretations Record (MUIR) tables from the web and extracting information on soil unit susceptibility to erosion. We used ARCView to join these soil attributes to the soils coverage, using the MUID field as the join field. This produced a soils coverage (**soils_mc6.zip,** shapefile name **soils_m6.shp**) that now contains both hydric soil and erosion risk information.

We used the "Woodland Management" designation of erosion risk (**wderosn**). **Wderosn** is a field in the MUIR tables where soil erosion risks are ranked as "slight", "moderate", or "severe." This attribute rates the risk of erosion to soils under lands managed for timber production. We chose this soil attribute for our soil erosion risk analysis because the vast majority of the study area is timber production land. We used these data to develop two separate erosion risk assessments. First, we ranked each 6th field watershed on the area covered with soils at risk of erosion (see **Sediment sources: Surface erosion: Soils** below) and second, we combined soils erosion risk and risk of shallow landslide in a multifactor analysis.

5.8.2.1 Results: Study area summary

We found soil erosion risk information for soil types covering 86 percent of the study area. There were some errors in the MUIR tables; for example, several of the soils units (e.g., 601S1E, 63810G, 63819E, 63820G, 63831G, and 63839F) were designated as having both “moderate” and “slight” or “severe” and “moderate” risk. In these cases, we used the higher of the two risk categories. For some soil types, there was no erosion risk information available for the study area.

In general, we found that a large proportion (45.8%) of the study area is covered with soils that are at “severe” risk for soil erosion (**Figure SED-3**). Soils with “moderate” and “slight” erosion risk cover 31.6 percent and 17.6 percent of the study, respectively. This has profound implications for land use actions on the extensive areas of high-risk soils.

5.9 Climate

Climate is one of the factors that determine how watersheds look and behave. For example, climate ultimately determines the type of vegetation (or potential vegetation) that is found in a region. Climate also determines how watersheds function, e.g., patterns in rainfall influence sediment and material transport in streams. Areas that share similar climatic characteristics are frequently grouped into Ecoregions. The concept of the ecoregion was introduced by Omernick in 1987 as a water quality management tool that grouped areas based on perceived patterns in climate, soils, potential vegetation, land form and land use. Since the concept was introduced, there have been many different ecoregion classifications schemes, so it is always a good idea to know what ecoregion definition is being used.

The MidCoast Region of Oregon lies within the Coast Range Ecoregion as defined by US EPA (Pater 1998). The Coast Range Ecoregion, sometimes referred to the Coastal Temperate Rain Forest (Redmond 1997), is largely defined by climatic patterns. The region is characterized by wet winters and relatively dry summers (Oregon Climate Service, *http://www.ocs.orst.edu/*) and mild temperatures all year. The ecoregion experiences heavy precipitation during the winter months and snowfall is minimal. Strong winter storms, with heavy winds, are frequent to the region.

5.9.1 Temperature

According to the Oregon Climate Service, in the Coast Range Ecoregion, temperatures above 90°F occur infrequently (on the average 1-2 times per year) and below freezing temperatures occur about 30 times per year, on average. The average monthly temperatures for the period of 1961-1990 measured in Newport are given in **Table 5.8**.

Table 5.8. Thirty year temperature averages (°F) measured at Newport, OR.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Mean	43.8	45.6	46.1	47.5	51.0	54.8	57.1	57.6	56.9	52.8	48.1	44.1	50.5
Mean Max	50.3	52.7	53.6	55.2	58.6	62.0	64.6	65.3	65.5	61.1	54.8	50.4	57.9
Mean Min	37.3	38.5	38.7	39.7	43.4	47.7	49.6	49.9	48.2	44.6	41.5	37.8	43.1

5.9.2 Precipitation

Forests in the mid-latitude region of western North America are among the wettest in the world (Redmond 1997): some form of precipitation falls on more than half of the days each year. Elevation is one of the most important considerations affecting precipitation in coastal Oregon. As the relatively warm, moist oceanic air hits the shore, it is forced upward by the Coast Range Mountains. As the air mass gains altitude its capacity to hold moisture decreases, resulting in rain. Rainfall ranges from about 70-100 inches per year along the coast (**Table 5.9**) to about 200 inches at the top of the Coast Range Mountains (Oregon Climate Service; Redmond 1997). Furthermore, there is quite a bit of local variability in precipitation patterns. This makes it difficult to generalize (over space) from discrete observations collected from individual weather reporting stations. One solution is to use a precipitation model.

Table 5.9. Average monthly and annual rainfall (inches) at Newport, OR 1961-1990

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
11.1	8.1	8.2	4.8	3.5	2.7	1.0	1.3	2.6	5.4	10.9	12.0	71.7

PRISM (Parameter-elevation Regressions on Independent Slopes Model h*ttp://www.ocs.orst.edu/prism/prism_new.html*) is an analytical tool, developed at Oregon State University, that combines observations made at individual weather stations, digital elevation models (DEM), and other spatial data sets to generate a spatially explicit estimate of estimates of monthly, yearly, and event-based climatic parameters, such as precipitation, temperature, and dew point. PRISM data, used around the world, are designed to map climate in the most difficult situations and is well suited for mountainous regions such as the Coast Range Ecoregion. PRISM data sets are constantly being updated and are available from the web.

Patterns in precipitation have profound implications to the organisms that live in the Coast Range Ecoregion. Streamflows are dependent upon the amount and timing (patterns) of rainfall. Streamflows, in turn, affect channel geomorphology and determine patterns (seasonal and daily) in salinity when rivers flow into estuaries. Both streamflows and the salt-freshwater interface are very important to multiple life stages of salmon. Although patterns in precipitation could be useful in ranking 6th field watersheds in this study, we did not consider them in our multifactor rankings.

5.9.3 Fog zone

The MidCoast Tech Team asked that we evaluate the fog zone in the study area. Currently, there are no spatial data sets that describe the "fog zone" for the Oregon Coast (Chris Daly, Spatial Climate Analysis Service, personal communication, 1999). Fog zone is not a climate parameter that is officially archived. Although there may have been numerous studies on this subject, there were not available through the Spatial Climate Analysis Service.

Fog zone information from an ODF study was available, but only as a graphic file (i.e., not as a spatial data set). The fog zone is reported as the "percent of hours with a ceiling < 300 ft and/ or visibility of < 1 mile." During July the area along the coast and extending 10-15 km inland in the study area is foggy 8-10 percent of the time. At higher elevations in the Coast Range, these values drop to 3-5 percent of the time.

5.10 Land ownership

We obtained the ownership GIS coverage from the MCWC CD_ROM (**own_osu^{M}**). Within this data layer, major and minor ownership types are identified. Major ownership types include: BLM, USFS, PI (Private Industrial), PNI (Private Non-Industrial), MISC, and STATE. Each of these major categories is broken down into more detailed ownership groups; for example, major companies are identified within the industrial timber ownership category, as are county holdings, etc. We summarized the data in the ownership layer for 500m X 500m grid cells (the resolution of the data). We found that Private Industrial (147, 922 ha or 39.9%) is the largest landholder category in the study area, followed by USFS (106, 048.6 ha, 28.6%), Private Non-industrial (PNI) (63,008.2 ha, 17.0%), BLM (38,968.2 ha, 10.5%), State (12, 631.3 ha, 3.4%), and MISC (2,358.7 ha, 0.6%).

We used ARCView to summarize the proportion of each ownership type by 6th Field Watershed as a single-factor summary. We mapped the areas of ownership for each major category in each basin insert (**Figure SET-5AL, SET-5OT**, etc.). In these individual basin maps, we broke out the five private industrial landowners with the largest landholdings in the entire study area as separate mapping units. Ownership information was also used in extrapolating road frequencies (see **Extrapolated road frequency** above).

5.11 Land use zoning

5.11.1 DLCD generalized zoning

Information on generalized land use zoning is useful for interpretation of watershed assessment data, and vital for action planning. Oregon's Department of Land Conservation and Development provides mapping of generalized land use zoning categories.

The area of each Generalized Land Use Zoning (**zoning_m6**) category by major basin is shown in **Table 5.10**. The vast majority (90.6%) of the study area is zoned for forestry use , and this is by far the dominant zoning class for each major basin. The only other zoning categories over 1% of the study area are Agriculture (4.3%), Urban (2.0%) and Rural Residential (1.4%).

Table 5.10. Area of generalized land use zoning categories by major basin.

	Area (ha)							
General zoning	**Alsea**	**Ocean Tribs**	**Salmon**	**Siletz**	**Yachats**	**Yaquina**	**Grand Total**	**% of total**
Ag	7,464	427	383	3,122	573	4,093	16,063	4.3
Estuary		114	134	89		15	352	0.1
For	112,447	50,505	17,250	90,494	10,527	56,564	337,786	90.6
Nat Res		186					186	0.0
Park	1	2,481	169	22		37	2,710	0.7
RCom		16	28			9	53	0.0
RInd	34			42		8	84	0.0
RR	529	2,376	738	614	72	1,038	5,368	1.4
RSC	86	820	500	210		92	1,709	0.5
Urban	339	4,987	61	330	59	1,625	7,400	2.0
Water	158	499	58	79	2	382	1179	0.3
Grand Total	121,058	62,412	19,321	95,003	11,232	63,863	372,890	100.0

Ag = Agriculture For = Forestry Nat Res = Natural Resource RCom = Rural Commercial
RInd = Rural Industrial RR = Rural Residential RSC = Rural Service Center

We used zoning in several analyses, such as **Potential floodplain restoration sites** below (flat areas near streams that are not zoned for development), and **Large Woody Debris Source Areas** below (areas prone to landslide that are zoned for forestry use). However, the main use of zoning information is probably during the next phase of watershed assessment and action planning, when local watershed groups will need to know zoning for prioritization of action sites at the stream reach level. To assist in this next phase, we mapped the actual zoning areas for each individual major basin (**Figures SET-AL** through **SET-4YQ**).

5.12 Existing watershed analyses

5.12.1 USFS and other federal watershed analyses

In the course of this assessment, we were in communication with many other groups conducting water analyses and other types of investigations in the study area. These included USFS, NMFS, ODFW, and other agencies. Our choice of methods for many of our analyses was based on the methods used by these groups, particularly for aquatic habitat assessment. We obtained data from (and provided data to) ODFW, USFS, NMFS and others in the course of developing the study, and will continue to work towards open sharing of data used in the assessment *via* the project website:

http://www.midcoastwatershedcouncil.org/watershed_assessment_2000/

The USFS and BLM (often in cooperation with USFWS) have conducted the largest number of watershed analyses within the study area for this assessment. We used these watershed analyses extensively to define problems and approaches for this assessment.

For example, we used many of the same data sources that were used for these watershed analyses, such as USFS Stream Inventory data, ODFW River Basin Management Plans, and NRCS Soil Survey data. When developing protocols for our assessment, we also considered those used in the USFS/BLM watershed analyses, although our primary guide for this assessment was the OWEB Watershed Assessment Manual (Watershed Professionals Network 1999). Because the main goal of this assessment was prioritization of 6th fields, we could not use the watershed analyses directly in this assessment. Each USFS/BLM watershed analysis covers only a small portion of our study area, and the sum of all areas analyzed by USFS/BLM in combination still does not provide comprehensive or consistent data coverage for the current MidCoast Sixth Field Assessment study area.

We reviewed and used the following watershed analyses in conducting the current assessment:

Table 5.11. Watershed analyses within the study area

Analysis	**Agencies & other authors**	**Date**
Cummins/Tenmile	Siuslaw NF	February 1995
Big Elk (Alsea)	Siuslaw NF	August 1995
South Fork Alsea	BLM	October 1995
Upper Siletz	BLM	December 1996
North Fork Alsea River	BLM	July 1996
Drift (Siletz)	USFS, BLM	September 1996
Lobster/Five Rivers	USFS, BLM	January 1997
Drift Creek (Alsea)	Siuslaw NF	May 1997
Yachats/Blodgett	USFS, BLM	October 1997
Salmon-Neskowin	Boateng & Assoc. for USFS, BLM	June 1999
Lower Alsea	USFS, BLM, USFWS	September 1999

5.12.2 Rock Creek Watershed Assessment

In 1999, we completed the Rock Creek Watershed Assessment (Garono and Brophy 1999) for the MidCoast Watersheds Council. The Rock Creek Assessment analyzed a single 5th field watershed below the 6th field level (the units of comparison were catchments averaging 80 acres in size), while the current assessment analyzed a much larger area, comparing 217 6th field watersheds across a total of 18 fifth field watersheds. Therefore, the techniques we used necessarily differed between the two assessments. Nonetheless, we did maintain many of the same goals and approaches for the current assessment (see **Goals and purposes** above).

5.12.3 Yaquina and Alsea Estuarine Wetland Site Prioritization

Green Point Consulting completed the Yaquina and Alsea River Basins Estuarine Wetland Site Prioritization project in 1999 (Brophy 1999). This project provided detailed review of characteristics of 78 tidal and formerly tidal wetland sites in the Yaquina and Alsea estuaries. The project included priority ratings and action recommendations for protection and restoration at each of the 78 sites. We did not use the results of this study directly in the current Sixth Field Watershed Assessment because comparable data did not exist for other estuaries in the study area. We recommend development of similar datasets for those other estuaries, and we highly recommend utilization of such datasets when planning watershed enhancement and restoration actions in or near the MidCoast estuaries. Actions taken in the watershed, whether in the estuary or upstream can help or harm estuarine wetlands, and conversely, restoration of, or damage to, estuaries strongly affects fish that travel through these environments enroute to the upper watershed (see **Estuaries** below).

5.12.4 OFDW/PNW cooperative analysis

In a cooperative project between ODFW and the USFS Pacific Northwest Research Station, characteristics of ODFW index basins (see **Species of concern: Salmonids: Populations** below) are being compared to other 5th field watersheds and to the rest of the Gene Conservation Group Area. Parameters for comparison are ownership, land cover from CLAMS, stand replacement (harvest), percent slope, elevation, geomorphologic formation, mean annual precipitation, mean summer temperature, and mean winter temperature (Kelly Burnett, USFS, personal communication, 1999).

5.12.5 FEMAT Key Watersheds

The 1993 FEMAT report (FEMAT 1993) identified nine Key Watersheds within the study area. These Key Watersheds were intended to serve as refugia for at-risk stocks of anadromous salmonids and resident fish species. The refugia “include areas of good habitat as well as areas of degraded habitat.” The areas in poorer condition were considered to have high potential for restoration. Tier 1 Key Watersheds “contribute directly to anadromous salmonid and bull trout conservation”, while Tier 2 watersheds are “important sources of high quality water.” All of the Key Watersheds in the MidCoast area are Tier 1 watersheds.

Table 5.12. FEMAT Key watersheds in MidCoast study area

Key Watershed name	**Area (ha)**	**Tier**
DRIFT CREEK (ALSEA)	17,467	1
CUMMINS/TENMILE/ROCK/BIG CREEKS	16,603	1
YACHATS RIVER	11,234	1
DRIFT CREEK (SILETZ)	10,742	1
UPPER LOBSTER CREEK	10,680	1
N. FORK SILETZ FIVE R/WARNICKE CREEK	4,673	1
N. FORK BEAVER CREEK	3,054	1
MILL CREEK	1,173	1
TOBE CREEK	751	1

5.13 Existing watershed restoration projects

Resource managers can use GIS data on existing restoration sites to help plan the locations of future restoration activities. By using the GIS to display data on habitat quality, salmonid migration corridors, and existing restoration sites, resource managers can pinpoint areas that might be critical for future restoration projects. Clustering restoration projects may be desirable in order to take advantage of interactions between different types of projects. For example, removal of a constructed berm could restore an active floodplain; areas near this floodplain could then be enhanced through conifer plantings that would provide large wood for enhanced instream structure in the future. Knowledge of locations of restoration activities can also help resource managers plan watershed monitoring activities. Watershed monitoring work should focus on areas where restoration is occurring, in order to determine the effects -- both expected and unexpected -- of restoration projects.

We located two sources of GIS data on restoration projects and summarized the data by 6th field watershed. The Oregon Watershed Enhancement Board conducts a Restoration Inventory which tracks restoration projects throughout the state; annual reports from this inventory are available online at:

http://www.oweb.state.or.us/pdfs/wri_reports/1999ar-wri.pdf

The Regional Ecosystem Office (REO), an organization that facilitates cooperation between local, state and federal agencies in support of the President's Forest Plan for the Pacific Northwest, is also building a database of restoration projects (the Interagency Restoration Database, or IRDA). The website for the project is located at:

http://www.reo.gov/restoration/

As of early 2000, 609 projects were contained in the OWEB and IRDA databases for the entire study area. The distribution of project types is shown in **Table 5.13**.

Table 5.13. Types of restoration projects in MidCoast study area

Project type	Number of projects
Instream	48
Riparian	141
Road	225
Combined	50
Fish passage	22
Miscellaneous	123
Total	609

Combined projects may contain elements of instream, riparian, road, fish passage, or other types of restoration activities.

The number of restoration projects within individual 6th fields ranged from 42 (South Fork Siletz) to zero. Fifty-four 6th field watersheds had only one or two restoration projects. Eighty-eight 6th field watersheds had no restoration projects. **Table 5.14** shows the 6th fields that had the highest total number of restoration projects reported in either the OWEB or the IRDA databases.

Table 5.14. 6th field watersheds with the highest number of existing restoration projects

			Number of projects by type:						
6th field watershed name	Major basin	6th field ID code	instream	riparian	road	combined	fish passage	misc. (undefined type)	total
SF_SILETZ	Siletz	40410	1	6	17	0	0	18	42
SUNSHINE	Siletz	40504	2	9	13	0	0	2	26
NORTH BEAVER2	Ocean Tribs	50502	0	1	0	1	0	24	26
U. SALMON RIVER	Salmon	40901	4	2	1	1	0	17	25
ELK	Siletz	40502	1	4	11	0	0	0	16
UPPER FARM	Siletz	40506	1	12	2	0	0	0	15
U. CEDAR	Siletz	40703	1	2	10	0	1	0	14
EUCHRE	Siletz	40704	0	2	11	0	0	0	13
BOULDER	Siletz	40403	0	0	8	0	0	4	12
GRAVEL	Siletz	40501	0	5	6	0	0	0	11
M. DRIFT	Alsea	50303	0	0	11	0	0	0	11
BUTTERMILK	Yaquina	40105	1	1	5	2	1	0	10
CRYSTAL	Yaquina	40106	2	0	5	1	0	2	10
HOMESTEAD	Yaquina	40206	1	0	8	0	0	0	9
CERINE	Siletz	40507	1	4	4	0	0	0	9
LITTLE_ROCK	Siletz	40606	1	1	0	3	1	3	9
BENTILLA	Siletz	40712	0	5	1	2	1	0	9
BIRCH	Alsea	50420	2	1	3	1	2	0	9

The GIS shapefiles and Excel spreadsheets for these existing restoration projects (available from the websites listed above) contain a unique project ID number which can be used to obtain more details on individual projects.

The OWEB and IRDA databases are still fairly new and are therefore changing rapidly as new data are entered. The IRDA database in particular does not yet have many entries. For example, a number of restoration projects are underway in the Ten Mile Creek area, but these were not contained in either the OWEB or IRDA databases acquired for this assessment. We recommend that MCWC download the most recent data from OWEB and from IRDA, and create a GIS layer for restoration projects not contained in those databases.

6 Species of concern

6.1 Salmonids: Introduction

There are seven biotypes (species and runs) of salmonids found in the MidCoast region (**Table 6.1**) and many of these groups have low populations and a few "are threatened with extinction" (Oregon Plan 2000, online at *http://www.oregon-plan.org/2000Ann Report/index.html*). In the summer of 1996, Governor John Kitzhaber developed Oregon's Coastal Salmon Restoration Initiative (OCSRI) with active partnerships with state and federal agencies, local governments, conservation organizations, industry representatives, watershed councils, and private landowners. The goal of OCSRI was to develop a plan to restore the vitality of wild salmon, steelhead, and cutthroat trout in coastal watersheds.

Table 6.1. Presence of salmonid biotypes by major basin/watershed

Major basin/ Watershed	Coho	Chum	Fall Chinook	Spring Chinook	Winter Steelhead	Summer Steelhead	Sea-Run Cutthroat
Salmon R.	X	X	X		X		X
Siletz R.	X	X	X	X	X	X	X
Yaquina R.	X	X	X		X		X
Alsea R.	X	X	X	X	X		X
Yachats R.	X	X	X		X		X
Cummins Cr.	X				X		X
Tenmile Cr.	X		X*		X		X

In Botkin et. al, 1993, source T. E. Nickelson et al. 1992. Status of anadromous salmonids in Oregon coastal basins. Portland, OR ODFW.
*Paul Engelmeyer, personal communication

Elements of the OCSRI Plan included:

- Specific actions to conserve "core" populations of salmon.
- Procedures to provide continuing leadership and improve interagency cooperation.
- Adjustments in harvest management and hatchery programs.
- Goals for riparian management in land-use planning.
- Measures to improve the condition of streams and riparian habitats.
- Proposals for funding and economic incentive programs.
- Opportunities to improve compliance with existing environmental laws.
- Public education programs.
- A proposal describing a comprehensive monitoring program.
- Descriptions of watershed council restoration projects.

The multifaceted OCSRI was later renamed the Oregon Plan.

The following discussion is meant to illustrate the severity of the current decline in salmonid populations and highlight some of the problems associated with obtaining accurate (in the sense of describing actual numbers of fish) population estimates. **Much of this information was not spatially explicit, did not cover the entire study area, or**

was too old to be of use in prioritizing 6th field watersheds. One notable exception was the Rapid Bioassessment Survey project (**Species of concern: Salmon distribution** below), which covered a good deal of the study area and probably can be used to identify coho "hotspots." However, there are limitations in using the Rapid Bioassessment survey to measure coho populations. This section is not an exhaustive list of what is know about salmonid populations in the study areas, but is meant as background information.

There is information on the status of salmonid populations in the Pacific Northwest; however, much of this information is anecdotal. Fish populations are frequently assessed using a variety of different survey methods, including catch data, dam counts, and more formalized juvenile counts and spawning surveys. Unfortunately, many of these survey methods, like most sample methods, include some sort of sampling bias. For example, catch data may be influenced by conditions other than the abundance of fish (fish population size). Catch data also are difficult to standardize to a unit of sample effort, and are therefore frequently expressed as angling hours.

Many other survey techniques also have sampling bias. For example, some spawning surveys are frequently conducted along subjectively selected stream segments and therefore are not suitable for use in developing accurate, basin-wide estimates of fish populations. In addition, reported results from many surveys may incorporate of some sort of “correction factor” intended to account for sample bias. Examples of correction factors commonly used include mortality estimates, exploitation rates, and/or bias correction (Botkin *et al* 1993). While correction factors are not entirely bad, these factors are often employed without being defined or their assumptions being documented. This makes it very difficult to determine and interpret what was actually measured.

6.1.1 Historic catch records

Catch records are frequently used to assess the status of game fish populations. These numbers are frequently expressed as the number of fish caught per level of effort, usually per angler hour. However, many factors can influence the number of fish that are actually caught. This makes catch records an unreliable tool to assess populations.

Some of the earliest information available on Oregon salmon runs comes in the form of catch records. Descriptions of salmon harvest from the late 1800s and early 1900s often include descriptions of how salmon were harvested with pitchforks because fish were so abundant (Boateng & Associates Inc. 1999). Indeed, many canneries were constructed along the Oregon coast to be close to the large salmon runs. For example, between 1923 and 1940 over 17,000 coho and 1,200 chum were harvested in the Siletz (Siuslaw National Forest 1997) and 3,200 steelhead and 900 chum in the Alsea (Lower Alsea River Watershed Analysis, 1999). In 1947, the Lincoln County catch included a staggering 1.3 million pounds of Chinook and “varying quantities” of coho (Boateng & Associates Inc. 1999).

By comparison, catch records from the 1970s show a dramatic decline in the number of fish caught (**Table 6.2**).

Table 6.2. Salmon caught by boat and shore anglers from March 1 - October 31, 1971. Numbers include lower watershed only. Source: Fish Commission of Oregon 1970-71 Resource Use Study (Gaumer 1973, 1974).

	Alsea River			Salmon River			Siletz River			Yaquina River		
	No. Boat	No Shore	***Total***	No. Boat	No Shore	***Total***	No. Boat	No Shore	***Total***	No. Boat	No Shore	***Total***
Chinook	110	9	***119***		45	***45***	250	11	***261***	218	33	***251***
Coho	278	128	***406***			***0***	140	29	***169***	723	141	***864***
Cutthroat	33	58	***91***	55	50	***105***	70	7	***77***			

6.1.2 Historic and recent Juvenile and Spawner Surveys

Surveys of both juvenile and spawning adults are also used to assess fish populations. Many of these techniques also have bias, and knowledge of protocols and data handling methodologies are necessary before results can be interpreted and compared. This criticism was recognized by ODFW personnel in 1980 when they made several recommendations to improve accuracy and precision of coho surveys. These improvements included the expansion of the number of index streams, to replace peak counts with estimates derived from Area-under-the-curve (AUC) techniques, and to separate indices from streams influenced by hatchery fish from others (Jacobs *et al* 2000). Therefore, care must be taken when interpreting and comparing earlier records.

Early estimates of juvenile production indicate that 1-2 million coho salmon were produced annually in Oregon coastal basins at the turn of the century (Nickelson *et al* 1992). Spawner surveys indicated that the coho run in the Alsea basin from 1923-1950 was approximately 50,000 (Lower Alsea River Watershed Analysis, 1999), rising to 80,000 adult coho in 1951. Resent coho spawner surveys show that compared to the 1923-1951 data, there has been a dramatic decrease in the number of spawning coho throughout the study area (**Table 6.3** and **Table 6.4**).

Table 6.3 shows 1999 counts of spawners per mile (and estimated run size per mile based on those counts) from both random and standard surveys. Random surveys are designed to provide a basis for accurate estimation of salmonid populations by randomly surveying streams. Standard surveys are designed to track salmonid populations over time at locations known to have high levels of use. Both survey techniques express the number of fish observed on a per mile basis and information on the length of stream surveyed and number of visits is also provided. Spawning coho are present in many of the surveyed streams in the study area, but in relatively low numbers compared to historic reports. Beaver Creek and the Yaquina River are reported to have the highest number of spawning coho; however, the stream survey length and number of visits are also comparatively high.

Table 6.3. 1999 Random & Standard Coho Spawner Surveys: Data by surveyed stream. Source: ODFW Webpages *http://osu.orst.edu/Dept/ODFW/other/spawn/ index.html.*

Major basin / Watershed		**Peak Counts**		**Estimated Run Size**	
RANDOM	**Miles/ visits**	**Adults / mi**	**Jacks / mi**	**Adults / mi**	**Jacks / mi**
Salmon R.	3.4 / 34	4	0	3	0
Devils Lake	1.3 / 10	3	0	3	0
Siletz R.	13 / 125	4	1	7	0
Yaquina R.	9 / 105	10	1	15	1
Beaver Ck.	4 / 49	19	4	52	6
Alsea R.	18.9 / 189	4	0	7	1
STANDARD					
Salmon R.	0.8/13	9	1	24	0
Devils Lake					
Siletz R.					
Yaquina R.	2.6/24	21	2	48	3
Beaver Ck.	1.2/15	29	2	84	5
Alsea R.	5.2/55	7	0	13	1

Table 6.4 shows estimates of coho spawner abundance for the major rivers in the study area. These estimates were prepared by ODFW. To make the results more comparable from year to year, ODFW attempted to remove reporting bias. For example, in Oregon, coastal coho generally spawn during November through January and survey conditions can vary dramatically during this period. Observations are directly affected by stream flows. Freshet events of moderate intensity and of short duration provide ideal survey conditions. Coho density estimates are often adjusted to account for the bias associated with visual counts by surveyors and other factors such as hatchery-reared fish, and to adjust for the estimated. Data in **Table 6.4** have been adjusted by ODFW so that they are comparable.

In addition, **Table 6.4** shows that coho spawner abundance varies considerably from year to year, even within one drainage basin. During the past 10 years, some of the basins were estimated to have very low numbers of coho spawners (e.g., Salmon and Yachats Rivers). Low breeding populations generally lead to a reduction in genetic variability and can have serious consequences for the continued viability of the run. The totals in **Table 6.4** also show that spawning coho populations are estimated to be at some of the highest levels reported in the past 10 years for the MidCoast Region.

Table 6.4. Annual estimates of wild coho spawner abundance in coastal river basins, 1990-1999. Source: ODFW Coastal Salmonid Inventory Project.

Major basin	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999*
Salmon R.	385	39	28	364	107	212	272	237	8	124
Siletz R.	441	984	2,447	400	1,200	607	763	336	394	997
Yaquina R.	381	380	633	549	2,448	5,668	5,127	384	365	2,596
Devils Lake & Beaver Ck.	23	--	756	500	1,259	--	1,340	425	1,041	3,397
Alsea R.	1,189	1,561	7,029	1,071	1,279	681	1,637	680	213	1,996
Yachats R.	280	28	337	287	67	117	176	99	102	151
TOTAL	2,699	2,992	11,230	3,171	6,360	7,285	9,315	2,161	2,123	9,261

*1999 estimates are preliminary.

Although ODFW removed some of the reporting biases to facilitate comparison of the past 10 years of coho spawning survey data, recent reports suggest that modern survey techniques have led to more accurate population estimates. Therefore, the more recently an observation was made, the more accurate it is believe to be. A 1993 review of studies on salmonid populations conducted between 1980 and 1993 found 122 publications on anadromous fish in Oregon, of which at least one was from the MidCoast study area (Hall 1991, Botkin *et al* 1993). One factor that will allow future comparisons to be made are the complete descriptions of methods and sampling schemes included in more recent studies. The authors go on to note, however, that many observations are still being made without an underlying sampling design (Botkin *et al* 1993) and at relatively small spatial and temporal scales (it is difficult to extrapolate the results of small scale studies to entire watersheds). A notable exception are several studies initiated by ODFW during the past 2-3 years which do have a sample design in place. Results from these studies should provide the most accurate estimates of salmonids available to date.

6.1.3 Hatcheries

The study area contains several salmonid hatcheries, and consideration of hatchery influence is important to watershed assessment. Unfortunately, we were not able to incorporate hatchery influence into this assessment due to lack of comprehensive, consistent GIS data at a scale that would allow prioritization of 6th field watersheds.

When setting priorities at the stream reach level, we recommend that MCWC get technical assistance to determine the status of wild *versus* hatchery salmon runs in the areas of interest, and to determine how proposed actions might affect the wild and hatchery fish. Both current and historic hatchery releases should be considered.

Table 6.5 shows salmon hatcheries in the study area (from the ODFW website at *www.dfw.state.or.us/ODFWhtml/FishProp/ hatchres.htm*; and from Wayne Hoffman and Paul Englemeyer, personal communication). Besides the listed hatcheries, the Nestucca Hatchery raises some fish from and for the MidCoast (including Siletz summer steelhead). Additional hatcheries outside the study area may contribute to reservoir trout releases. Further information is available from Bob Buckman, ODFW (541) 867-4741.

Table 6.5. Hatcheries in the MidCoast study area

Name	Location	Stocks
Fall Creek Fish Hatchery	Alsea	Unknown
Salmon River Fish Hatchery	Otis	Chinook Coho Steelhead
Rock Creek Hatchery	Logsden	Coho
North Fork (Alsea) Hatchery	Alsea	Steelhead

In 1979, one ODFW-authorized private hatchery was listed by ODFW for the study area: the Oregon Aqua Foods hatchery (chum, coho, chinook), on Yaquina Bay (Cummings 1979).

6.2 Salmonid Distribution

6.2.1 ODFW distribution maps

We summarized distribution of salmonids in the study area from GIS data available from ODFW. These GIS layers showed habitat "believed to be used by wild, natural, and/or hatchery salmonid populations." ODFW defines "currently" as being within the past five reproductive cycles. These maps were produced using the best professional judgment of ODFW staff and staff from other natural resource agencies within Oregon. ODFW goes on to explain that "Areas displayed may not be utilized by a species of fish on an annual basis due to natural variations in run size, water conditions, and other environmental factors." Furthermore, fish distribution data were mapped by ODFW to a 100K streams base layer. Therefore, many smaller streams, used by some salmonid species, may not be adequately represented in these data sets.

Nevertheless, we transferred information from separate GIS coverages depicting coho, chum, summer and winter steelhead, and spring and fall chinook to our 6th field watershed coverage (**salmonid_types.zip**, shapefile name **salmonid_types_by_6th.shp**). We created columns for each of these six biotypes in the attribute table and indicated if a salmonid biotype was present in that 6th field by placing a "1" in that column (1=present). We then added the columns for the six salmonid biotypes to give the total number of biotypes expected to occur, based on the ODFW maps, for each 6th field watershed.

Values for the number of salmonid biotypes ranged from 0 to 6 across the study area. Several 6th field watersheds in the Alsea and Siletz River basins had 5 or 6 biotypes. Total number of biotypes per 6th field watershed is shown in **Figure SOC-10**.

ODFW's distribution maps show specific stream reaches (on the 100K streams layer) that are used by each salmonid species for three types of use: spawning, rearing, and migration. We mapped these reaches (color-coded by use type) for six salmonid biotypes in the study area: coho (**Figure SOC-1**), fall chinook (**Figure SOC-2**), spring chinook (**Figure SOC-3**), winter steelhead (**Figure SOC-4**), summer steelhead (**Figure SOC-5**), and chum (**Figure SOC-6**). In addition, the ODFW coho distribution for each major basin is shown on each Coho Potential Winter Habitat map (**Figure AQ-18AL**, etc.) and Coho Potential Summer Habitat map (**Figure AQ-19AL**, etc.) in the Basin Inserts, and the ODFW winter steelhead distribution is shown on each Winter Steelhead Potential Habitat map (**Figure AQ-20AL**, etc.).

6.2.2 ODF Fish Limits maps

As a part of its role in regulating timber harvest activities on Oregon lands, the Oregon Department of Forestry maintains maps of fish use in streams. These maps show the known or estimated upstream limits of game fish presence in many coastal streams. All game fish are considered, including resident cutthroat trout. These maps are not available in GIS form at the present time and could not be used in this assessment. However, they may be valuable to local watershed groups planning watershed enhancement activities.

6.2.3 ODFW Salmonid Core Areas

ODFW provides a GIS coverage of salmonid core areas[W] (Oregon Plan Core Areas, *http://www.oregon-plan.org/reports.html*) on a 1:100K streams base map. According to the Oregon Plan, "Core Areas are reaches or watersheds within individual coastal basins that are judged to be of critical importance to the sustenance of salmon populations that inhabit those basins. Core Areas contain habitat needed to sustain populations. Furthermore, Core Areas provide a source for repopulating habitats as restoration programs are implemented." Core areas were identified by a Scientific Panel assembled to create and review the Oregon Plan. Therefore, these areas are based on their best professional judgment.

Core areas should be considered high priority areas for watershed protection and enhancement activities.

We clipped the coverage to the study area and color-coded the reaches considered to be core areas for each species/biotype (**Figure SOC-7**).

We summed the total length of core area stream reaches for each 6th field watershed, adding the core areas for each biotype separately. (For example, if one kilometer of stream is considered to be a core area for three species, this would count as 3 km of core area). Twenty-five 6th field watersheds contained more than 10 km of salmon core areas. These watersheds are shown in **Table 6.6**. Sunshine Creek in the Siletz basin stood out with over 42 km of core areas.

Table 6.6. 6th field watersheds with greatest length of salmon core areas.

6th field watershed name	Major basin	6th Field ID code	Total core area (km)
SUNSHINE	Siletz	40504	41.7
ELK	Siletz	40502	26.7
M. FIVE	Alsea	50210	26.0
DIGGER	Alsea	50417	25.1
YAQUINA HEADWATERS	Yaquina	40101	18.8
NORTH YACHATS	Yachats	50508	18.6
CERINE	Siletz	40507	17.6
L. BUCK	Alsea	50208	15.6
BIRCH	Alsea	50420	15.4
U. DRIFT2	Alsea	50304	14.6
MILL	Yaquina	40308	14.3
WILDCAT	Siletz	40808	14.1
CRAB	Alsea	50212	13.9
LONG PRAIRIE	Siletz	40718	13.7
M. DRIFT	Alsea	50303	12.3
GREEN RIVER	Alsea	50216	12.0
NORTH BEAVER2	Ocean Tribs	50502	12.0
UPPER FARM	Siletz	40506	11.9
GOPHER	Alsea	50302	11.8
EUCHRE	Siletz	40704	11.0
HORSE	Alsea	50301	10.9
RYDER	Alsea	50110	10.6
TANGERMAN	Siletz	40713	10.5
SIMPSON	Yaquina	40103	10.5
MIDDLE_LOBSTER	Alsea	50211	10.4

6.2.4 Rapid Bioassessment

The Rapid Bioassessment (RBA) project (begun in 1998) provides data on distribution and abundance of juvenile coho, steelhead and cutthroat in MidCoast basins. As stated in the project reports (Bio-Surveys Inc. 1998, 1999), "The basins and sub-basins surveyed were selected and prioritized by ODFW and MidCoast technical advisors." The survey method involves snorkeling every fifth pool along the surveyed stream reach and recording counts of juvenile fish observed. For each stream, the survey ended (for 1998-99) when at least two units without coho were observed, although in some cases surveys continued beyond this point.

Briefly, the RBA protocol is a visual estimate of juvenile salmonids as observed by divers in the stream. This method reportedly works well on juvenile coho because the young coho act aggressively toward the diver (Steve Trask, personal communication, 2000). This method generally works less well on other salmonids like cutthroat and steelhead. In fact, when a diver enters the pool, the coho are generally counted on the first pass and other salmonids are counted on subsequent passes because they are attracted to food items stirred up by the diver. Counts are generally tallied, based on a single pass by a diver, for each pool; therefore, there is no way to estimate the accuracy of the observation on a pool-by-pool basis.

Two GIS coverages of Rapid Bioassessment data (1 coverage for 1998, 1 for 1999) were created at the Siuslaw National Forest office in Corvallis (contact: Diane Rainsford). The RBA data were mapped to the densified streams layer[W]. We then intersected the GIS coverages with the 6th field coverage (**6th_field.shp)** to produce the layers provided in this assessment (**rba98_by6th.shp** and **rba99_by6th. shp**). As requested by the MCWC Tech Team, we summarized two parameters from the Rapid Bioassessment data for each 6th field watershed: juvenile coho per square meter, and pool complexity. Both of these parameters were calculated by the Rapid Bioassessment project staff and are present within the shapefiles listed above. In this section, we discuss the coho juvenile density data (coho/ sq m). Pool complexity is discussed under **Aquatic habitats: Stream structure** below.

Before averaging coho per sq m, we followed recommendations in the Rapid Bioassessment 1998 report (Bio-Surveys Inc. 1998) to eliminate from the averages those pools outside the observed distribution of coho for each stream. The points included in the averages were saved as separate shapefiles (**rba98_distrib_by6th.zip** and **rba99_distrib_by6th.zip**). Specifically, we excluded from the average those pools located upstream of the last pool in which coho were observed, and, for mainstems, downstream of the first pool in which coho were observed. According to Bio-Surveys, Inc., which conducted the snorkel surveys, this procedure prevents underestimation of true rearing density (Bio-Surveys Inc. 1998).

6.2.4.1 Summary of results

We determined the average juvenile coho density within the observed coho distribution for each 6th field. The average densities were stored in a summary layer (**cosq9899** in **rba_sum_final.shp**). For most streams, data were collected only in one of the two years. Where data were collected during both years, we used the average density across both years. We weighted the average values by the number of pools snorkeled in each year to normalize results, then color-coded the 6th fields for average coho density across the two survey years (**Figure SOC-8**). We also summed the number of pools surveyed in either 1998 or 1999 (data field **Npls9899** in summary shapefile) for each 6th field (**Figure SOC-11**). Sixth field watersheds with less than 10 pools snorkeled during 1998 and 1999 are indicated with a red outline on the maps.

Table 6.7 shows the 6th field watersheds that were ranked in the top 10 (out of all 217 6th field watersheds) for average juvenile coho density during 1998-99.

Table 6.7. 6th field watersheds ranked highest for juvenile coho density.

6th field watershed name	Major basin	6th field ID code	# of pools surveyed, 1998-99	Average coho/sq m, 1998-99
UPPER_LOBSTER	Alsea	50219	3	2.0867
MILL	Yaquina	40308	45	1.3713
LITTLE ELK	Yaquina	40111	159	1.2939
BEAR	Yaquina	40108	40	1.1938
SLIVER	Alsea	50218	14	1.1218
NORTH BEAVER2	Ocean Tribs	50502	110	1.0536
HORSE	Alsea	50301	142	0.9234
ROCK1	Ocean Tribs	41012	55	0.8435
CRYSTAL	Yaquina	40106	36	0.8340
OLALLA	Yaquina	40302	98	0.7305

We also mapped individual snorkeled pools for each major basin, color-coded by coho density (**Figures SOC-9AL, SOC-9OT, etc.**). These maps allow local watershed groups to see exactly where the highest coho densities were surveyed.

6.2.4.2 Interpretation

The 6th field summary shapefile (**rba_sum_final**) shows which 6th fields had, on average, the highest values for juvenile coho density during 1998 and 1999. When interpreting these values, it is important to note that the number of pools snorkeled varies widely between 6th fields (ranging from 1 to 250). For example, a high value for coho density may not be significant or representative of the 6th field if only 10 or 20 pools were snorkeled in that 6th field. A suitable next step is to review the underlying data layers (**rba98_by6th** and **rba99_by6th**, which contain all pools snorkeled, and **rba98_distrib_by6th** and **rba99_distrib_by6th**, which contain only pools within the observed distribution of coho) to see exactly where the snorkeled pools are located.

Discrepancies and possibly scale differences between the 6th field base layer and the densified stream layer (on which the RBA GIS layer was created) result in small errors in 6th field placement of data. For example, the 6th field boundaries do not precisely correspond to the drainage basins of streams in the densified streams layer^{W}. This explains why some 6th fields have only 1 to 5 pools surveyed -- the surveyed stream was divided between two 6th fields in the process of intersecting the RBA coverage with the 6th fields coverage. To help avoid misinterpretation, 6th field watersheds with less than 10 pools surveyed were marked with red outlines on the coho density map (**Figure SOC-8**).

6.3 Salmonid populations

6.3.1 Rapid Bioassessment

The Rapid Bioassessment project addresses both salmonid distribution and populations. It is discussed in **Salmonid distribution** above.

6.3.2 ODFW life cycle monitoring (index sites)

ODFW life cycle monitoring is focused on characterizing freshwater and ocean survival rates by trapping adults in and smolts out within index basins. Adult traps are placed at fish ladders with the goal of obtaining a complete adult count. Tag - recapture studies are used to determine the actual proportion of fish counted.

ODFW has chosen index sites based on three factors: 1) location (the goal is good dispersion of sites throughout the area of interest); 2) size of basin (larger basins are preferred); and 3) feasibility of trapping fish at the potential site. Three sites in the MidCoast Watersheds appear to have 100% counts for coho: Mill Creek Siletz, Cascade (Alsea) and Mill Creek Yaquina. Data from the small number of index sites could not be used for prioritizing 6th field watersheds, but will be useful to the MidCoast council in planning site-specific actions. Current data are available at the ODFW life-cyle monitoring website: *http://osu.orst.edu/Dept/ODFW/life-cycle/index.html*.

7 Aquatic Habitats

7.1 Introduction

We used several data sources to determine the condition of aquatic habitats in the study area. As with other sections of the assessment, we placed emphasis on datasets that were comprehensive and consistent in coverage across the study area, and that were already in GIS format.

Our first source was the provisional Digital Elevation Model (DEM) data acquired from the Oregon State University CLAMS project. We used the DEM to produce comprehensive, consistent-scale coverages of stream morphology, specifically stream gradient and stream confinement.

We also used aquatic habitat survey data gathered in the field (and compiled in the office) by county, state and federal agencies and by private industrial groups. The aquatic habitat surveys (referred to as "AHI" data in this report) gave us data on several factors prioritized by MCWC: percent pools by area, channel widths per pool, large woody debris frequency, riffle habitat, side channel/secondary channel habitat, stream channel shading, active bank erosion, and stream substrates. Analysis of these data formed a large part of this assessment. Technical details of the methods used for these analyses are found both in this **Main Report** and in **Appendix A: Supplemental Methods**. We recommend users of this assessment read both documents to understand the methods.

In addition to the differences in data sources, it is important to remember when using AHI data that the extent of AHI data in the study area is quite limited. Aquatic habitat conditions can reflect watershed processes that occur over large areas. However, when only a limited proportion of the stream network is surveyed, it is possible that the conditions found may not be typical of the entire watershed (see ***Survey extent: Percent of 1:100K stream network surveyed*** below). In addition, some of the surveys are more than five years old (see **Survey date** below). While these data will remain useful until they are replaced by more recent surveys, it is important to note that the Coast Range of

Oregon is a dynamic environment where the conditions reported in some of the older surveys may no longer be accurate.

Our three sources of aquatic habitat survey data included one source of data that was already in GIS format (ODFW's Aquatic Habitat Inventory GIS, a 1:100K data layer), and two sources consisting of tabular data (USFS Region 6 Stream Inventory data, and Aquatic Habitat Inventory data gathered by staff of the Lincoln Soil and Water Conservation District). We summarized all data by 6th fields for use in 6th field prioritizations and multi-factor analyses. We summarized the GIS data in ArcView, and we summarized the tabular data in Excel.

We used slope derived from the DEM and land use zoning data from the MidCoast GIS to determine possible sources of large woody debris recruitment, and hydric soils information from NRCS to determine possible locations of wetlands. We obtained GIS data from ODOT on the locations and characteristics of a limited number of culverts within the study area.

7.2 Stream channel morphology from DEMs

7.3 Stream confinement

Stream confinement refers to the extent to which the stream is confined by hills, cliffs, terraces or other landscape features. Confinement is not the same as stream entrenchment (see **Appendix B: Ecological Processes**). Stream confinement is an important factor in many watersheds because it is directly related to watershed characteristics and functions, such as presence and formation of wetlands, floodplain connectivity, availability of off-channel habitat, and flooding and peak flows. Since stream confinement information was not available for the study area, we used ARCView to generate a stream confinement layer from the 10 m DEMs (see **Appendix A: Supplemental Methods**). First, we created a slope grid from the DEM GRID. In the resulting slope grid each cell (10 m X 10 m) contains a continuous slope value represented in degrees. ARCView calculates slope as the rate of maximum change for each cell from its nine neighbors using a 3 by 3 cell window.

After several trials, we considered slopes of 0-5 degrees to represent 'flat areas' along streambeds and slopes greater than 5 degrees to be steep areas. We then created a shapefile from the reclassified slope grid (**derived_stream_confinement.zip**, shapefile name **der_st_confinement.shp**). Generally, for a stream to be considered as ‘confined’ (or 'moderately confined') the width of the valley between confining features must be less than four times the active channel width (Watershed Professionals Network 1999). Conversely, for a stream to be considered to be ‘unconfined’ the valley width must be greater than four times the channel width. Stream channel widths vary considerably in the study area. For the purposes of this analysis, we considered the average channel width to be 10 m, the limit of resolution for the 10 m DEM grid. A 10m channel width seemed to be suitable considering that lower watersheds contain many wider channels, and low order streams in the Oregon Coast Range may only be 1-2m wide (Schoonmaker *et al* 1997).

Using the 10m nominal channel width, we also considered that streams are not always centered in their valleys. Using the GIS we removed small (<1.5 ha), isolated ‘flat areas.’ Therefore, stream segments must shown to be flowing through 'flat areas' greater than 1.5 ha to be considered as ‘unconfined’ stream segments in our analysis. Stream segments flowing through 'steep areas,' or flowing through 'flat areas' but less than 1.5 ha were considered to be confined.

7.3.1 Results: Study area summary

The areas classified as "unconfined" using the procedure described above are shown in **Figure AQ-1**. We used derived stream confinement in several multi-factor analyses (see **Multi-factor analyses of salmonid habitat** and **Recommendations: Potential floodplain restoration sites** below).

7.4 Stream gradient

Stream gradient, the slope of the streambed, is an important watershed attribute and is an important component of salmonid habitat. Typically, steeper stream gradients have faster water velocities than flat streambeds. As water velocity increases, so does the water’s capacity to transport sediment and other materials, including large gravel, suspended sediments and large woody debris.

There are several ways to measure stream gradient. In the field, stream gradient can be measured directly with a clinometer. More commonly, stream gradient is measured from USGS 7.5 min topographic maps by measuring the change in vertical elevation (rise) over the stream segment length (run). One method is to count the number of contour intervals within a given map distance on a topographic map (Watershed Professionals Network 1999). Stream gradient can be expressed two ways, as a percent slope (length of rise over length of run) or as the number of degrees of slope (ranges from 0° or horizontal, to 90° or vertical).

Stream gradient information was not available for the entire study area. There was, however, stream gradient class information available in the USFS densified streams layer for most of the Alsea and parts of the Ocean Tributary and Siletz 6th Field watersheds. (After completion of our analysis, this gradient information was extended by USFS to cover the entire USFS densified streams layer). Stream gradient information is necessary for channel typing described in the Oregon Watershed Assessment Manual, and is also useful for determining areas that may be suitable salmonid habitat. In order to prioritize 6th field watersheds, we developed stream gradient information (**der_stream_ gradient.zip**, shapefile name **der_gradient_4.shp**) for the entire study area using GIS, through analysis of the digital elevation model (DEM). We tried several approaches (see ‘Stream Gradients” in **Appendix A: Supplemental Methods**). The stream gradient data layer that was produced is a computer-generated representation of stream gradient: it is meant to be used as a study-area-wide surrogate for stream gradient information until a better representation of stream gradient can be produced. Before our stream gradient data (or other stream gradient data developed from offsite data) are used to guide site-specific projects, field teams should verify where the data correctly represent stream gradient and where they do not. Certainly, there are some limitations to the derivation of stream gradient from the DEMS. Despite these limitations, this method probably describes actual stream gradients at least as accurately as the current practice of determining average stream gradient for an entire reach from measurements made on paper topographic maps.

7.4.1 Results: Study area summary

MCWC requested we analyze stream gradients in six classes: 0-1%, 1-2%, 2-4%, 4-8%, 8-14%, and over 14% (**Figure AQ-2**). The DEM analysis generates stream gradients in whole degrees only. Using the DEM results, we were able to obtain the following slope classes that roughly correspond to the MCWC slope classes of interest. (We were not able to subdivide the 0-1% and 1-2% slope classes, since 1 degree = 1.75%). **Table 7.1** shows the proportion of the total DEM-derived stream length that falls into each of the slope classes.

Table 7.1. Proportion of stream length by gradient class for the MidCoast study area

Slope (degrees)	**Percent Slope**	**Proportion of Total Stream Length**
0	0.0	7.3%
1	1.75	7.9%
2	3.5	12.9%
3-5	5.24-8.75	24.9%
6-8	10.51-14.1	16.2%
≥ 9	≥15.8	30.8%

7.5 Channel types

Channel type information was not available for the entire study area, although we were able to obtain channel type information from USFS for a limited portion of the study area. In order to develop a study-area-wide stream channel type layer, we queried the DEM-derived stream gradient and stream confinement layers. This resulted in a detailed channel type layer (**der_channel_types.zip**, shapefile name **der_chan_type3.shp**), limited only by the quality of the 10 m DEM and the computer models.

For this assessment, the derivation of stream channel types was dependent on DEM-derived stream gradients and DEM-derived stream confinement. The digital elevation model (DEM) cells are 10 X 10 m and are, therefore, too large to detect small but biologically important topographic detail such as 1 or 2 m slope breaks that form confining stream terraces. As a result, the GIS methods used to derive confinement and gradient probably obscure important topographic information necessary to better describe these two stream attributes. In addition, stream gradient was calculated in degrees and was converted to percent slope. Since 1 degree equals 1.75% slope, our method did not allow us to separate out the lowest stream gradient classes (1% *versus* 2%). Despite these limitations, we proceeded with derivation of important characteristics (gradient, confinement and stream location) from the DEM data, because at the time of this study, no other complete GIS data were available at a scale appropriate for our analysis. The first approximation of these important stream characteristics generated from the DEM will serve as a stand-in until comprehensive data are available and have been field-checked for accuracy.

Because DEM-derived stream gradients were originally calculated in degrees by ARCView our conversion to slopes were rounded, as described in **Stream gradients** above. The slope categories we created from the DEM gradient analysis resulted in the channel types shown in **Table 7.2**.

Table 7.2. Stream Channel Types

Slope %	Confined	Unconfined
0		EL, ES, FP1
≤ 1.75	LC	FP2-3
3.50	MC	MM
5.24-8.75	MV	MV-U
10.51-14.1	SV	SV-U
≥15.8%	VH	VH-U

We found that it was necessary to create several new categories that are not described in the OWEB manual (Unconfined for MV, SV, and VH). These categories represent areas where the stream channel is not confined in the upper watershed -- for example, stream confluences or areas of beaver activity. In any case, we recommend that this data layer be field checked as soon as possible. We used the computer to classify all categories with slopes > 0 and we hand coded the EL, ES and FP1 stream channel types.

7.5.1 Results: Study area summary

Results of the channel type analysis are shown in **Table 7.3** below and in **Figure AQ-3**.

Table 7.3. Summary of length and proportion of total stream network by stream channel type.

Stream Channel Type	Description	Length (m)	Percent of total stream length
VH	Very steep headwater	1,918,904.4	30.7%
SV	Steep narrow valley	975,285.6	15.6%
MV	Moderately steep narrow valley	850,160.9	13.6%
MV-U	Moderately steep narrow valley, unconfined	686,758.8	11.0%
MM	Moderate gradient, moderately confined	653,066.5	10.4%
FP2-3	Low-gradient small to medium floodplain	416,717.8	6.7%
FP1	Low-gradient large floodplain	356,134.0	5.7%
EL	Large estuary	136,914.6	2.2%
MC	Moderate gradient confined	124,490.7	2.0%
LC	Low gradient confined	61,525.3	1.0%
ES	Small estuary	40,399.8	0.6%
SV-U	Steep narrow valley - unconfined	33,872.8	0.5%
VH-U	Very steep headwater -- unconfined	5,761.5	0.1%
Total		6,259,992.6	100.00%

We found that the majority (about 60%) of stream channels in the study area belong to the high gradient, confined channel types. These types of channels function to transport sediment, wood and other materials from the upper watershed to the lower stream reaches. Therefore, we recognize that these higher gradient channels are important components of "fish habitat," even though fish do not inhabit them directly.

7.6 Aquatic habitat survey (AHI) data

7.6.1 ODFW benchmarks

Several organizations have produced habitat benchmarks, or ranges of values for habitat parameters that they consider indicative of desirable and undesirable salmonid habitat conditions. The set of benchmarks recommended in the OWEB Watershed Assessment Manual (Watershed Professionals Network 1999) are from the Oregon Department of Fish and Wildlife and are shown in **Table 7.4**.

Table 7.4 ODFW habitat benchmarks

Stream characteristic	**Undesirable**	**Desirable**
Pools		
Pool area (percent of total stream area)	<10	>35
Distance between pools (# of channel widths)	>20	5-8
Residual pool depth (meters)		
Small streams (<7m width)	<0.2	>0.5
Medium streams (≥7m & <15m width)		
Low gradient (slope <3%)	<0.3	>0.6
High gradient (slope >3%)	<0.5	>1.0
Large streams (≥15m width)	<0.8	>1.5
Complex pools/km (pools w/wood complexity>3)	<1.0	>2.5
Riffles		
Width:Depth ratio (Western Oregon)	>30	<15
Substrate		
Gravel substrate (% area)	<15	≥35
Silt+sand+organic substrates (combined % area)		
Volcanic parent material	>15	≤8
Sedimentary parent material	>20	≤10
Channel gradient <1.5%	>25	≤12
Shade		
Shade (reach average %)		
Stream width <12m (western Oregon)	<60	≥70
Stream width >12m (western Oregon)	<50	≥60
Woody debris		
Large woody debris (15cm X 3m minimum size)		
# of pieces/100m stream length	<10	≥20
Volume/100m stream length (cubic m)	<20	≥30
'Key' pieces (>60cm X 10m) per 100m stream length	<1	≥3
Riparian conifers		
Riparian conifers within 30m of stream		
Number >20in dbh/1000 ft stream length	<150	≥300
Number >35in dbh/1000 ft stream length	<75	≥200

Source: (Watershed Professionals Network 1999)

7.7 Extent of AHI data

7.7.1 Absolute lengths surveyed

We compared the length and proportion of the stream network surveyed to identify 6th field watersheds that either lack aquatic habitat surveys or require additional data collection.

A total of 1,606 km of aquatic habitat survey data were analyzed for this assessment. We calculated the total length of streams surveyed and number of 6th fields with data from each data source. As an index of the extent of survey data relative to the total stream network, we also calculated the proportion of the length of the 1:100 K streams layer surveyed. **Table 7.5** shows these surveyed lengths and proportions. All lengths shown in **Table 7.5** were based on corrected field-measured lengths [see ODFW protocol (Moore *et al* 1998)], not GIS feature lengths. For details on different length parameters, see **GIS length *versus* field-measured length** in **Appendix A: Supplemental methods**). We used the 1:100 K streams layer for the proportion of the stream network surveyed, because the AHI data use it as a base layer. (For a more detailed discussion of the proportional length surveyed, see **Survey extent: Percent of 1:100K stream network surveyed** below). The total number of 6th fields with data from all sources is less than the sum of the individual sources because some 6th fields had data from more than one source. However, there were few cases of overlap in data from different sources; in general, streams surveyed by ODFW were not surveyed by USFS and *vice versa*.

Table 7.5. Aquatic habitat survey data sources and lengths

Source	**Length surveyed (m)**	**Survey extent**	**# of 6th fields with data**
USFS Region 6	582,664	19.6%	62
ODFW AHI GIS	907,328	30.5%	94
Lincoln District AHI	116,246	3.9%	19
Total surveyed	**1,606,237**	**54.0%**	**154**

* "Survey extent" equals total length surveyed, expressed as percent of the total length of the 1:100K streams layer for the study area.

For comparison, the total length of the DEM-generated streams layer is 6,293,804m, and the total length of the 1:100K streams layer is 2,974,963m. And, there are 217 6th field watersheds in the study area.

We found that not all 6th field watersheds have been equally surveyed. For those 6th field watersheds surveyed, the mean length surveyed is 10,430m. Of the 217 6th field watersheds, 63 watersheds had no AHI survey data, and an additional 46 had less than 5 km of survey data. **Figure AQ-4** shows the watersheds color-coded by the length of streams surveyed. The differences in length and proportion of stream network surveyed should be considered when evaluating results of the analysis.

7.7.2 AHI Survey extent

We also considered the "survey extent," or the proportion of the stream network surveyed. Since the total length of the stream network varies from one 6th field to the next, another useful way to look at the level of AHI sampling effort is to calculate the proportion of a 6th field's stream network that was surveyed. This proportion could be referred to as the "survey extent". We calculated a parameter in the aquatic habitat inventory summary layer (**aqhab_sum_final.zip**, shapefile name **aqhab_sum_final.shp**) called **p100k_all** to express the proportional extent of survey data. **P100k_all** shows the length of available survey data for each 6th field expressed as a percentage of the length of the 1:100K streams layer in that 6th field. We chose the 1:100K streams layer as a basis for comparison because the ODFW AHI data were supplied in GIS format using the 1:100K streams base layer. We found that values for **p100k_all** ranged from 0 to 421% with a mean of 56% (**Figure AQ-5**). Some 6th field watersheds show a total survey extent exceeding 100% of the length of the 100K streams layer. This is to be expected, because many streams surveyed are not shown on the 100K streams layer or are depicted on the 1:100K map as being shorter than their field-measured length, so the sum of surveyed lengths can add up to more than the length of the 100K streams layer (i.e., field measured length is greater than map length).

7.8 AHI survey date

Survey dates for aquatic habitat data used in this assessment ranged from 1990 to 1999. Distribution of survey length by year and by data source is shown in **Table 7.6** below. Since the bulk of the AHI data that were available to us for this assessment are over 5 years old, we recommend resurvey of critical reaches as soon as possible. Conditions measured in aquatic habitat surveys, such as quantities of large woody debris and substrate composition can change considerably over the course of a single year. Therefore, 5 to 10 year old data may no longer accurately represent conditions in the watershed. In fact, 79% of the stream surveys (by length) were done in 1995 or earlier.

Table 7.6. Aquatic habitat survey length by year and source.

	Length (m)				
YEAR	**USFS R6**	**ODFW GIS**	**LD AHI**	**Total**	**Proportion**
1990		13,176		13,176	0.67%
1991	62,518			62,518	3.17%
1992	228,294	185,004		413,298	20.93%
1993	133,452	235,965		369,417	18.71%
1994	186,901	225,076		411,977	20.86%
1995	84,267	165,904	38,565	288,736	14.62%
1996	62,136	12,084	13,001	87,221	4.42%
1997	16,152	130,486	46,101	192,739	9.76%
1998	92,718		4,183	96,901	4.91%
1999	24,152		14,728	38,880	1.97%
Total	890,590	967,695	116,578	1,974,863	100.00%

7.9 AHI data: Sources

7.9.1 AHI survey extent threshold

We used average or summed values of AHI data from several sources to characterize 6th field watersheds. Some 6th field watersheds had very little AHI data and, therefore, existing data may not have been representative of the watershed condition. We felt it could be misleading to characterize these watersheds using only the very small amounts of AHI data available. Thus, we set a threshold for minimum length of AHI data that would be used to characterize a 6th field watershed. We set this threshold at 5 percent of the length of the 1:100K streams layer. That is, we did not summarize AHI data from 6th fields where the length of AHI data was less than 5 percent of the length of the 1:100K streams layer for that basin. This threshold was applied to all AHI data analyses. To determine the length of survey available, we used actual surveyed length (from USFS and Lincoln District surveys) or GIS length (from ODFW GIS data). See **Appendix A: Supplemental methods** ("**Interpreting the results of AHI analyses: GIS length *versus* field-measured lengths**") for a discussion of why we chose these length measurements for this purpose.

7.9.2 GIS data

We acquired and evaluated GIS data on aquatic habitats from two sources -- the ***ODFW AHI GIS*** and a GIS layer of stream survey data obtained from USFS. In the final analysis, we were not able to make use of the USFS GIS data (for reasons described below). However, USFS Stream Inventory data were a vital part of this assessment through use of the USFS Region 6 tabular data (**REG6habs_final.xls**) as described below.

7.9.2.1 ODFW GIS data

ODFW GIS coverages of aquatic habitat data were obtained from the Freshwater Habitat Project website: *http://osu.orst.edu/Dept/ODFW/freshwater/inventory/gis.html***.**

These GIS data are available in two formats: reach-level data (**aqhab_odfw_final.zip**) and habitat unit-level data (available at the ODFW website shown above). Both datasets are based upon the same field data; the reach-level GIS layer summarizes the habitat-unit level data and adds some office-based information. We analyzed these data both at the habitat level and at the reach level, depending on MCWC needs and the variable of interest.

7.9.2.2 USFS GIS data

In addition to the ODFW GIS data, a GIS coverage of aquatic habitat data was obtained from the USFS through Shawn McKinney at the Siuslaw National Forest Supervisor's Office in Corvallis. Mr. McKinney developed the GIS layer as a part of a regional-scale analysis of aquatic habitats. The data were obtained as an ArcInfo export file. We compared the USFS GIS layer to the Region 6 tabular data described below and determined that the USFS GIS layer showed only about 1/3 of the USFS-surveyed streams. The USFS GIS layer also contained data from stream surveys conducted by BLM, ODFW, and industry groups which were also found in the ODFW GIS dataset.

Consequently, the USFS GIS layer was not used in this assessment because it overlapped significantly with the ODFW GIS coverage and the USFS Region 6 tabular data (see next section), and contained only a limited subset of parameters compared to the Region 6 tabular data.

7.9.3 Non-GIS data

We also acquired aquatic habitat data from two non-GIS data sources: USFS Region 6 Stream Inventory tabular data, and Lincoln District Aquatic Habitat Inventory data.

7.9.3.1 USFS Region 6 tabular data

We obtained tabular USFS stream inventory data from the USFS Region 6 Office (contact: Carol Apple, 503-808-2911). These data, collected in 1991 through 1999, covered many reaches not included in the USFS GIS layer. The format of the data ("SMART" database output to comma-delimited text files only, no column headers, separate tables for different types of data, very limited metadata) required time-consuming manipulation and summarization to extract data needed for the assessment. However, these data more than doubled the total miles of field-based aquatic habitat survey information available for the assessment, so we felt the time commitment was justified.

We worked with the Region 6 tabular data in Excel (**REG6habs_final.xls**), creating cross-references to provide identifying information for each record. We used Excel to create pivot tables that summarized parameters of interest by reach and by 6th field (HUC). Data were tied to 6th field watersheds using the Siuslaw National Forest watershed codes, described in the Stream Inventory Handbook (U.S. Forest Service 1999). Details on contents of the Excel spreadsheet and other data manipulations are found in **Appendix A: Supplemental Methods**.

Data that are in GIS format can be analyzed in ways that are not possible with data tables alone. Therefore, we attempted to obtain the Region 6 Stream Inventory data in GIS format. We also investigated the possibility of converting the tabular data to GIS format. Although maps provided with USFS watershed analyses suggested that at least some stream inventory data had been entered into GIS, we were not able to obtain these data from USFS for this assessment. We also checked to see if LLIDs had been assigned to the surveyed stream reaches. LLIDs describe specific locations to which tabular data can be spatially referenced and, therefore, be used to create a GIS layer. To investigate this possibility, USFS referred us to the Pacific States Marine Fisheries Commission (PSMFC). According PSMFC staff (David Grave, personal communication), LLIDs had not been assigned to USFS-surveyed streams in our study area. Without a streams layer containing LLIDs, creating a new GIS layer would have been beyond the scope of this project. Since the tabular format of the data was acceptable for its use in 6th field prioritization, we did not further pursue creation of a GIS layer from the USFS data. We were able to assign nearly all of the tabular data to 6th fields using the Siuslaw National Forest watershed codes contained in the data (see **Appendix A: Supplemental Methods** for details).

7.9.3.2 Lincoln District AHI data

To make this assessment as complete as possible, we used data from surveys conducted by Mark Stone and Kip Wood of the Lincoln Soil and Water Conservation District ("Lincoln District" data). These surveys were collected using the same protocol as ODFW uses for all of its Aquatic Habitat Inventory projects. The Lincoln District survey data had been summarized by ODFW and paper copies of the summaries were provided to us by the Lincoln District. However, the Lincoln District data were not available electronically because ODFW had not incorporated the results of the surveys into its GIS and was not able to provide a database of the summary results. Therefore, we re-entered the Lincoln District data into an Excel spreadsheet (**aqi_LD_final.xls**) to allow analysis by 6th field watershed. These data were summarized using the methods described for each parameter below.

7.10 AHI data: Analyses

7.11 Stream Morphology from AHI data

7.11.1 Riffles

The occurrence of riffle areas in streams is useful in evaluating fish habitat, particularly for steelhead. Under ODFW and USFS stream survey protocols, riffles are defined as areas of fast, shallow flow. The ODFW protocol divides riffles into two types, "Riffle" and "Riffle with pockets." The USFS protocol does not subdivide riffles.

We obtained the total length of riffle areas for the three AHI data sets separately. To obtain the total length of riffle units for each 6th field from USFS Region 6 tabular data, we summed the corrected lengths of all units defined as type "R" (riffle). For the ODFW GIS data and the Lincoln District AHI data, we summed the lengths of all units classified as type "RI" (riffle) and "RP" (riffle with pockets). The ODFW total length (GIS feature length) was calculated in the habitat-level GIS layer to obtain a reach total, then joined that total to the reach-level GIS layer (**aqhab_odfw_final.shp**). We calculated total riffle length in the Lincoln District database (**aqi_LD_final.xls**). Total riffle length per reach from all three sources was then summarized by 6th field and joined to the aquatic habitat summary table (**Lrif_all** in **aqhab_sum_final.shp**). The total length of riffle habitat for each 6th field watershed is shown in **Figure AQ-6**.

7.11.1.1 Interpretation

MCWC requested we use total length of riffle units from AHI surveys to compare and prioritize 6th field watersheds (rather than proportion of the surveyed stream network that consists of riffle units). Several issues must be considered when interpreting the results of analysis of absolute lengths. We describe these issues in **Appendix A: Supplemental methods** (**AHI data**, subsections on **Absolute length *versus* proportion of surveyed length** and **Proportional extent of survey data**).

One issue that arises when using absolute lengths for comparing watersheds is the difficulty of separating real differences in habitat quality from differences in sampling effort. As can be seen by comparing **Figure AQ-6** (length of riffle units) to **Figure**

AQ-4, (length of aquatic habitat surveys), the length of riffle habitats is very closely correlated with the total length of streams surveyed. This is due to the use of absolute lengths for this analysis, as requested by MCWC. However, use of proportional lengths can also raise interpretation problems. For example, proportional lengths obscure the very real differences between the biological value of a small total amount of habitat and a large amount. To make use of the advantages and adjust for the disadvantages of each method, we recommend MCWC re-analyze the data using proportional lengths, and use both analysis methods together as appropriate to allow the best possible management decisions.

7.11.2 Side channel / secondary channel habitat

Side channels and secondary channels are important to salmonids because they provide refuge from rapid stream velocities during high flow events. The ODFW and USFS stream survey protocols define each habitat unit as either a primary (mainstem) or secondary (side) channel. To obtain length of secondary and side channels for each 6th field from USFS Region 6 tabular data, we summed the lengths of all units defined as type "SC" (side channel). For the ODFW GIS data and the Lincoln District AHI data, we summed secondary channel length (the field "sechnll" in the ODFW GIS coverage) to obtain a total for each 6th field. We then summed all three values together to obtain a total length of secondary/side channels for each 6th field (**Lschnl_all** in **aqhab_sum_ final.shp**); this length is shown in **Figure AQ-7**.

7.11.2.1 Interpretation

MCWC requested we use total length of side/secondary channels from AHI surveys to compare and prioritize 6th field watersheds (rather than proportion of the surveyed stream network that consists of side/secondary channels). Several issues must be considered when interpreting the results of analysis of absolute lengths. We describe these issues in **Appendix A: Supplemental Methods** (**AHI data**, subsections on **Absolute length *versus* proportion of surveyed length** and **Proportional extent of survey data**).

One issue that arises when using absolute lengths for comparing watersheds is the difficulty of separating real differences in habitat quality from differences in sampling effort. As can be seen by comparing **Figure AQ-6** (length of side/secondary channels) to **Figure AQ-4**, (length of aquatic habitat surveys), the length of side/secondary channels is very closely correlated with the total length of streams surveyed. This is due to the use of absolute lengths for this analysis, as requested by MCWC. However, use of proportional lengths can also raise interpretation problems. For example, proportional lengths obscure the very real differences between the biological value of a small total amount of habitat and a large amount. To make use of the advantages and adjust for the disadvantages of each method, we recommend MCWC re-analyze the data using proportional lengths, and use both analysis methods together as appropriate to allow the best possible management decisions.

7.11.3 Percent pools

Pools are important to salmonids because they provide a diversity of habitats in the stream system. The variety of channel bed form and flow characteristics provided by pools give salmonids many different environments for foraging, shelter from predators and high stream velocities, and resting. Water temperatures in pools are often layered in summer, providing deeper, cooler water for escape from high surface temperatures. ODFW and USFS stream survey protocols define pools as areas of little or no water surface gradient, having a hydraulic control such as a log, impinging streambank, boulder, bedrock wall, or other obstruction.

"Percent pools" represents the proportion of the total surface area of a stream reach that consists of habitat units defined as pools. We calculated percent pools for the USFS tabular data by dividing pool area by total area for all habitat types. Percent pools were present as a reach characteristic in the ODFW GIS data and in the ODFW paper summaries from which the Lincoln District data were entered.

We averaged percent pools for each 6th field separately for each data source. To normalize results, we weighted this average by the length of each reach. (We found that it was rare for one stream reach to be included in all three data sources). We then averaged percent pools across all data sources (field **Zpls_all**) in the summary shapefile **aqhab_sum_final.shp**, weighting this final average by the length surveyed from each data source. The results (average percent pools for each sixth field watershed) are shown, along with ODFW benchmarks for this parameter, in **Figure AQ-8.**

7.11.4 Channel widths per pool

Pool frequency expresses how many pools are found per unit of stream length or stream area. "Channel widths per pool" is an inverse measure of pool frequency. A higher value of channel widths per pool represents a lower pool frequency, i.e., a less desirable condition (fewer pools). "Channel widths per pool" (**cwpool**) was present as a reach characteristic in the ODFW GIS data (**aqhab_odfw_final.shp**) and in the ODFW summaries from which the Lincoln District data were entered. Channel widths per pool were calculated for the USFS Region 6 tabular data using the ODFW formula:

$$\text{cwpool} = \frac{\text{(reach length) / (reach average active channel width)}}{\text{Number of pools in reach}}$$

where reach length = primary channel length + secondary channel length.

We averaged channel widths per pool for each 6th field separately for each data source. To normalize results, we weighted this average by the length of each reach. We then calculated 6th field averages for channel widths per pool across all data sources (field **cwpl_all**) in the summary shapefile **aqhab_sum_final.shp**), weighting this final average by the length surveyed from each data source. The results (average channel widths per pool for each sixth field watershed) are shown, along with ODFW benchmarks for this parameter, in **Figure AQ-9**.

Within the study area, 6th field averages for channel widths per pool ranged from 1.7 to 347, with an average of 21.8. The ODFW benchmarks for channel widths per pool show that a value of over 20 is considered “undesirable”, while values of 5 to 8 are considered “desirable.” A total of 43 6th field watersheds (about 20%) had “undesirable” average channel widths per pool of over 20. One hundred eleven 6th field watersheds had an average of less than 20 channel widths per pool (between “desirable” and “undesirable”), and 58 6th field watersheds had a “desirable” average of less than 8 channel widths per pool. The presence of a few 6th field watersheds with very high values for this parameter affected averages. For example, the highest of these was Elk Creek of the Middle Siletz drainage, with an average value of 347 channel widths per pool, resulting from 1.5 km of survey with only a single pool shown in the ODFW database.

Interpretation of these data also requires consideration of the stream morphological factors producing high channel widths per pool. High values for this parameter may be present both in the lowest parts of the watershed, where normal stream morphology results in few pools, as well as in the upper, higher-gradient streams. Thus, a single benchmark may not be particularly useful in interpreting the data.

7.11.5 Channel width-to-depth ratio

Channel width-to-depth ratio is of interest in watershed assessment because it is one way of describing stream channel morphology. A high width-to-depth ratio is considered undesirable because shallow water can be warmed rapidly by sunlight and surrounding warm soil and air in summer, creating temperatures too high for salmonids. We conducted several analyses of data available to us to see if we could use width-to-depth ratio in this assessment. ODFW and USFS protocols calculate width-to-depth ratio differently (see next section).

USFS Region 6 data versus *ODFW data:* According to the ODFW AHI GIS metadata (Jones 1999), width-to-depth ratio is calculated from wetted width and depth in riffles. Although the USFS Region 6 stream inventory data contain wetted width and depth, width-to-depth ratio calculated from these data for riffle units does not appear to be equivalent to the ODFW width-to-depth ratio as benchmarked in the OWEB Watershed Assessment Manual. We calculated width-to-depth ratio for all reaches in the Region 6 database, and compared the results to the ODFW benchmarks. Since nearly all streams had a ratio at the low end of the ODFW benchmark scale (average width-to-depth ratio was only 12.7), it appears that protocol differences prevent direct comparison of USFS and ODFW width-to-depth ratios. There are several possible reasons for this lack of equivalence. The ODFW benchmarks provided in the OWEB Watershed Assessment Manual (Watershed Professionals Network 1999) specify that width-to-depth ratio is "active-channel based." However, the ODFW reach-level AHI GIS contains only a field called **WDRATIO** which is described as being calculated "in riffles as wetted width/wetted depth" (Jones 1999). Also, the USFS protocol measures riffle unit depth as maximum depth, while the ODFW protocol measures typical or modal depth of riffle units. Width-to-depth ratio was not requested as a priority analysis by MCWC, so no further action was taken to resolve these methodological discrepancies for the purposes of this assessment.

Potential of using width-to-depth ratio as a surrogate for entrenchment / floodplain connectivity: MCWC requested we investigate the possibility of using width-to-depth ratios as a surrogate for entrenchment and floodplain connectivity data. We analyzed width-to-depth ratio for the study area to determine possible analytical approaches. We found that width-to-depth ratios are apparently not comparable between the USFS data and the ODFW data (see **USFS Region 6 data *versus* ODFW data** above), greatly limiting our ability to use width-to-depth ratio as a factor in 6th field prioritization. Despite this potential problem, we investigated the relationship between channel form and width-to-depth ratio for the ODFW AHI GIS reaches. Unconstrained channel forms (US, UA, and UB in **aqhab_odfw_final.shp**) are broad valley floor channel types in which the channel frequently floods over its banks into its floodplain. Of the 441 reach-level records in the ODFW AHI GIS, 31 reaches (totaling 51,000 m in length) are defined as unconstrained channel forms (US, UA, or UB). For these unconstrained channel form records, mean width-to-depth ratio is 31, standard deviation is 30, and range is 3 to 151. For comparison, the overall mean width-to-depth ratio among all 441 ODFW records is 22, standard deviation is 17, and range is 0 to 151. This difference (between the width-to-depth ratio for constrained *versus* unconstrained channel forms) is not significant using a t-test ($t=0.786$, $p>0.10$).

Entrenchment and floodplain connectivity: Since 1998, the ODFW AHI survey protocol (Moore *et al* 1998) has included collection of data on entrenchment and floodplain connectivity. The ODFW GIS layer metadata state that entrenchment is calculated as the ratio of floodprone width to active channel width. Neither entrenchment nor floodprone width data were collected prior to 1998. The AHI GIS dataset that was available for this assessment contained only records from prior to 1998, so data on entrenchment and floodprone width are not available for this assessment. Even a more recent GIS layer would have entrenchment and floodprone width data for only a subset of records (those collected since 1998). The recent addition of these measurements to the AHI protocol makes further collection of AHI data even more important.

7.11.6 Channel modifications

Channel modifications could not be addressed in this assessment due to a lack of data. No GIS data sources for channel modifications were available at the time of this study. Even non-GIS data on this topic is very difficult to find. Detailed, site-specific information on channel modifications will be important for the next phase of sub-6th field assessment work, and in developing site-specific action plans. We recommend Basin Planning Teams conduct fieldwork to determine locations of channel modifications, and record the locations and attributes of the modifications in the MidCoast GIS.

7.12 In-stream structure

7.12.1 Rapid bioassessment pool complexity

The Rapid Bioassessment project (Bio-Surveys Inc. 1998) rated pool complexity for each pool snorkeled. Pool complexity is a visual estimate based on percent of the pool surface area that has cover from wood, large substrate, undercut banks, and overhanging vegetation. Values for pool complexity range from 1 to 5: 1 = 0% cover, 2 = 1-25% cover, 3 = 26-50% cover, 4 = 51-75% cover, and 5 = >75% cover.

To maintain a close relationship between the juvenile coho density and pool complexity data, we chose to use the same pools for both analyses. Thus, as we did for juvenile coho density, we followed recommendations in the Rapid Bioassessment 1998 report (Bio-Surveys 1998) to eliminate from the averages data from pools outside the observed distribution of coho. As recommended, we utilized data only from pools falling within the distribution of coho for each surveyed stream. The points included in the averages were saved as separate shapefiles (**rba98_distrib_by6th.zip** and **rba99_distrib_by6th.zip**). Specifically, we excluded from the average those pools located upstream of the last pool in which coho were observed, and, for mainstems, downstream of the first pool in which coho were observed.

We averaged the 1998 and 1999 values of pool complexity within the observed coho distribution for each 6th field in a summary layer (**plco9899** in **rba_sum_final.shp**). We weighted the average values by the number of pools snorkeled in each year to normalize results, then color-coded the 6th fields for pool complexity (**Figure AQ-10**). We also summed the number of pools surveyed in either 1998 or 1999 (**Npls9899**) for each 6th field. Sixth field watersheds with less than 10 pools snorkeled during 1998 and 1999 are indicated with a red outline on the pool complexity map.

7.12.2 Large Woody Debris

Large woody debris (LWD) and Key LWD (defined by ODFW as pieces of woody debris over 60 cm in diameter) are important components of stream structure. Large wood provides cover that can shelter salmonids from predators, and contributes organic material to the aquatic food chain. Logs provide stream structure to help reduce stream velocities, create pools, and generally diversity in the stream environment.

7.12.3 LWD frequency

During stream surveys, the quantity of large woody debris in a stream is expressed as "wood frequency", or pieces of wood per 100m of stream length (see description of protocol differences). The USFS Region 6 protocol (U.S. Forest Service 1999) calculates wood frequency based on stream area, while the ODFW GIS layer (reach dataset) bases the calculation on stream length. Since the ODFW habitat benchmark (Watershed Professionals Network 1999) uses wood pieces per 100m of stream length, we chose to create new summary parameters within the USFS Region 6 dataset (**REG6habs_final.xls**) to make the USFS data as comparable as possible to the ODFW data.

We created new variables in **REG6habs_final.xls**, which are **lwd_100m** (number of pieces of large woody debris per 100m primary channel length) and **keylwd_100m** (number of key pieces of large woody debris per 100m primary channel length). To obtain these values, we summed all pieces of woody debris from the habitat unit database to get LWD pieces per reach. We summed USFS categories "medium" and "large" to get total key pieces per reach. (These sums are as close to the ODFW definitions of "LWD" and "key LWD" as possible, given the protocol differences; see **Interpretation** below.) We then divided these totals by the reach length and multiplied by 100 to get LWD pieces and key pieces per 100m. We then calculated 6th field averages for these values, weighting by reach length to normalize results (**R6av_lwd10** and **R6av_key10** in **aqhab_sum_final.shp**).

For the ODFW GIS data, the reach-level parameters **LWDPIECE1** and **KEYLWD1** (**aqhab_odfw_final.shp**) provided values that are comparable to the wood pieces per 100m measures calculated for the USFS R6 wood frequency values. For the Lincoln District AHI data, we used the values "All pieces per 100m" and "Key pieces per 100m" from the Valley and Channel Summary sheets.

We averaged together the LWD pieces/100m and key pieces/100m values from the three data sources for a final average wood frequency per 6th field. These averages were weighted by the corrected length of survey data from each source to normalize results. The results (average LWD pieces/100m and average key pieces/100m for each 6th field watershed) are shown in **Figures AQ-11** and **AQ-12**, along with ODFW benchmarks for these parameters.

7.12.3.1 Interpretation

Use caution in interpreting results of analyses that make use of data collected using different protocols. As previously mentioned, the methods for quantifying large woody debris differ between the ODFW Aquatic Habitat Inventory protocol (Moore *et al* 1998) and the USFS Region 6 Stream Inventory protocol (U.S. Forest Service 1999). For example, the ODFW method counts all woody debris that is within, partially within, or suspended over the active channel, while the USFS protocol counts only woody debris that is within the active channel. There are also differences in how diameter of woody debris is measured. ODFW estimates diameter at 2 m above the base of the stem, while USFS estimates diameter at a variable distance from the base, depending on the length of the woody debris piece and the bankfull width of the stream in which the debris is located. Finally, ODFW counts woody debris with a diameter of 6" or greater, while the USFS protocol records only woody debris with a diameter of 12" or more.

Despite the differences between the protocols, we decided to combine the data from ODFW and USFS to obtain an average value for LWD pieces and key pieces per 100m for each 6th field, as described above.

7.12.4 LWD source areas

The importance of large woody debris is recognized in Pacific Northwest forests. Woody debris can directly affect the organisms that inhabit our forests by serving as shelter or as a food source. In addition, woody debris and other organic material can affect the physical environment of the forest (thus, indirectly affecting organisms) by slowing down water moving over the forest floor and into streams. Reduction of water velocity can lead to reductions in sediment delivery to forest streams. Therefore, large wood can play a role in establishing the complex terrestrial and in-stream environments favorable for many organisms, such as salmon (see **Appendix B: Ecological Processes**). Of all the structural components in the terrestrial ecosystem, woody debris is one of the slowest components of the forest ecosystem to recover after disturbance (Spies *et al.* 1988). A watershed management strategy should strive to (1) identify and preserve areas that serve as large wood sources and (2) regenerate areas where large wood may no longer be present.

Many salmon habitat restoration actions involve the short-term measure of placing large wood directly in streams to enhance salmonid habitat. Longer-term strategies can also be used to manage watersheds. For example, watershed managers can plan for large wood recruitment by allowing trees to reach larger sizes in areas that may be prone to mass wasting events.

Charlie Dewberry (Schoonmaker *et al* 1997) describes a process where small "hollows" were identified in Knowles Creek. Dewberry recognized that these hollows accumulate sediments over thousands of years. During winter storms, debris torrents can originate in these hollows leading to the delivery of sediments and large wood to the stream network. Therefore, the restoration of Knowles Creek not only called for the placement of large woody debris in streams, but also planted and planned for the maturation of trees in and down slope from these hollows. These actions focused on both watershed structure and watershed function (the ecological process of sediment and large wood delivery to streams).

We considered longer-term ecological processes in this watershed assessment. Unfortunately, we did not find any primary data sources to evaluate each 6th field watershed's ability to contribute LWD to streams. The CLAMS95^{W} data, which describe 12-14 vegetation cover classes, do exist; however, due to concerns about the spatial accuracy of the data, the MCWC Tech Team directed us not to use these data for this analysis. Instead, we used the results of the landslide risk assessment (SMORPH), zoning information and the derived streams network to perform a multi-factor analysis.

First, we used ArcInfo to create a 200 ft buffer around the Derived Streams Layer (200 ft on each side). This buffer was used to 'clip' the shallow landslide risk grid. We found that the 200 ft stream buffer contained about 19.4% of the study area. That is, about a 5th of the study area is within 200 ft of a stream. We then selected stream segments passing through areas zoned for forestry from the stream buffer-SMORPH coverage. Thus, we considered potential large wood source areas to be areas that had a high risk of shallow landslide, were in areas zoned for forestry, and occurred within 200 ft of a stream. We ranked watersheds by the proportion of the total stream buffer area occupied by areas at high risk of shallow landslide (**Figure AQ-13**).

The patterns of potential large wood delivery to streams (**Figure AQ-13**) largely follow patterns of shallow landslide risk (**Figure SED-1**): where shallow landslide risk is great, so is the potential for large wood to be delivered to streams. We found that the average 6th field had about 24.0% of its stream buffer area identified as large wood source areas. Individual 6th field watersheds had from 0.4% to 43.4% of their 200 ft stream buffer occupied by areas both prone to shallow landslide and zoned for forestry.

Most of the major river basins had 6th field watersheds that had high proportions of their stream buffer areas identified as potential wood sources. These watersheds are listed in the **Basin Inserts**.

As more information becomes available, this multi-factor analysis can be improved. For example, an up-to-date vegetation layer would be very useful to identify areas that are prone to landslide and currently covered with mature conifers or that are bare. Management strategies could then be geared toward preserving the best remaining sources of large wood, in the case of the former, and planting conifer seedlings in the case of the latter. This was the strategy undertaken on Knowles Creek. Finally, the intermediate GIS layer that was produced during this analysis is useful for locating specific areas (100 m^2 areas) prone to shallow landslide, zoned for forestry, that occur within 200 ft of a stream.

7.13 Substrates

For the 6th field assessment, as requested by MCWC, we analyzed data on particle size of substrates from riffle units. The analyses conducted were: (1) length of riffle units with gravel-sized substrate dominant; (2) length of riffle units with bedrock dominant; and (3) length of riffle units with gravel-to-boulder-sized substrate dominant. In each case, "dominant" was defined as a particular particle size (or range of particle sizes) occupying more than 50% of the surface area of the streambed (Moore *et al* 1998).

Field crews following the ODFW AHI protocol estimate the percent of the streambed covered by each substrate particle size (silt and fine organic matter, sand, gravel, cobble, boulder, and bedrock). These data are available in the ODFW habitat-unit-level GIS layer. We summarized these data by reach for units defined as "riffle" or "riffle with pockets", to obtain average riffle substrate composition (% gravel, % cobble, etc.) for each reach. We then joined those reach averages to the ODFW reach-level GIS shapefile (**aqhab_odfw_final.shp**). We then selected the reaches where the substrate of interest occupied more than 50% of the streambed, summarized the GIS feature length of those selected reaches by 6th field, and joined to the 6th field summary layer (**aqhab_sum_final.shp**).

The USFS Region 6 data did not contain percent composition of substrates, but instead contained a field describing the dominant substrate for each “Natural Sequence Order” (NSO) or survey unit. The USFS stream survey protocol (U.S. Forest Service 1999) did not describe how “dominant” was defined. However, the protocol did list the size categories for substrates, which were identical to those used by ODFW, so the data could be handled similarly. In the Region 6 database (**REG6habs_final.xls**), we summed the lengths of all habitat units (NSO's) with substrate dominated by each particle size or range of particle sizes.

For the Lincoln District data, we used substrate data from units classified as "riffle" and "riffle with pockets" to determine lengths of stream dominated by the various substrate categories. As for the other data sources, we summarized those lengths by 6th field.

For each 6th field watershed, we summed the lengths of riffle units with the three substrate types from all three aquatic habitat survey data sources. We mapped the total length for each category separately (**Figure AQ-14** for gravel, **Figure AQ-15** for bedrock, **Figure AQ-16** for gravel to boulders). We also used these data for multi-factor analyses of coho and steelhead habitats below.

7.13.1 Interpretation

In the ODFW GIS dataset, the field RIFGRA represents "average percent gravel in riffle units only" (Oregon Department of Fish and Wildlife 1999), but according to ODFW staff, the averages are also taken from cascade and/or rapids units, if there aren't enough riffle units in a particular stream segment (Charlie Stein, ODFW, personal communication). Staff judgment is used to make the decision on whether or not to include cascade and/or rapids units. Their decision therefore could not be duplicated by our team, so we went back to the habitat unit level data and used substrate data from habitat units defined as type "RI" (riffle) and "RP" (riffle with pockets). By using this procedure, we extracted data from the ODFW information that was comparable to the data from the USFS data.

MCWC requested we use total length of riffle units with various substrates to compare and prioritize 6th field watersheds (rather than proportion of the surveyed stream network that consists of riffles with those substrates). Several issues must be considered when interpreting the results of analysis of absolute lengths. We describe these issues in **Appendix A: Supplemental methods** (**AHI data**, subsections on **Absolute length *versus* proportion of surveyed length** and **Proportional extent of survey data**). The main issue is the difficulty of separating habitat differences from differences in sampling effort. As described for the riffle length analysis above, the results of the substrate analyses were closely correlated with the total length of streams surveyed. This is the result of using absolute lengths for comparing watersheds. However, use of proportional lengths can also raise interpretation problems. For example, proportional lengths obscure the very real differences between the biological value of a small total amount of habitat and a large amount. To make use of the advantages and adjust for the disadvantages of each method, we recommend MCWC re-analyze the data using proportional lengths, and use both analysis methods together as appropriate to allow the best possible management decisions.

7.14 Riparian conditions

7.14.1 Stream channel percent shade

As defined by ODFW, percent shade expresses the "amount of shade provided to the stream by riparian vegetation and topography" (Moore *et al* 1998). The value represents the percent of the 180 degree arc above the stream channel that is occupied by these shade-providing features. We obtained reach average percent shade data from the ODFW reach-level GIS coverage (**shade** in **aqhab_odfw_final.shp**) and from the paper ODFW summaries of the Lincoln District data.

We summarized the ODFW and the Lincoln District data separately to calculate the length-weighted percent shade for each 6th field (**Dfw_shade** and **LD_shade** in **aqhab_sum_final.shp**). We then averaged the data from the two sources (weighting by total surveyed length from each source) to obtain an overall average percent shade for each 6th field (**Shd_all** in **aqhab_sum_final.shp**). The results, along with ODFW benchmarks for this parameter, are shown in **Figure AQ-17**.

The USFS Region 6 database (**REG6habs_final.xls**) did not contain data for percent shade, although it did contain some related data such as stream canopy cover and riparian vegetation. We conducted preliminary analysis on these data to determine their potential suitability as surrogates for percent shade. Stream canopy cover is described by reach. This value is a categorical score (1-4), but it is not documented in the 1999 edition of the USFS Stream Inventory Handbook (U.S. Forest Service 1999). After conversations with USFS staff, we determined that this data field is not an adequate surrogate for percent shade, because cover includes habitat features other than shade, such as woody debris; and because the field was poorly populated (over 1/3 of reaches had no data entered).

Another related data field was riparian vegetation. Riparian vegetation, like stream canopy cover, was not often recorded by field crews (or was not entered into data files). This field is only populated for about 6000 records out of the 54,000 total habitat units (NSO's). The USFS riparian vegetation data describe type of vegetation (shrubs *versus* small trees *versus* large trees; hardwood *versus* conifer, etc.) but contain no quantitative measurements of shading. Channel shading cannot be directly predicted from riparian vegetation. For example, streambank trees may not shade a wide channel, and scattered conifers, even if large, may not shade a high percentage of the channel area. Therefore, we did not feel that riparian vegetation was a suitable stand-in for percent shade. Other factors that led us to reject the USFS riparian vegetation data as a stand-in for percent shade were the uncertainty that would result from extrapolating from a 10% populated data field, and the fact that the riparian vegetation data were categorical rather than numeric.

7.15 Wetlands

Wetlands serve many important functions in the watershed. Floodplain wetlands add diversity and ecological complexity to the streamside environment, and contribute many organisms and valuable nutrients to stream systems. Floodplain wetlands also provide water storage that helps maintain stream flow during summer (Mitsch 1993). Wetlands can help reduce sediment input to streams because water velocities are usually reduced when surface water flows through wetlands. Wetlands may also retain and remove, detoxify, or immobilize pollutants that would otherwise enter and pollute streams. During high flows, wetlands function directly as off-channel habitat. Salmonids forage directly in wetlands during high flow periods, and use these wetlands to escape from rapid stream velocities.

7.15.1 Data sources

As for other analyses in this assessment, we sought comprehensive wetland maps in GIS format, at a scale appropriate for 6th field prioritization. Wetland mapping in Oregon is provided mainly by National Wetland Inventory (NWI) and Local Wetland Inventory (LWI) data. Except for a narrow band along the coast (**nwi_mc**^{M} on the MidCoast GIS), NWI maps are not available in GIS form. Some LWI maps are available in digital form from the Oregon Division of State Lands. However, these inventories do not provide data useful in the current assessment because they generally only include wetlands within city limits, Urban Growth Boundaries of cities, or other limited areas.

Because digital wetland maps were not available for the entire study area, we used hydric soils as a surrogate (see **Setting: Soils: Hydric soils** above). Hydric soils indicate possible locations of wetlands, but hydric soils are not a substitute for wetland inventory data or more detailed on-site wetland delineations. This is because the federal and state regulatory agencies require the presence of three factors for an area to be defined as a jurisdictional wetland. These three factors include not just hydric soils, but also hydrophytic vegetation (vegetation adapted to wetland conditions) and wetland hydrology. We recommend MCWC support wetland inventory efforts in the study area, and acquire digital data on wetlands as it becomes available. Knowing the locations of wetlands will be particularly important for sub-6th field analyses.

7.16 Estuaries

Each of the major rivers in the study area (Salmon, Siletz, Yaquina, and Alsea) has formed an extensive estuary where it enters the ocean, and smaller streams may have small estuaries or mixing zones at their mouths. Estuaries are highly productive water bodies where fresh water meets and mingles with seawater. As such, estuaries provide vital habitat for many salmonid species (Recht 1999) and estuarine environments deserve strong focus in MidCoast Watersheds Council activities, particularly since they are relatively limited in size compared to the range of non-tidal wetland habitats.

Estuaries provide resources for rapid growth of juvenile salmonids during rearing and smoltification, which can greatly improve survival once smolts reach the ocean (Recht 1999). Food resources for this rapid growth are provided by a variety of estuarine habitats such as tidal marsh channels, tidal streams, eelgrass beds, and mud flats. Besides providing rich food resources, estuarine habitats also provide osmotic transition from freshwater to ocean environments, rich foraging opportunities, escape from rapid river velocities, and hiding places from predators.

Like wetlands along major river corridors, estuaries are particularly prone to human disturbance. People tend to settle at the mouths of rivers, and many of the MidCoast's estuarine wetlands were filled and developed decades ago. For example, the Toledo and Olalla Slough 6th field watersheds have a high proportion of their area composed of Coquille soils (likely tidal wetlands, or former tidal wetlands). These 6th field watersheds are under considerable development pressure. Several other coastal cities in the study area are built at least partly on filled tidal marshes. In a recent report, Good (2000) calculated a 42% loss in total estuary area for the Salmon estuary, a 22% loss for the Siletz, 26% for the Yaquina, and 21% for the Alsea. Loss of tidal wetlands for these estuaries ranged from 57% of the historic areas for the Salmon to 71% for the Yaquina.

It is challenging to try to decide how data on estuaries can be used in an assessment such as the MidCoast Sixth Field Watershed Assessment. The Estuary Plan Book provided mapped broad categories of estuarine habitats (Cortright 1987) and it is possible to track changes in such habitats over time. However, some of the Estuary Plan Book's mapped estuarine environments, particularly mud flats and subtidal aquatic beds, are located outside the 6th field watershed boundaries, which were the prioritization unit of study for this assessment. Therefore, habitat types could not be summarized by 6th field watershed.

In addition, many of the data used in comparing 6th field watersheds do not exist for estuarine environments. A prominent example is stream inventory data. Protocols used by ODFW and USFS for aquatic habitat surveys are designed for non-tidal streams; therefore, estuarine habitats are excluded from these surveys. The physical and functional characteristics of tidal streams and tidal channels in marshes are very different from the characteristics of non-tidal streams. For example, ODFW aquatic habitat benchmarks list high proportions of organics and fine sediments as undesirable, but a mud substrate is the undisturbed reference condition for virtually all tidal marsh channels, which are heavily used by juvenile salmonids. Desirable conditions for non-tidal streams include shading of the channel by riparian trees. By contrast, marsh tidal channels generally lack woody riparian vegetation, but still provide excellent shelter due to overhanging banks and very deep vertical channel profiles. Tidal exchange also helps keeps water temperatures cool even in the absence of woody riparian vegetation.

Because comparable data do not exist for estuarine environments and upstream habitats, we took two approaches to estuaries in this assessment. One was to select a surrogate data source -- soil type -- that might indicate extent of estuarine habitats within 6th field watersheds (see **Coquille soils** below). The other approach was to analyze estuarine habitat types in the four major estuaries in the study area, independent of 6th field boundaries (see **Habitat types** below).

7.16.1 Coquille soils

We were able to use the extent of a tidally influenced soil type (Coquille) as a surrogate for extent of estuarine habitats within the study area. The advantage of using soil type as a surrogate for estuarine wetland habitats was the availability of consistent and comprehensive soil type data for the entire study area. Also, soils data were available at a scale of 1:24,000, which matched the scale of the 6th field watershed coverage and was therefore suitable for this assessment. However, there are also major limitations to this analysis. Some diked tidal marshes are no longer mapped as Coquille soils, despite the fact that they originally formed under tidal conditions. Also, low marshes, aquatic beds of eelgrass and algae, mud flats and other subtidal areas that provide important salmonid habitat are not included in the soil survey maps because they are not terrestrial.

Despite these limitations, analysis of Coquille soils provides interesting data that can be used to compare 6th field watersheds. Coquille silt loam is the predominant soil type formed in tidal marshes within the study area's estuaries (USDA Natural Resource Conservation Service 2000). Coquille silt loams make up 1,885 ha of the 10,414 ha of hydric soils found in the study area, or about 18% of the total hydric soils area.

Therefore, many of the 6th field watersheds that are ranked high for proportion of hydric soils are 6th field watersheds that contain estuarine wetlands.

Table 7.7 shows the 6th field watersheds that have the largest areas of Coquille silt loams. These are 6th field watersheds that are likely to contain major areas of tidal wetlands, and these watersheds should be prioritized for tidal marsh protection and restoration activities.

Table 7.7. 6th field watersheds ranked by area of Coquille silt loam soils (formed under tidal conditions)

6th field watershed name	Major basin	6th field watershed code	Total area of Coquille soils (ha)
Boone Slough	Yaquina	40315	435.0
L. Salmon River	Salmon	40911	242.0
L. Siletz River	Siletz	40812	222.0
Gordy/L. Drift	Siletz	40811	129.0
U. Parker	Alsea	50501	124.4
Lower Poole Slough	Yaquina	40309	102.0
Toledo	Yaquina	40304	89.5
Siletz	Siletz	40701	77.5
Yaquina-Olalla	Yaquina	40306	69.0
Olalla Slough	Yaquina	40305	59.4
Salmon	Salmon	40910	50.3
King Slough	Yaquina	40314	46.7
Olalla	Yaquina	40302	41.1
L. Schooner	Siletz	40810	39.9
Spencer	Ocean Tribs	41007	21.7
Abbey	Yaquina	40303	19.4
Yaquina Bay	Yaquina	40313	19.3
Olalla - West	Yaquina	40301	16.3
Depot	Yaquina	40311	16.0
Beaver	Yaquina	40312	15.0
Slack	Yaquina	40307	12.8
Blodgett	Ocean Tribs	50507	11.8

7.16.2 Habitat types

In setting priorities for watershed protection and enhancement, it is important to consider the extent of estuarine habitat types within the different MidCoast estuaries. Salmonids use many different habitat types in estuaries during the rearing and smoltification periods, such as tidal marsh channels, aquatic beds of eelgrass and algae, and mud flats.

The Oregon Estuary Plan Book (Cortright 1987) contains mapping of habitat types for each estuary. The limitations of the mapping include the low level of attribute detail provided, the age of the data, and the incomplete coverage of estuarine habitats. Habitat types mapped are very broad. For example, tidal marsh is divided simply into low salt marsh, high salt marsh, and freshwater marsh. The mapping is dated (it is based on information gathered in the late 1970's and early 1980's) and there are several portions of the estuaries (particularly upper freshwater tidal zones) that are not mapped. Despite these limitations, the mapping at least provides an initial overview of the distribution of the major habitat types found in the estuaries. **Table 7.8** shows the distribution of the major categories of estuarine habitat types across the four estuaries in the study area.

Table 7.8. Estuary Plan Book habitat types for estuaries in the MidCoast area

	ALSEA	SALMON	SILETZ	YAQUINA	TOTAL
Habitat type	**Area (ha)**				
Unconsolidated / rock bottom	368.1	38.7	128.1	847.1	1381.9
Shore	18.6	2.1	8.8	87.3	116.8
Sand/mud flat	289.7	8.2	169.8	265.9	733.5
Aquatic bed: seagrass/algae	229.5	30.8	188.7	392.8	841.6
Diked tidal marsh	214.8	229.0	188.5	442.9	1075.2
Low salt marsh	23.3	5.2	37.2	58.2	123.8
High salt marsh	165.3	96.6	89.6	179.8	531.2
Freshwater tidal marsh				0.8	0.8
Total	1,322.3	414.2	810.8	2,549.7	5,096.9

The Estuary Plan Book maps (and, therefore, the figures in **Table 7.8** above) do not reflect changes in habitat extent since its publication in 1987. It is important to note that the area of freshwater tidal marsh shown in the Plan Book mapping is particularly inaccurate, because the EPB mapping does not extend far enough upriver to capture these important environments. In the study area, upper brackish and freshwater tidal environments extend upstream at least to River Mile 19 in the Yaquina (well beyond Mill Creek, in Section 9), River Mile 10 in the Alsea (Bain Slough), and River Mile 4 (Chinook Bend) in the Siletz (Brophy 1999, 2001).

More detailed and more recent studies of estuarine habitats are available for the Salmon estuary (Mitchell 1981; Morlan 1991), Siletz estuary (Brophy 2001), and Yaquina and Alsea estuaries (Brophy 1999). These studies are described below. A study of Coastal Wetland Change is currently underway as a joint effort of several state and federal environmental agencies. Information on the study is available at the Oregon Division of State Lands website: (*http://statelands.dsl.state.or.us/Vol12_1.pdf*). In addition, other studies are underway outside the MidCoast area, utilizing new technologies for mapping estuarine habitats. For example, high spatial resolution eelgrass mapping was done in Tillamook Bay in 1995 and there is currently an estuarine habitat mapping project, using hyperspectral imagery, underway in Hood Canal (WA) and along the Lower Columbia River (Garono *et al* 2000).

A detailed study of vegetation communities in the Siletz estuary was conducted by Green Point Consulting in 2000 (Brophy 2001). This study provided GIS mapping of plant communities in the estuary, and showed that the Siletz estuary currently contains a total of 252 ha of tidal and formerly tidal wetlands. Vegetation communities were mapped within all estuarine habitat types, including low salt marsh, high salt marsh, brackish marsh, freshwater tidal marsh, muted tidal marsh, formerly tidal marsh that is now freshwater wetland, and spruce tidal swamp. Of the mapped communities, about 135 ha have been disturbed by diking, tidegates, ditching, restrictive culverts, and other human activities, with the result that tidal influence is muted in these areas. The remaining 117 ha are relatively undisturbed and have full tidal influence. The area figures from the 2001 study are slightly lower than from the estuary plan book and are more accurate due to finer-scale mapping.

A 1999 Green Point Consulting study of estuarine wetland sites in the Yaquina and Alsea estuaries (Brophy 1999) provided highly detailed site-specific data on site condition, site ownership, restoration priorities, dates of alteration, and many other factors. The study prioritized a total of 79 sites for restoration and protection activities (43 sites in the Yaquina and 36 sites in the Alsea estuary). The study provides detailed current data for all sites that was not previously available, and also updates and corrects information in the Estuary Plan Book. For example, one major Alsea estuary site was marked as diked in the Estuary Plan Book but based on the 1999 study, this site was apparently never diked. In addition, the Brophy study extends farther upriver to include upper brackish marshes and freshwater tidal habitats not covered in the Estuary Plan Book. Freshwater tidal habitats may be particularly important to salmonids (Charles Simenstad, 2000, personal communication).

The Brophy study did not specifically map boundaries for sites, and acreage figures provided are approximate. Based on these approximate acreages, in the Yaquina estuary, this study showed a total of over 410 ha of muted tidal wetland sites were described and prioritized for restoration. These sites are affected by dikes, ditches, tidegates, restrictive culverts, road crossings, or other alterations. An additional 113 ha of relatively undisturbed tidal marsh sites were described and prioritized for protection. Despite the fact that the Brophy study provided only approximate acreages, the total surface area of sites investigated in the Brophy study matches quite closely with the areas of diked and undiked marsh sites shown in the Estuary Plan Book.

In the Alsea estuary, the Brophy study showed a total of over 210 ha of tidal marsh sites that were in relatively undisturbed condition in 1999 (no major hydrologic alterations to the site itself), and an additional approximately 190 ha of formerly tidal or muted tidal wetlands affected by dikes, tidegates, restrictive culverts, and other human alterations. As for the Yaquina, the total hectare areas are fairly similar to those in the estuary plan book.

7.16.3 Existing estuary restoration projects

The study area contains several prominent research and restoration efforts in estuaries. The Salmon River estuary is the site of several long-term research projects on tidal marsh ecology, methods and outcomes of estuarine wetland restoration, and salmonid use of estuaries (David Evans and Associates Inc. 1999; Frenkel and Morlan 1990; Mitchell 1981; Morlan 1991). In the Siletz estuary, USFWS and the Confederated Tribes of Siletz Indians are conducting restoration work and studies of estuarine ecology (Roy Lowe, Eric

Nelson, David Pitkin, USFWS, personal communication, fall 2000; Stan Van De Wetering, CTSI, personal communication, fall 2000). Detailed vegetation mapping was conducted in 2000 to support these studies (Brophy 2001). Three tidal marsh restoration projects on the Yaquina are in the planning and implementation phase (Brophy 2000).

7.16.4 Interpretation and recommendations

Because habitat characteristics in estuaries are so different from those in the non-tidal portions of the watershed, it is difficult to make direct comparisons between 6th field watersheds containing large areas of tidal environments and those lacking tidal areas. Prioritizing tidal *versus* non-tidal 6th field watersheds is not recommended. Instead, we recommend conducting substantial watershed restoration and protection efforts in **both** tidal and non-tidal environments. In the action planning process, *we recommend assigning a high priority ranking to 6th field watersheds that estuarine habitats -- equal to the highest-ranked 6th field watersheds containing only non-tidal habitat*. The types of watershed protection and restoration actions will differ between tidal and non-tidal systems, so such priority must be assigned up front, in establishing general priority areas for action. We also recommend using the existing report on Alsea and Yaquina estuarine wetlands (Brophy 1999) to focus these efforts, and we recommend collection of additional data of this type to guide future efforts in other estuaries within the study area.

7.17 Springs

Springs can provide cool water to streams, helping to lower their temperatures in summer when stream temperatures often exceed the optimum for salmonids. We digitized springs off paper USGS quadrangle maps for the study area, using a heads-up digitization procedure (**springs1.shp**). Twenty-eight springs were digitized. This is no doubt only a small fraction of the springs found in the study area, but the layer provides MCWC with a place to record and store spring locations mapped by local observers.

7.18 Stream temperatures

Stream temperatures are discussed in **Water Resources: Water Quality: Water Temperature** below.

7.19 Fish barriers

No GIS data on fish barriers suitable for ranking 6th field watersheds were available for this assessment. However, MCWC provided us with the characteristics of some known barriers which affect 6th field watersheds that are ranked high in the **Multi-factor analyses of salmonid habitats** below (Wayne Hoffman, personal communication, 2001). These are:

1. Siletz Falls, which have a fish ladder and trap; neither coho nor winter steelhead are allowed to pass the trap, but summer steelhead are allowed to pass.
2. Alsea Falls, which is a complete barrier to anadromous fish;
3. A perched culvert and fill at Highway 101 which affects passage to Rocky Creek (Ocean Tributary);
4. A dam at the North Fork (Alsea) Hatchery;

5. The tide gate on Boone Slough, which may be a barrier (its ability to pass salmon has not been investigated);
6. The falls on Bear Creek (Yaquina), which block access to about half the potential habitat in the Bear Creek 6th field.

These barriers are also mentioned in the results sections for the individual multi-factor analyses, below.

Other barriers are known within the study area, such as the falls on Big Rock Creek, (Garono and Brophy 1999). However, the list above includes only those barriers affecting 6th field watersheds that ranked high in the three multi-factor analyses of salmonid habitat (below). Again, we recommend MCWC record locations of all known barriers in the MCWC GIS.

Other sources of information on barriers are described under the individual types of barriers (**Culverts**, **Dams**, **Natural barriers: Rapids, falls**) below.

7.19.1 Culverts

7.19.1.1 Existing culvert inventories

The Oregon Department of Transportation (ODOT) has created a GIS coverage of culverts that covers the study area (contact ODOT). There are 209 culverts in the GIS layer within the study area, and the database contains information on attributes such as each culvert's priority for replacement, its construction materials, length, diameter, drop, depth, slope, surrounding salmonid habitat quality, and salmonid species affected. Although the ODOT dataset will be useful for stream reach-level assessment, it did not contain enough culverts to be useful in ranking 6th field watersheds.

7.19.1.2 GIS analysis for potential culvert locations

GIS can be used to determine possible culvert locations, by finding sites where roads intersect streams in appropriate-scale coverages. Our only comprehensive roads layer was at a scale of 1:100K, inadequate for this type of analysis. Due to the coarse scale of the roads layer, GIS analysis of road-stream intersections was rejected by MCWC in favor of fieldwork by Basin Planning Teams or other local observers (see **Data Recommendations** below).

7.19.2 Dams

Dams alter watershed hydrology by dampening or evening out the extremes of peak and low flows, and retaining sediments. We compared the MidCoast GIS dams coverage (**mvbdams.shp**[M]) to an older map of dam sites and proposed dam sites from the Oregon Water Resources Department (Oregon Water Resources Board 1964). We found that the MidCoast GIS coverage was missing a number of dam sites on the OWRD map, and *vice versa*. We digitized dams and proposed dams off the OWRD map using a heads-up digitization procedure (**1964_dam2.shp**). We found 57 dams within the study area. We distributed a printed map of the study area showing the digitized dams, for annotation and correction by MCWC local Basin Planning Teams. Twenty dam locations in the north portion of the study area were marked as incorrect by MCWC and BPT members and removed from the **1964_dam2.shp** coverage. Two additional dams were added during this local editing process; these were also added to **1964_dam2.shp**. The **1964_dam2.shp** layer provides MCWC with a layer for recording and storing locations of dams and other hydrologic modifications as they are located and mapped by local observers.

7.19.3 Natural barriers: rapids, falls

No comprehensive data on natural barriers to anadromous fish migration were available for this assessment. The StreamNet program (*http://www.streamnet.org/gisdata.html*) is developing GIS data on natural barriers (Cedric Cooney, ODFW, personal communication), but the dataset is not yet available for MidCoast watersheds. We recommend MCWC acquire the StreamNet data when they become available, but also highly recommend that local Basin Planning Teams record locations of known barriers in their GIS (and provide that information to StreamNet).

7.20 Multi-factor analyses of salmonid habitat

Multi-factor analyses of coho and winter steelhead habitat were conducted using combinations of stream channel characteristics (derived from DEMs), AHI data, soils data, and coho juvenile survey data.

As described above, no GIS data on anadromous migration barriers appropriate for ranking 6th field watersheds were available for this assessment, so we were not able to incorporate effects of barriers into these multi-factor analyses. Therefore, a limitation of this analysis is the fact that some top-ranked watersheds (or portions thereof) may be inaccessible to anadromous fish. In the **Results** section for each multi-factor analysis, we describe the 6th field watersheds that ranked high, but are inaccessible to salmonids according to information provided to us by MCWC. However, other 6th field watersheds or portions are no doubt inaccessible, due to either natural and artificial barriers. **We recommend that when MCWC uses the results of these analyses for prioritizing management actions, they should refine the prioritization by adding local knowledge to the discussion.** Such local knowledge should include locations of fish barriers and other factors influencing choice and siting of management actions. MCWC should also seek to acquire new data on such factors to fill data gaps, as described in **Data collection and monitoring recommendations** below.

7.20.1 Coho winter habitat: Introduction

Juvenile coho rear in low-gradient streams during both winter and summer. During winter, juvenile coho need complex stream structure, side channels, and cover that offer opportunities to shelter, forage, and escape from high stream velocities. Unconfined streams with good a connection between the floodplain and stream channel are more likely to provide off-channel habitat. Streams flowing through hydric soils are also likely to be connected to floodplain wetlands and other off-channel habitat during high winter flow periods. Pools and off-channel habitat offer reduced stream velocities and opportunities for juvenile coho to rest out of the main stream current. Large woody debris in stream channels increases channel roughness and helps to create pools and secondary channels, and also offers cover to protect juveniles from predation and shelter them from high velocities during peak flows.

We conducted two multi-factor analyses of coho winter habitat for this assessment. The first was the **Potential Coho Winter Habitat Analysis** below. As requested by the MidCoast Watersheds Council Tech Team, this analysis located stream reaches that were classified as "unconfined" (having flat areas near the stream), low-gradient (0 to 2 degrees, or 0 to 3.5% slope), and flowing through hydric soils. The **Functioning Coho Winter Habitat Analysis** used the results of the potential habitat analysis, and added in four other factors from AHI surveys as described below.

The potential habitat analysis was a sub-6th field analysis that provided data on specific stream reaches meeting the criteria of low gradient, "unconfined" as defined by DEM analysis, and flowing through hydric soils. By contrast, the Functioning Coho Winter Habitat analysis was a 6th field ranking.

7.20.2 Potential coho winter habitat

The potential coho winter habitat analysis is an example of a multi-factor analysis designed to answer specific questions at spatial scales below the 6th field watershed level. In this analysis, we selected sites at the stream reach level. As requested by MCWC, we included the following components in our analysis of potential coho winter habitat:

1. Gradient (criterion: low-gradient, (0-2 degrees = 0-3.5% slope)
2. Confinement (criterion: unconfined)
3. Soils (criterion: hydric)

This analysis was accomplished by doing a series of selections in ARCView and then using the Geoprocessing Wizard to clip the stream layer so that only the stream segments meeting all of these criteria were selected.

Step 1: Using the derived stream gradient layer, we used the query tool to select stream segments that had a stream gradient ranging from 0-2 degrees.

Step 2: Using the hydric soils layer, we used the query tool to select polygons that contained hydric soils.

Step 3: We then clipped the streams layer by the hydric soils using the Geoprocessing Wizard. This resulted in a newly created coverage showing low gradient stream segments that passed over hydric soils.

Step 4: We used the resulting clipped stream shapefile and repeated the process with stream confinement to select only low-gradient, unconfined stream segments flowing through areas of hydric soils.

7.20.2.1 Results: Study area summary

The length of potential habitat (low-gradient, unconfined streams flowing through hydric soils) in each 6th field watershed ranged from 0 to 16.4 km, with an average of about 1.5 km per 6th field watershed.

Table 7.9 shows the nineteen 6th field watersheds that had the greatest length of potential coho winter habitat. The specific stream reaches identified are shown in the **Basin Inserts**, in Figures **AQ-18AL** through **AQ-18YQ**. These figures also show coho habitat as mapped by ODFW.

Table 7.9. 6th field watersheds with greatest length of potential coho winter habitat

6th field watershed name	Major basin	6th field code	Length of potential coho winter habitat (m)
SF_SILETZ[1]	Siletz	40410	16,387
BUTTERMILK	Yaquina	40105	12,653
BOONE SLOUGH	Yaquina	40315	11,964
BEAVER	Ocean Tribs	50501	10,953
SILETZ	Siletz	40701	9,056
L. SALMON RIVER	Salmon	40911	7,597
SUNSHINE	Siletz	40504	7,339
FOGARTY	Ocean Tribs	41001	7,067
UPPER_SF_ALSEA[1]	Alsea	50119	6,244
L. SILETZ RIVER	Siletz	40812	5,880
GREEN RIVER	Alsea	50216	5,625
YACHATS	Yachats	50512	5,617
GORDY/L. DRIFT	Siletz	40811	5,444
UPPER_NF_ALSEA[1]	Alsea	50102	5,357
HONEYGROVE	Alsea	50113	5,071
BUMMER	Alsea	50116	4,975
THIEL	Ocean Tribs	50515	4,937
LINCOLN CITY/DEVIL'S LAKE	Ocean Tribs	41011	4,668
L. BUCK	Alsea	50208	4,464

[1] Anadromous migration barriers affect this watershed and may affect other watersheds. See text for details.

7.20.2.2 Interpretation

As described in **Multi-factor analyses of salmonid habitat** above, some of the watersheds in **Table 7.9** are affected by barriers to migration of anadromous fish. Although no GIS data on anadromous migration barriers appropriate for ranking 6th field watersheds were available for this assessment, MCWC provided us with information on some known barriers (Wayne Hoffman, personal communication, 2001) which affect 6th field watersheds listed in **Table 7.9**. Specifically, the South Fork Siletz watershed is above Siletz Falls, which has a fish ladder and trap, but currently, coho are not being passed through the trap to the ladder. Boone Slough is behind a tide gate whose ability to pass salmon has not been investigated. It is former intertidal wetland and has little if any spawning habitat associated with it. The Upper South Fork Alsea watershed is above Alsea Falls, which is a complete barrier to anadromous fish. Currently, passage to the Upper North Fork Alsea is blocked by a dam at the North Fork Hatchery. The MCWC is attempting to obtain funding for a project to repair the fish ladder on this dam. Coho appear to be extirpated from Thiel Creek, and currently little spawning gravel exists in that creek (Wayne Hoffman, personal communication, 2001).

Exercise caution in interpreting the results of this analysis. DEM-derived stream confinement and gradient have not been field-verified, and should be ground-truthed before site-specific actions are planned. Hydric soils information is taken from soil surveys, which do involve field verification. However, hydric soils may have formed under hydrologic regimes that are no longer present. For example, hydric soils often form in actively connected floodplains, but an area of hydric soil may no longer experience regular flooding if a stream is now downcut and separated from its floodplain.

It is important to note that estuaries provide important salmonid habitat, and not all estuarine environments could be included in this study. The 6th field watershed boundaries that were basis for prioritization exclude some estuarine environments (e.g., subtidal aquatic vegetation beds). However, stream segments identified as low-gradient, unconfined, and flowing through hydric soils generally include tidal portions of streams, so the Potential Coho Winter Habitat analysis does incorporate some estuarine habitats.

7.20.3 Functioning coho winter habitat

The functioning coho winter habitat analysis ranks 6th field watersheds using a combination of factors that influence coho winter habitat. In this analysis, we mapped areas that might provide good habitat for coho during the winter. We used information from the potential coho winter habitat and map rules developed by the MidCoast Watershed Council Tech Team. Data limitations affected this analysis; the only available data source for the factors in this analysis consisted of AHI data, and the extent of AHI surveys varies widely from one 6th field watershed to another. As requested by MCWC, we included the following habitat factors in the ranking:

Table 7.10. Factors used in coho winter habitat multi-factor analysis

Factor	**Effect of high numeric value on ranking (+/-)**
Length of potential habitat (unconfined* low-gradient streams flowing through hydric soils)	+
LWD frequency (pieces/100m)	+
Percent pools by area	+
Channel widths per pool	-
Length of side channel habitat	+

* See DEM analysis of stream confinement for details on definition of "unconfined"

We used the following data sources for the above factors:

Table 7.11. Data sources for coho winter habitat analysis

Factor	**Data source**
Length of unconfined, low-gradient streams flowing through hydric soils	Digital elevation model (DEM)
LWD frequency (pieces/100m)	AHI data
Percent pools by area	AHI data
Channel widths per pool	AHI data
Length of side channel habitat	AHI data

As described above, due to lack of GIS data on anadromous migration barriers, this analysis addressed only physical factors but did **not** reflect existing barriers to anadromous migration, except as noted in **Results** below. Therefore, some of the top-ranked 6th field watersheds are inaccessible to anadromous fish; these are noted below.

Six of the factors in the analysis consist of AHI data. AHI data came from three separate sources -- USFS Region 6 tabular data, ODFW GIS data, and Lincoln District AHI data. For those factors that were analyzed as numeric means or percentages (LWD, % pools, and channel widths per pool), there were protocol differences between the different data sources. Because of these differences, we needed to use a ranking method that would be independent of the specific values for each parameter. We used several steps to rank 6th fields for each numeric AHI factor:

1) Determined average value for 6th field from each data source separately
2) Determined ranking (0-217) for each 6th field from each data source separately
3) Normalized the rankings from each data source to a scale of 100
4) Averaged the normalized rankings from the three data sources to get a single "average rank" for each factor.

For length of side channel habitat, we summed the lengths from all data sources and ranked the 6th fields from top (rank 1, greatest length of gravel-dominated riffles) to bottom (shortest length) based on the total length. As for the numeric AHI factors, we normalized the rankings to a scale of 100 to allow their use in multi-factor rankings (below). We used the same ranking procedure for the DEM-derived length of unconfined, low-gradient streams flowing through hydric soils (see unconfined low-gradient streams analysis for details on the definition of "unconfined" for this analysis).

We combined all of the above factors into a single ranking for each 6th field (**cohow_rk** in **aqhab_sum_final.shp**). Since each factor's rank was normalized to a scale of 100, we simply averaged together the rankings for all factors to get the single final multi-factor ranking for each 6th field. Possible values for the ranking therefore ranged from 1 (best) to 100 (worst).

7.20.3.1 Results: Study area summary

Table 7.12 shows the mean, maximum, and minimum value for each parameter used in the functioning coho winter habitat analysis.

Table 7.12. Sample statistics for factors used in functioning coho winter habitat analysis.

	Channel widths/ pool	**LWD pieces/ 100m**	**Length of side & secondary channels (m)**	**Length of potential habitat (m)**
Mean	21.9	8.5	583.1	1,524.7
Minimum	1.8	0.0	0.0	0.0
Maximum	347.3	36.9	4,902.0	16,386.7
Count*	154	154	153	217

* Count = number of 6th field watersheds that had data for the parameter listed
** Potential habitat = low-gradient, unconfined streams flowing through hydric soils (from DEMs)

Sixth field watershed rankings for functioning coho winter habitat are shown in **Figure AQ-21**. **Table 7.13** shows the 6th field watersheds that were ranked in the top 10 (out of all 217 6th field watersheds) for functioning coho winter habitat.

The major contributing factors to each watershed's high ranking are shown. These are the specific aquatic habitat characteristics that contributed most to the watershed's high ranking, by having an individual factor ranking in the top 20 on a scale of 100. (For a 6th field watershed to fall in the top 10 overall ranking, the other factors also were generally at least in the top half and often in the top quarter of the scale of 100.) Where "potential habitat" is shown as a major contributing factor, this means that the length of potential habitat (as defined in **Potential coho winter habitat** above) was among the longest in the study area, thus contributing greatly to the overall high ranking of the 6th field.

Table 7.13. 6th field watersheds ranked highest for functioning coho winter habitat

Rank (scale of 1 to 100; 1 is best)	6th field watershed name	Major basin	6th field code	Major contributing factors
7.54	HONEYGROVE	Alsea	50113	% pools, channel widths/pool, LWD, side channels, potential habitat
13.00	UPPER_SF_ALSEA[1]	Alsea	50119	channel widths/pool, LWD, side channels, potential habitat
16.15	GREEN RIVER	Alsea	50216	% pools, channel widths/pool, side channels, potential habitat
21.12	SF_ALSEA_HEAD-WATERS[1]	Alsea	50120	% pools, channel widths/pool, LWD
23.83	SPENCER	Ocean Tribs	41007	channel widths/pool, LWD, side channels
25.82	LOWER_SPOUT	Yaquina	40203	% pools, channel widths/pool
29.19	SF_SILETZ[1]	Siletz	40410	side channels, potential habitat
30.34	BEAVER	Ocean Tribs	50501	side channels, potential habitat
30.36	SUNSHINE	Siletz	40504	% pools, side channels, potential habitat
31.85	CAPE	Ocean Tribs	50711	LWD, side channels, potential habitat

1 Anadromous migration barriers affect this watershed, and may affect other watersheds. See text for details.

7.20.3.2 Interpretation

As described in the introduction to **Multi-factor analyses of salmonid habitat** above, some of these high-ranked watersheds are affected by barriers to migration of anadromous fish. Although no GIS data on anadromous migration barriers appropriate for ranking 6th field watersheds were available for this assessment, MCWC provided us with information on some known barriers (Wayne Hoffman, personal communication, 2001) which affect 6th field watersheds listed in **Table 7.13**. Specifically, the Upper South Fork Alsea and South Fork Alsea Headwaters watersheds are above Alsea Falls, which is a complete barrier to anadromous fish. The South Fork Siletz watershed is above Siletz Falls, which has a fish ladder and trap, but currently, coho are not being passed through the trap to the ladder.

Only 6th fields with AHI data could be ranked in this analysis. Some 6th fields lacking AHI data may have good coho habitat functions were not considered in this analysis. We recommend AHI surveys be conducted for areas not yet surveyed but offering good coho winter habitat potential, and we also recommend re-survey of areas surveyed several years ago to determine whether habitat has changed since the earlier survey. As with all analyses based on AHI data, interpretation depends heavily on the date of the survey and the length and proportion of streams surveyed.

We followed the above ranking procedures because we felt they provided the best interpretation of the data. However, many different ranking systems are equally defensible for an analysis of this type. If they wish, MCWC members will be able to re-rank 6th fields using alternative systems by manipulating the aquatic habitats summary shapefile **aqhab_sum_final.shp**.

As requested by MCWC, we used absolute lengths for analysis of potential habitat and side channels. Analysis of proportional lengths is recommended as a supplement to the absolute lengths analysis. A discussion of proportional lengths *versus* absolute lengths is found in "**Interpreting the results of aquatic habitat analyses: Absolute lengths *versus* proportion of surveyed lengths**" in **Appendix A**.

The data used in the Functioning Coho Winter Habitat analysis were taken from stream surveys, which are conducted only in nontidal habitats. Therefore, 6th field watershed rankings for Functioning Coho Winter Habitat do not reflect presence of vital estuarine habitat. Estuaries are an important part of salmonid winter habitat: chinook, coho, chum, steelhead and cutthroat all use estuaries during the fall and winter months (Brophy 1999). As described in **Estuaries** below, we recommend that the Action Planning process should assign high ranking to 6th field watersheds containing extensive estuarine habitats, at least equal to the highest-ranked 6th field watersheds in the Functioning Coho Winter Habitat.

7.20.3.3 Recommended uses

The rankings can help prioritize 6th fields for actions designed to improve coho winter habitat, such as creation or restoration of off-channel habitat and placement of large woody debris. The rankings should not be used alone for this purpose, but should be used in conjunction with other data, particularly field verification of suitable conditions.

Before using the rankings, we recommend careful review of the detailed methods for each individual analysis that was a part of the multi-factor analysis. All datasets have their limitations and proper uses, and many of these are discussed in the methods sections for the individual analyses.

7.20.3.4 Data recommendations

The data collected in AHI surveys can change considerably over the course of a single year. Therefore, any future analyses of coho winter habitat should use the most recent AHI survey data. We recommend surveying new reaches that appear to offer high potential habitat value, as well as re-surveying critical reaches for which survey data are more than a couple of years old.

Since AHI data from USFS and Lincoln District sources were not georeferenced, it was not possible to develop a site-specific, reach-by-reach analysis of functioning habitat that incorporated all of the available AHI data. However, it would be possible to locate some specific reaches that meet all of the Functioning Coho Winter Habitat criteria, by using the Aquatic Habitat Inventory data that originated from the ODFW GIS. This analysis would be a logical next step for the Basin Planning Teams. For such a site-specific analysis, it will be particularly important to consider the age of the AHI data (survey date). Ground-truthing or re-survey of critical reaches is recommended, particularly if the AHI data in question are several years old.

Scale is a consideration in site-specific analyses such as the one described above. The ODFW data are entered on a 1:100K streams layer, while the DEM analysis is conducted at the 1:24K scale that is considered appropriate for watershed assessment at the 5th field level. This scale difference will need to be considered when conducted any site-specific analysis that uses both DEM and ODFW GIS data.

7.20.4 Coho summer habitat: Introduction

During summer, juvenile coho need some of the same structural stream characteristics that they need in winter: low-gradient, unconfined streams offer the best potential habitat both winter and summer. They also need stream characteristics that help keep water cool: streamside shading; gravel substrates that allow stream flow to connect with cooler groundwater; pools that offer layered temperature profile; and the cover provided by large woody debris. Bedrock substrates reduce the functional value of summer coho habitat by reducing connectivity to groundwater, allowing stream temperatures to be warmed by sunlight and warm summer air.

7.20.5 Potential coho summer habitat

We conducted two multi-factor analyses of coho summer habitat for this assessment. The first was the **Potential Coho Summer Habitat Analysis** below. As requested by the MidCoast Watersheds Council Tech Team, this analysis located stream reaches that were classified as "unconfined" (having flat areas near the stream), and low-gradient (0 to 2 degrees, or 0 to 3.5% slope). We selected these reaches within ArcView from the DEM-derived streams layer (**st1400-c.shp**). The potential habitat analysis was a sub-6th field analysis that provided data on specific stream reaches meeting the criteria of low gradient and "unconfined" as defined by DEM analysis. (By contrast, the Functioning Coho Summer Habitat analysis was a 6th field ranking.)

7.20.5.1 Results: Study area summary

Table 7.14 shows the nineteen 6th field watersheds that had the greatest length of potential coho summer habitat. The specific stream reaches identified are shown in the **Basin Inserts**, in Figures **AQ-19AL** through **AQ-19YQ**. These figures also show coho habitat as mapped by ODFW.

Table 7.14. 6th field watersheds with greatest length of potential coho summer habitat

6th field watershed name	Major basin	6th field ID code	Length of potential coho summer habitat (m)
SF_SILETZ[1]	Siletz	40410	37,124
BOONE SLOUGH[1]	Yaquina	40315	36,565
BEAVER	Ocean Tribs	50501	36,150
SILETZ	Siletz	40701	28,350
LINCOLN CITY/DEVIL'S LAKE	Ocean Tribs	41011	27,408
ROOT	Siletz	40705	26,334
BENTILLA	Siletz	40712	24,556

Table 7.14. 6th field watersheds with greatest length of potential coho summer habitat

6th field watershed name	**Major basin**	**6th field ID code**	**Length of potential coho summer habitat (m)**
BUTTERMILK	Yaquina	40105	21,827
L. SALMON RIVER	Salmon	40911	17,878
DEPOT	Yaquina	40311	16,206
LITTLE ELK	Yaquina	40111	15,810
OJALLA	Siletz	40710	15,249
BUMMER	Alsea	50116	14,968
BIRCH	Alsea	50420	14,906
LITTLE_ROCK	Siletz	40606	14,488
U. SALMON RIVER	Salmon	40901	14,185
GORDY/L. DRIFT	Siletz	40811	14,089
RYDER	Alsea	50110	13,864
TANGERMAN	Siletz	40713	13,428

[1] Anadromous migration barriers affect this watershed and may affect other watersheds. See text for details.

7.20.5.2 Interpretation

As described in the introduction to **Multi-factor analyses of salmonid habitat** above, some of the watersheds in **Table 7.14** are affected by barriers to migration of anadromous fish. Although no GIS data on anadromous migration barriers appropriate for ranking 6th field watersheds were available for this assessment, MCWC provided us with information on some known barriers (Wayne Hoffman, personal communication, 2001) which affect 6th field watersheds listed in **Table 7.14**. Specifically, the South Fork Siletz watershed is above Siletz Falls, which has a fish ladder and trap, but currently, coho are not being passed through the trap to the ladder. The Boone Slough watershed is behind a tide gate whose ability to pass salmon has not been investigated. It is former intertidal wetland and has little if any spawning habitat associated with it.

Exercise caution in interpreting the results of this analysis. DEM-derived stream confinement and gradient have not been field-verified, and should be ground-truthed before site-specific actions are planned.

It is important to note that estuaries provide important salmonid habitat, and not all estuarine environments could be included in this study. The 6th field watershed boundaries that were basis for prioritization exclude some estuarine environments (e.g., subtidal aquatic vegetation beds). However, stream segments identified as low-gradient, unconfined, and flowing through hydric soils generally include tidal portions of streams, so the Potential Coho Summer Habitat analysis does incorporate some estuarine habitats.

7.20.6 Functioning coho summer habitat

The functioning coho summer habitat analysis ranks 6th fields using a combination of factors that influence coho summer habitat. In this analysis, we used information provided to us by the MidCoast Tech Team to map areas that were believed to be in use by coho during the summer. Data limitations affected this analysis; the available data sources for the factors in this analysis consisted of AHI data and Rapid Bioassessment (RBA) data, and the extent of AHI and RBA surveys varies widely from 6th field to 6th field.

There are many possible definitions of "functioning coho summer habitat." The MidCoast Watersheds Council requested we incorporate the following factors into this multi-factor analysis:

Table 7.15. Factors used in functioning coho summer habitat analysis

Factor	**Effect of high value on ranking (+/-)**
Length of potential habitat (unconfined,* low-gradient)	+
LWD frequency (pieces/100m)	+
Percent pools by area	+
Channel widths per pool	-
Length of riffle habitat with gravel substrate dominant	+
Length of riffle habitat with bedrock substrate dominant	-
Percent shading of stream channel	+
Rapid Bioassessment average coho/sq m	+

* See DEM analysis of stream confinement for details on definition of "unconfined"

We used the following data sources for the above factors:

Table 7.16. Data sources for functioning coho summer habitat analysis

Factor	**Data source**
Length of unconfined, low-gradient streams	Digital elevation model (DEM)
LWD frequency (pieces/100m)	AHI data
Percent pools by area	AHI data
Channel widths per pool	AHI data
Length of riffle habitat with gravel substrate dominant	AHI data
Length of riffle habitat with bedrock substrate dominant	AHI data
Percent shading of stream channel	AHI data
Average juvenile coho/sq m	Rapid Bioassessment (RBA)

As described above, due to lack of GIS data on anadromous migration barriers, this analysis addressed only physical factors and juvenile coho data, but did **not** reflect existing barriers to anadromous migration. Therefore, portions of the top-ranked 6th field watersheds may not be accessible to anadromous fish.

Six of the factors in the analysis consist of AHI data. AHI data came from three separate sources -- USFS Region 6 tabular data, ODFW GIS data, and Lincoln District AHI data.

For those factors that were analyzed as numeric means or percentages (LWD, % pools, channel widths per pool, and % shade), there were protocol differences between the different data sources. Because of these differences, we needed to use a ranking method that would be independent of the specific values for each parameter. We used several steps to rank 6th fields for each numeric AHI factors:

1) Determined average value for 6th field from each data source separately
2) Determined ranking for each 6th field from each data source separately
3) Normalized the rankings to a scale of 100
4) Averaged the rankings from the three data sources to get an "average rank" for each factor. Missing data were not averaged in this process. Where data were missing, this did not affect the watershed's ranking, because rankings were averaged, not summed.

For length of riffle habitat with gravel substrate dominant, we summed the lengths from all data sources and ranked the 6th fields from top (rank 1, greatest length of gravel-dominated riffles) to bottom (rank 100, shortest length) based on the total length. We used the same procedure for the DEM-derived length of unconfined, low-gradient streams (see unconfined low-gradient streams analysis for details on the definition of "unconfined" for this analysis).

For length of bedrock habitat with gravel substrate dominant, we summed the lengths from all data sources and ranked the 6th fields from top (rank 1, shortest length of bedrock-dominated riffles) to bottom (100, longest length of bedrock-dominated riffles).

We then averaged the rankings for all of the above factors into a single ranking, **cohos_rnk**. Possible values for **cohos_rnk** ranged from 1 (best-functioning habitat using these criteria) to 100 (lowest-functioning habitat using these criteria).

7.20.6.1 Results: Study area summary

Table 7.17 shows the mean, maximum, and minimum value for each parameter used in the functioning coho summer habitat analysis.

Table 7.17. Sample statistics for factors used in functioning coho summer habitat analysis.

	Percent pools	**Channel widths/ pool**	**LWD pieces/ 100m**	**Percent shade**	**Length of riffle units (m)**	**Length of riffles w/ bedrock substrate (m)**	**RBA juvenile coho/sq m 1998-99**	**Length of potential habitat (m)****
Mean	37.7	21.9	8.5	76.0	3,450.4	196.1	0.3	5,484.1
Minimum	0.6	1.8	0.0	25.0	0.0	0.0	0.0	0.0
Maximum	80.6	347.3	36.9	100.0	24,112.7	2,943.8	2.1	37,124.2
Count*	154	154	154	106	154	154	115	217

* Count = number of 6th field watersheds that had data for the parameter listed
** Potential habitat = low-gradient, unconfined streams (from DEMs)

Sixth field watershed rankings for functioning coho summer habitat are shown in **Figure AQ-22**. **Table 7.18** shows the 6th field watersheds that were ranked in the top 10 (out of all 217 6th field watersheds) for functioning coho summer habitat.

The major contributing factors to each watershed's high ranking are shown. These are the specific aquatic habitat characteristics that contributed most to the watershed's high ranking, by having an individual factor ranking in the top 20 on a scale of 100. (For a 6th field watershed to fall in the top 10 overall ranking, the other factors also were generally in the top half of the scale of 100.) Where "potential habitat" is shown as a major contributing factor, this means that the length of potential habitat (as defined in **Potential summer coho habitat** above) was among the longest in the study area, thus contributing greatly to the overall high ranking of the 6th field.

Table 7.18. 6th field watersheds ranked highest for functioning coho summer habitat

Rank (scale of 1 to 100; 1 is best)	**6th field watershed name**	**Major basin**	**6th field code**	**Major contributing factors**
22.05	GREEN RIVER	Alsea	50216	% pools, channel widths/pool, gravel substrate, potential habitat
22.28	HONEYGROVE	Alsea	50113	% pools, channel widths/pool, LWD, bedrock*
26.43	RYDER[2]	Alsea	50110	% shade, bedrock, potential habitat
28.07	MOLOCH	Ocean Tribs	41008	% pools, channel widths/pool, LWD, potential habitat
28.65	SPENCER	Ocean Tribs	41007	channel widths/pool, LWD, bedrock*
28.97	LOWER_SPOUT	Yaquina	40203	% pools, channel widths/pool, % shade, bedrock*, coho/sq m
29.21	SF_SILETZ[1]	Siletz	40410	gravel substrate, bedrock*, potential habitat

Table 7.18. 6th field watersheds ranked highest for functioning coho summer habitat

Rank (scale of 1 to 100; 1 is best)	6th field watershed name	Major basin	6th field code	Major contributing factors
30.69	CRAB	Alsea	50212	% pools, gravel substrate, coho/sq m
30.99	SIMPSON	Yaquina	40103	% shade, bedrock*
31.32	U. LOBSTER	Alsea	50206	LWD, bedrock*, coho/sq m

1 Anadromous migration barriers affect this watershed and may affect other watersheds. See text for details.
2 The Ryder Creek 6th field ranked in the top 10 for functioning coho summer habitat, but had only 720m of stream length surveyed (on Hayden Creek). Results may not be representative of the entire 6th field.
*Where "bedrock" is a contributing factor, the 6th field's length of riffles with bedrock substrate dominant was among the **shortest** in the study area.

7.20.6.2 Interpretation

As described in **Multi-factor analyses of salmonid habitat** above, some of the high-ranked watersheds in **Table 7.18** are affected by barriers to migration of anadromous fish. Although no GIS data on anadromous migration barriers appropriate for ranking 6th field watersheds were available for this assessment, MCWC provided us with information on some known barriers (Wayne Hoffman, personal communication, 2001) which affect 6th field watersheds listed in **Table 7.18**. Specifically, the South Fork Siletz watershed is above Siletz Falls, which has a fish ladder and trap, but currently, coho are not being passed through the trap to the ladder.

Data availability was an important factor in this analysis. All 6th fields with AHI data available were ranked in this analysis, even those which may be inaccessible to coho. Sixth field watersheds without RBA data were ranked, as were 6th fields without % shade data. We felt it was best to rank all 6th fields with AHI data, even those without RBA data, since lack of RBA data does not necessarily indicate lack of coho or coho access. Some 6th fields may not currently be populated with coho (or may not have been surveyed), but may offer good opportunities for restoration actions such as barrier removal that could re-introduce coho into those areas.

Percent shade data were available only from AHI data collected using the ODFW protocol and not USFS Region 6 tabular data (which did not contain % shade). Rapid Bioassessment data were available for only 115 6th field watersheds, and not all of these 115 had AHI data. Of the 154 6th field watersheds that had AHI data, only 94 had % shade data. The number of 6th fields that had the various types of data is shown in **Table 7.19**.

Table 7.19. Data available for coho summer habitat multi-factor analysis

Types of data available	**# of 6th fields**
All data available (AHI including % shade, RBA, DEM)	64
All data except % shade available	90
All data except % shade and RBA data	154

In every 6th field that had AHI data, we averaged the normalized rankings for all available data. In this way, no 6th field received a lower ranking because it was missing data; but all available data could raise or lower a 6th field's ranking based on their individual factor rankings.

As for the Functioning Coho Winter Habitat Analysis and the Functioning Winter Steelhead Habitat Analysis, only 6th fields with AHI data could be ranked in this analysis. Some 6th fields lacking AHI data may have good coho habitat functions. We recommend AHI surveys for areas not yet surveyed but offering good coho summer habitat potential, and we also recommend re-survey of areas surveyed several years ago to determine whether habitat has changed since the earlier survey.

The data used in the Functioning Coho Summer Habitat analysis were taken from stream surveys, which are conducted only in nontidal habitats. Therefore, 6th field watershed rankings for Functioning Coho Summer Habitat do not reflect presence of vital estuarine habitat. Estuaries are an important part of salmonid winter habitat; chinook, coho, chum, steelhead and cutthroat all use estuaries during the fall and winter months (Brophy 1999). As described in **Estuaries** below, we recommend that the Action Planning process should assign high ranking to 6th field watersheds containing extensive estuarine habitats, at least equal to the highest-ranked 6th field watersheds in the Functioning Coho Summer Habitat.

We followed the above ranking procedures because we felt they provided the best interpretation of the data. However, many different ranking systems are equally defensible for an analysis of this type. If they wish, MCWC members will be able to re-rank 6th fields using alternative systems by manipulating the aquatic habitats summary shapefile **aqhab_sum_final.shp**.

As requested by MCWC, we used absolute lengths for analysis of potential habitat and substrates. Analysis of proportional lengths is recommended as a supplement to the absolute lengths analysis. A discussion of proportional lengths *versus* absolute lengths is found in "**Interpreting the results of aquatic habitat analyses: Absolute lengths *versus* proportion of surveyed lengths**" in **Appendix A: Supplemental Methods**.

7.20.6.3 Recommended uses

The rankings can help prioritize 6th fields for actions designed to improve coho summer habitat. The rankings should not be used alone for this purpose, but should be used in conjunction with other data, particularly field verification of suitable conditions.

Before using the rankings, we recommend careful review of the detailed methods for each individual analysis that was used in the multi-factor analysis. All datasets have their limitations and proper uses, and many of these are discussed in the methods sections for the individual analyses.

7.20.6.4 Data recommendations

The data collected in AHI surveys can change considerably over the course of a single year. Therefore, any future analyses of coho summer habitat should use the most recent AHI survey data. We recommend surveying new reaches that appear to offer high potential habitat value, as well as re-surveying critical reaches for which survey data are more than a couple of years old.

Since AHI data from USFS and Lincoln District sources was not georeferenced, it was not possible to develop a site-specific, reach-by-reach analysis of functioning habitat that incorporated all of the available AHI data. However, it would be possible to locate some specific reaches that meet all of the Functioning Coho Summer Habitat criteria, by using the Aquatic Habitat Inventory data that originated from the ODFW GIS. This analysis would be a logical next step for the Basin Planning Teams. For such a site-specific analysis, it will be particularly important to consider the age of the AHI data (survey date). Ground-truthing or re-survey of critical reaches is recommended, particularly if the AHI data in question are more than a year or two old.

Scale is a consideration in site-specific analyses such as the one described above. The ODFW data are entered on a 1:100K streams layer, while the DEM analysis is conducted at the 1:24K scale that is considered appropriate for watershed assessment at the 5th field level. This scale difference will need to be considered when conducted any site-specific analysis that uses both DEM and ODFW GIS data.

7.20.7 Winter steelhead habitat: Introduction

Spawning winter steelhead use small, moderate-gradient tributary streams with gravel-to-cobble sized substrate and low levels of fine materials (silt, sand, and organic sediments).

We conducted two multi-factor analyses of winter steelhead habitat for this assessment. As requested by MCWC, we did not distinguish between habitat used by this species in winter *versus* summer.

7.20.8 Potential winter steelhead habitat

The first winter steelhead habitat analysis was the **Potential Winter Steelhead Habitat Analysis**. As requested by the MidCoast Watersheds Council Tech Team, this analysis located stream reaches that were classified as "confined", and moderate-gradient (1 to 5 degrees, or 1.75 to 8.75% slope). This analysis was accomplished within ArcView by selecting from the **DEM-derived streams layer** those segments with gradient 0 to 2 degrees, and confinement "unconfined." The potential habitat analysis was a sub-6th field analysis that provided data on specific stream reaches meeting the criteria of moderate gradient and "confined" as defined by DEM analysis. (By contrast, the Functioning Winter Steelhead Habitat analysis was a 6th field ranking.)

7.20.8.1 Results: Study area summary

Table 7.20 shows the nineteen 6th field watersheds that had the greatest length of potential winter steelhead habitat. The specific stream reaches identified are shown in the **Basin Inserts**, in Figures **AQ-20AL** through **AQ-20YQ**. These figures also show winter steelhead habitat as mapped by ODFW.

Table 7.20. 6th field watersheds with greatest length of potential winter steelhead habitat

6th field watershed name	Major basin	6th field code	Length of potential winter steelhead habitat (m)
U. SALMON RIVER	Salmon	40901	10,905
LITTLE ELK	Yaquina	40111	9,879
BUTTERMILK	Yaquina	40105	8,994
UPPER_SF_ALSEA[1]	Alsea	50119	8,368
BEAR	Yaquina	40201	7,515
SF_SILETZ[1]	Siletz	40410	7,329
BENTILLA	Siletz	40712	7,280
EUCHRE	Siletz	40704	6,618
MOLOCH	Ocean Tribs	41008	6,617
CERINE	Siletz	40507	6,529
CANAL	Alsea	50419	6,137
NORTH BEAVER2	Ocean Tribs	50502	6,127
BUMMER	Alsea	50116	6,105
GRAVEL	Siletz	40501	6,081
BEAVER	Ocean Tribs	50501	6,069
PEAK	Alsea	50111	5,906
NORTH YACHATS	Yachats	50508	5,881
U. CEDAR	Siletz	40703	5,792
SUNSHINE	Siletz	40504	5,660
L. BIG ELK	Yaquina	40208	5,645
ROOT	Siletz	40705	5,643

[1] Anadromous migration barriers affect this watershed and may affect other watersheds. See text for details.

7.20.8.2 Interpretation

As described in **Multi-factor analyses of salmonid habitat** above, some of the watersheds in **Table 7.20** are affected by barriers to migration of anadromous fish. Although no GIS data on anadromous migration barriers appropriate for ranking 6th field watersheds were available for this assessment, MCWC provided us with information on some known barriers (Wayne Hoffman, personal communication, 2001) which affect 6th field watersheds listed in **Table 7.20**. Specifically, the Upper South Fork Alsea is above Alsea Falls, which is impassable to anadromous fish. The South Fork Siletz and Gravel Creek watersheds are above Siletz Falls, which has a fish ladder and trap, but currently, Specifically, the South Fork Siletz watershed is above Siletz Falls, which has a fish ladder and trap. Currently, summer steelhead but not winter steelhead are being passed through the trap to the ladder. Bear Creek has a falls which blocks about half the potential habitat in the 6th field.

Exercise caution in interpreting the results of this example. DEM-derived stream confinement and gradient have not been field-verified, and should be ground-truthed before site-specific actions are planned.

It is important to note that estuaries provide important steelhead habitat (NOAA 1990), and the criteria used to evaluate potential steelhead habitat excluded estuarine environments. Steelhead use estuaries for a few days during their transition from freshwater systems to the ocean, and although residence time is brief, the osmotic transition and foraging opportunities offered by estuaries may be very important to juvenile survival in the ocean.

7.20.9 Functioning winter steelhead habitat

The Functioning Winter Steelhead Habitat Analysis ranks 6th fields using a combination of factors that influence winter steelhead habitat. In this analysis, we attempted to determine whether potential winter steelhead habitat was, in fact, functioning. Data availability and data limitations affected this analysis; all the factors added to the potential habitat analysis were from AHI, and the extent of AHI surveys varies widely from 6th field to 6th field.

There are many possible definitions of "functioning winter steelhead habitat." The MidCoast Watersheds Council requested we incorporate the following factors into this multi-factor analysis:

Table 7.21. Factors used in functioning winter steelhead habitat analysis

Factor	**Effect of high value on ranking (+/-)**
Length of potential habitat (confined,* moderate-gradient)	+
Length of riffle habitat	+
Length of riffle habitat with gravel-to-boulder-sized substrate dominant	+

* see DEM analysis of stream confinement for details on definition of "confined"

MCWC recognizes that other factors are important in determining the functional level of winter steelhead habitat (such as low water temperature, high water velocity, and deep water), but we did not have adequate data to address these factors in this assessment.

As described above, due to lack of GIS data on anadromous migration barriers, this analysis addressed only physical factors but did **not** reflect existing barriers to anadromous migration. Therefore, portions of the top-ranked 6th field watersheds may not be accessible to anadromous fish.

We used the following data sources for the factors chosen for the functioning winter steelhead habitat analysis:

Table 7.22. Data sources for functioning winter steelhead analysis		
Factor	**Data source**	**Analysis link**
Length of confined, moderate-gradient streams	Digital elevation model (DEM)	derived_stream_confinement.htm, der_stream_gradient.htm
Length of riffle habitat	AHI data	ahi_riff_length.htm
Length of riffle habitat with gravel-to-boulder-sized substrate dominant	AHI data	ahi_gravel_2_boulder.htm

For length of riffle habitat, we summed the lengths from all data sources and ranked the 6th fields from top (rank 1, greatest length of riffles) to bottom (rank 100, shortest length) based on the total length. We used the same procedure for the length of riffle units with gravel-to-boulder-sized substrate dominant. Both rankings were normalized to a scale of 100.

We then averaged the rankings for all three factors into a single ranking, **wist_rnk**. Possible values for **wist_rnk** ranged from 1 (best-functioning habitat using these criteria) to 100 (lowest-functioning habitat using these criteria).

7.20.9.1 Results: Study area summary

Table 7.23 shows the mean, maximum, and minimum value for each parameter used in the functioning coho summer habitat analysis.

Table 7.23. Sample statistics for factors used in functioning winter steelhead habitat analysis.			
	Length of riffle units (m)	**Length of riffle units with gravel substrate (m)**	**Length of potential habitat (m)**
Mean	3,450	2,535	3,345
Minimum	0	0	180
Maximum	24,112	14,016	10,905
Count	154	154	217
* Count = number of 6th field watersheds that had data for the parameter listed ** Potential habitat = moderate-gradient, confined streams (from DEMs)			

Table 7.24 shows the 6th field watersheds that were ranked in the top 10 (out of all 217 6th field watersheds) for functioning winter steelhead habitat.

The major contributing factors to each watershed's high ranking are shown. These are the specific aquatic habitat characteristics that contributed most to the watershed's high ranking, by having an individual factor ranking in the top 10 on a scale of 100. (For a 6th field watershed to fall in the top 11 overall ranking, the other factors also were generally in the top quarter of the scale of 100.) Where "potential habitat" is shown as a major contributing factor, this means that the length of potential habitat (as defined in **Potential**

winter steelhead habitat above) was among the longest in the study area, thus contributing greatly to the overall high ranking of the 6th field.

Table 7.24. 6th field watersheds ranked highest for functioning winter steelhead habitat

Rank (scale of 1 to 100; 1 is best)	**6th field watershed name**	**Major basin**	**6th field code**	**Major contributing factors**
2.15	CANAL	Alsea	50419	riffle length; gravel-to-boulder substrate
3.98	NORTH YACHATS	Yachats	50508	riffle length; gravel-to-boulder substrate
4.29	CAPE	Ocean Tribs	50711	riffle length; gravel-to-boulder substrate
5.29	EUCHRE	Siletz	40704	riffle length; gravel-to-boulder substrate
6.57	PEAK	Alsea	50111	riffle length; gravel-to-boulder substrate
7.66	BLODGETT	Ocean Tribs	50507	riffle length; gravel-to-boulder substrate
11.14	SF_SILETZ[1]	Siletz	40410	potential habitat
11.22	L. YACHATS	Yachats	50510	riffle length; gravel-to-boulder substrate
11.96	CERINE	Siletz	40507	potential habitat
12.70	U. BUCK	Alsea	50214	riffle length; gravel-to-boulder substrate

1 Anadromous migration barriers affect this watershed and may affect other watersheds. See text for details.

7.20.9.2 Interpretation

As described in **Multi-factor analyses of salmonid habitat** above, some of the high-ranked watersheds in **Table 7.24** are affected by barriers to migration of anadromous fish. Although no GIS data on anadromous migration barriers appropriate for ranking 6th field watersheds were available for this assessment, MCWC provided us with information on a known barrier (Wayne Hoffman, personal communication, 2001) which affects one of the 6th field watersheds listed in **Table 7.24**. Specifically, the South Fork Siletz watershed is above Siletz Falls, which has a fish ladder and trap. Currently, summer steelhead but not winter steelhead are being passed through the trap to the ladder.

The winter steelhead habitat ranking uses only three factors, and two of them are closely related (length of riffle habitat, and length of riffle habitat with gravel-to-boulder-sized substrate dominant). Future analyses should incorporate other important steelhead habitat factors such as stream temperature, stream velocity, water depth, LWD, pool complexity, and fine substrates.

Only 6th fields with AHI data could be ranked in this analysis. Some 6th fields lacking AHI data may have good winter steelhead habitat functions. We recommend AHI surveys for areas not yet surveyed but offering good winter steelhead habitat potential, and we also recommend re-survey of areas surveyed several years ago to determine whether habitat has changed since the earlier survey. As with all analyses based on AHI data, interpretation depends heavily on the date of the survey and the length and proportion of streams surveyed.

We followed the above ranking procedures because we felt they provided the best interpretation of the data. However, many different ranking systems are equally defensible for an analysis of this type. If they wish, MCWC members will be able to re-rank 6th fields using alternative systems by manipulating the aquatic habitats summary shapefile **aqhab_sum_final.shp**.

As requested by MCWC, we used absolute lengths for analysis of potential habitat and side channels. Analysis of proportional lengths is recommended as a supplement to the absolute lengths analysis. A discussion of proportional lengths *versus* absolute lengths is found in "**Interpreting the results of aquatic habitat analyses: Absolute lengths *versus* proportion of surveyed lengths**" in **Appendix A: Supplemental Methods**.

The data used in the Functioning Winter Steelhead Habitat analysis were taken from stream surveys, which are conducted only in nontidal habitats. Therefore, 6th field watershed rankings for Functioning Winter Steelhead Habitat do not reflect presence of vital estuarine habitat. Estuaries are an important part of salmonid winter habitat; for example, steelhead use the Yaquina estuary during the winter months and the Alsea estuary during the summer months (NOAA 1990). As described in **Estuaries** below, we recommend that the Action Planning process should assign high ranking to 6th field watersheds containing extensive estuarine habitats, at least equal to the highest-ranked 6th field watersheds in the Functioning Winter Steelhead Habitat.

7.20.9.3 Recommended uses

The rankings can help prioritize 6th fields for actions designed to improve winter steelhead habitat, such as placement of large woody debris and riparian fencing. The rankings should not be used alone for this purpose, but should be used in conjunction with other data, particularly field verification of suitable conditions.

Before using the rankings, we recommend careful review of the detailed methods for each individual analysis that was used in the multi-factor analysis. All datasets have their limitations and proper uses, and many of these are discussed in the methods sections for the individual analyses.

7.20.9.4 Data recommendations

The data collected in AHI surveys can change considerably over the course of a single year. Therefore, any future analyses of winter steelhead habitat should use the most recent AHI survey data. We recommend surveying new reaches that appear to offer high potential habitat value, as well as re-surveying critical reaches for which survey data are more than a couple of years old.

Since AHI data from USFS and Lincoln District sources were not georeferenced, it was not possible to develop a site-specific, reach-by-reach analysis of functioning habitat that incorporated all of the available AHI data. However, it would be possible to locate some specific reaches that meet all of the Functioning Winter Steelhead Habitat criteria, by using the Aquatic Habitat Inventory data that originated from the ODFW GIS. This analysis would be a logical next step for the Basin Planning Teams. For such a site-specific analysis, it will be particularly important to consider the age of the AHI data (survey date). Ground-truthing or re-survey of critical reaches is recommended, particularly if the AHI data in question are several years old.

Scale is a consideration in site-specific analyses such as the one described above. The ODFW data are entered on a 1:100K streams layer, while the DEM analysis is conducted at the 1:24K scale that is considered appropriate for watershed assessment at the 5th field level. This scale difference will need to be considered when conducted any site-specific analysis that uses both DEM and ODFW GIS data.

7.21 Multi-factor salmonid habitat analyses: Synthesis

Multi-factor analyses of coho winter and summer habitat and winter steelhead habitat were major products of this assessment. **Table 7.25** shows the 6th field watersheds that ranked in the top quarter (top 39 out of 154 watersheds ranked) for both the coho winter habitat analysis and the coho summer habitat analysis. The 6th fields in bold type and starred were also in the top quarter of the rankings for winter steelhead habitat.

Table 7.25. 6th field watersheds ranking in the top quarter for both functioning coho winter and functioning coho summer habitat

6th field watershed name	Major basin	6th field code
HONEYGROVE	Alsea	50113
UPPER_SF_ALSEA[1]	Alsea	50119
GREEN RIVER	Alsea	50216
SF_ALSEA_HEADWATERS[1]	Alsea	50120
SPENCER	Ocean Tribs	41007
LOWER_SPOUT	Yaquina	40203
SF_SILETZ[1]	Siletz	40410
ROCKY[1]	Ocean Tribs	41005
ROCK1*	Ocean Tribs	41012
L. BUCK	Alsea	50208
MOLOCH	Ocean Tribs	41008
CRAB*	Alsea	50212
U. YACHATS*	Yachats	50513
ROOT	Siletz	40705
SPOUT	Yaquina	40207
PREACHER*	Alsea	50213

U. SALMON RIVER	Salmon	40901
M. FIVE	Alsea	50210
SEELY	Alsea	50112
LITTLE ELK*	Yaquina	40111

1 Anadromous migration barriers affect this watershed and may affect other watersheds. See text for details.
* Watershed also ranks in top quarter for functioning winter steelhead habitat.

7.21.1.1 Interpretation

As described in **Multi-factor analyses of salmonid habitat** above, some of the high-ranked watersheds in **Table 7.25** are affected by barriers to migration of anadromous fish. Although no GIS data on anadromous migration barriers appropriate for ranking 6th field watersheds were available for this assessment, MCWC provided us with information on a known barrier (Wayne Hoffman, personal communication, 2001) which affects one of the 6th field watersheds listed in **Table 7.25**. Specifically, the South Fork Siletz watershed is above Siletz Falls, which has a fish ladder and trap. Currently, summer steelhead but not winter steelhead are being passed through the trap to the ladder. The Upper South Fork Alsea and South Fork Alsea Headwaters watersheds are above Alsea Falls, which is impassable to anadromous fish. Rocky Creek is currently blocked to all anadromous passage by a fill and perched culvert under Highway 101, at the creek's mouth.

8 Water Resources

8.1 Water quality

Water quality is a term that is often used to describe many properties of bodies of water including, but not limited to temperature, nutrient concentration (most commonly nitrogen and phosphorus), pH, conductivity, alkalinity, dissolved oxygen concentration, contaminant (pollutant) concentration, and concentration of indicator bacteria. All of these factors vary in time and space within streams, rivers, lakes, and estuaries, which make them very difficult to study. Yet, water quality often limits (in biological terms) the types and abundance of organisms that live in these aquatic environments.

For this assessment, we focused on existing data sources. We used the Oregon DEQ 303(d) list, and data contained in EPA STORET database. STORET is used by DEQ to determine which stream segments are of poor water quality. In addition, we found stream temperature information from Siuslaw National Forest.

8.1.1 303(d) listed streams

The 1972 Federal Water Pollution Control Act (amended as The Clean Water Act in 1977) established broad water quality goals for the nation's fishable and swimmable waters. The Oregon Department of Environmental Quality (ODEQ) is one of the agencies that monitor water quality in the State of Oregon. ODEQ is required by the federal Clean Water Act to maintain a list of steam segments that do not meet water quality standards, the so-called 303(d) list. Water bodies that do not meet water quality standards are said to be water quality limited or impaired. The term, "water quality limited", refers to a limitation in a beneficial use of that water body. Beneficial uses of state waters, as defined by the Oregon Legislature (ORS 468.710) include: domestic, municipal, irrigation, power development, industrial, mining, recreation, wildlife and fish uses, and pollution abatement. Water quality standards, levels or concentrations of water quality variables, such as fecal coliform bacteria, temperature, or dissolved oxygen, have been established to classify state waters as "supporting", "partially-supporting", or "not-supporting" certain beneficial uses.

We obtained GIS coverages of Oregon's 1998 List of Water Quality Limited Waterbodies (the "303[d] list") from the ODEQ website. The zipped coverages included two ArcInfo export files, one for streams (**s303_98.e00**$^{\mathbf{W}}$), and one for lakes and reservoirs (**l303_98.e00**$^{\mathbf{W}}$). The lakes coverage included only one lake in the study area (Devil's Lake, listed for chlorophyll a concentration and pH). Since this was the only listed lake, 303(d) listed lakes were not incorporated into the quantitative analysis. The 303(d) listed streams coverage is based on the 1:100K streams layer.

We used ARCView to intersect the 303(d) coverage with the 6th Field Watershed layer. We then summarized the total length of 303(d) listed streams for each 6th field. We then joined the table of total stream lengths to the 6th field GIS layer and color-coded 6th fields by this length. The length shown includes streams listed for all criteria; however, most of the stream length (90%) was listed for high temperatures; about 10% of the listed length was impaired by habitat modification or sedimentation, and about 5% was listed for fecal coliform contamination.

The 303(d) list is used as a first step in locating water quality-impaired reaches, as described in the OWEB Watershed Assessment Manual. The 303(d) list does not include all streams that are impaired by high temperatures, sedimentation, fecal coliform, or other factors. Most of the 303(d) listed streams are main stem rivers or large tributaries. This may reflect the methods used to designate 303(d) streams (i.e., larger rivers may receive more scrutiny during the designation process) as well as actual differences in water quality. For 6th fields that show a high length of 1:100K streams that are 303(d) listed, we recommend using finer-scale data to locate and characterize the nature of the water quality impairment. For example, STORET data may provide useful data for some locations in the study area. For areas within the Siuslaw National Forest, the Forest's stream temperature data will provide useful details. Carefully planned monitoring is recommended to increase the understanding of water quality issues in the study area.

8.1.2 NPDES permits

The 1972 Federal Water Pollution Control Act defined two sources of pollution: point and nonpoint. **Point sources** of pollution can be clearly identified; examples include discharges from industry and sewage treatment plants. Such discharges often enter the receiving waters *via* a discharge pipe. All point sources discharging into navigable waters are regulated by the National Pollutant Discharge Elimination System (NPDES). In Oregon, the Department of Environmental Quality is responsible for implementing components of the NPDES program, such as storm water discharge permits.

The purpose of the NPDES Program is to protect human health and the environment. By point sources, EPA means discrete conveyances such as pipes or man made ditches. All facilities (excluding individual households) must obtain permits if their discharges go directly to surface waters. Examples of pollutants that may threaten public health and the nation's waters are: human wastes, ground-up food from sink disposals, laundry and bath waters, toxic chemicals, oil and grease, metals, and pesticides (EPA, *http://www.epa.gov/owm/npdes.htm*).

Point sources of pollution include wastewater treatment plants and other effluent discharges. The Clean Water Act requires that all point sources discharging pollutants into waters of the United States must obtain an NPDES permit. This includes storm water discharges associated with “industrial activity,” according to a fact sheet put out by ODEQ. Industrial activity is defined as having the industry listed by EPA or having storm or snow melt leaving the site through a point source (pipe, culvert, ditch, basin, channel, etc.) and reaching surface waters directly or though storm drainage. Some construction activities are also included.

There are 10 or less NPDES permittees in the study area, so this parameter was not suitable for use in prioritizing 6th field watersheds. Named permittees include the sewage treatment plants in the cities of Siletz, Lincoln City, Waldport, and Toledo; the NW Fisheries Science Center in the Yaquina basin; the Salishan Sanitary District in the Siletz basin; and the Tyson Seafood Group in the Yaquina basin.

8.1.3 Non-point pollution sources

Nonpoint sources of pollution may have no readily identifiable source, or may originate from broad areas rather than discrete points. Examples are pesticides entering streams from aerial spraying; run-off from urban, construction, and agricultural activities; animal wastes entering streams from pastures; and septic tank seepage. Nonpoint source pollution can enter the receiving waters *via* overland or underground flow. It is much more difficult to identify and manage non-point sources of pollution than point sources.

No GIS data were available on non-point pollution sources, and therefore we were not able to prioritize 6th field watersheds on this basis. However, part of good watershed management includes awareness of these pollution sources. We recommend that local watershed groups work towards increasing awareness of nonpoint pollution sources, and take action to reduce these pollution sources. Examples of actions that can reduce pollutants entering streams from surface water runoff include riparian fencing, riparian plantings, grazing management and pasture rotation, and education for responsible pesticide use.

8.1.4 EPA's STORET

The STORET (short for STOrage and RETrieval) database is a repository for water quality, biological, and physical data. STORET contains raw biological, chemical, and physical data on surface and ground water collected by federal, state and local agencies, Indian Tribes, volunteer groups, academics, and others. Data collected from all 50 States, territories, and jurisdictions of the U.S., along with portions of Canada and Mexico, are stored in the system. If water quality was measured, it generally ends up in the STORET database.

Currently, STORET data are available as two separate databases, divided according to when data were originally supplied to EPA. The older of the two databases is called the STORET Legacy Data Center (LDC for short), and the more current is called Modernized STORET. Water quality observations made prior to 1999 are stored in the LDC database. Both data sets are available *via* the Internet (*http://www.epa.gov/storet/*).

We obtained available STORET data on CD-ROM. The CD-ROM contains data that were available at the time the CD-ROM was created (May 2000). We followed up by checking for data updates on the EPA STORET web site.

In general, we found that water quality was measured infrequently and not in enough locations to be of use in prioritizing 6th field watersheds. We provide summaries of the STORET data and sampling locations to assist the MidCoast in their Action Planning.

The following is a brief description of how the data are organized in STORET. Individual water quality measurements, called parameters, are given unique parameter codes. Within the STORET database parameters are grouped into 18 major categories (group codes) which include administrative, bacteriological, biological, dissolved oxygen, flow, general inorganic, general organic, metal, nitrogen, oxygen demand, pesticide, phosphorus, physical, radiological, solid, temperature, miscellaneous, and other. Measurements are made at STORET stations, each identified by a unique number. Data can be retrieved by 4th field HUC, by station, or by parameter number or group codes.

There are two 4th field HUCs that drain the MidCoast study area, 17100204 (Siletz-Yaquina) and 17100205 (Alsea).

For the Siletz-Yaquina HUC (17100204) there are data from 236 individual STORET stations with more that 1,300 observations made from the early 1960s through the late 1990s. Since data are collected for different reasons by different agencies and entered into STORET it can be difficult to use STORET data to determine trends in water quality (see Busse and Garono, 1996; Busse, 1998).

We queried the STORET database for stations where multiple measurements were made after 1990. Those sample stations and the water quality variables are listed below in **Table 8.1**.

Table 8.1. Summary of Water Quality Sample Stations found within the STORET database for the MidCoast Region.

Station	Name/ Type	Parameter No	Variables/ (No. Observations)	Dates of Records	
				Start	End
404536	Deer Creek (Ambient Stream)	00300	Dissolved Oxygen (2)	1 Oct 1992	1 Sep 1994
		00076	Turbidity (2)	1 Oct 1992	1 Sep 1994
404539	Rock Creek RM 1.5 (Ambient Stream)	00300	Dissolved Oxygen (1)	29 Sep 1992	29 Sep 1992
		00010	Temp (1)	29 Sep 1992	29 Sep 1992
		00076	Turbidity (1)	29 Sep 1992	29 Sep 1992
404540	Tenmile Creek (Ambient Stream)	00300	Dissolved Oxygen (1)	29 Sep 1992	29 Sep 1992
		00010	Temp (1)	29 Sep 1992	29 Sep 1992
		00076	Turbidity (1)	29 Sep 1992	29 Sep 1992
404541	Cummins Creek (Ambient Stream)	00010	Temp (2)	30 Sep 1992	16 Aug 1993
		00076	Turbidity (2)	30 Sep 1992	16 Aug 1993
		00300	Dissolved Oxygen (2)	30 Sep 1992	16 Aug 1993
404542	Peak Creek RM 3.5 (Ambient Stream)	00300	Dissolved Oxygen (1)	30 Sep 1992	30 Sep 1992
		00010	Temp (1)	30 Sep 1992	30 Sep 1992
		00076	Turbidity (1)	30 Sep 1992	30 Sep 1992
405042	Cullen Creek RM 0.3 (Ambient Stream)	00300	Dissolved Oxygen (2)	25 Aug 1994	6 Aug1996
		00010	Temp (2)	25 Aug 1994	6 Aug 1996
		00076	Turbidity (2)	25 Aug 1994	6 Aug 1996
405043	Lint Creek at RM 3.1 (Ambient Stream)	00300	Dissolved Oxygen (1)	25 Aug 1994	25 Aug1994
		00010	Temp (2)	25 Aug 1994	25 Aug 1994
		00076	Turbidity (2)	25 Aug 1994	25 Aug 1994
405044	Yaquina River at Eddyville (Ambient Stream)	00010	Temp (8)	30 Aug 1994	18 Mar 1997
		00300	Dissolved Oxygen (4)	30 Aug 1994	14 Aug 1996
		00076	Turbidity (6)	30 Aug 1994	18 Mar 1997
405056	Steer Creek Upper (Ambient Stream)	00010	Temp (1)	17 Aug 1994	17 Aug 1994
		00300	Dissolved Oxygen (1)	17 Aug 1994	17 Aug 1994
		00076	Turbidity (1)	17 Aug 1994	17 Aug 1994
405057	Steer Creek Lower (Ambient Stream)	00010	Temp (1)	18 Aug 1994	18 Aug 1994
		00300	Dissolved Oxygen (1)	18 Aug 1994	18 Aug 1994
		00076	Turbidity (1)	18 Aug 1994	18 Aug 1994

Table 8.1. Summary of Water Quality Sample Stations found within the STORET database for the MidCoast Region.

Station	Name/ Type	Parameter No	Variables/ (No. Observations)	Dates of Records	
				Start	End
AGATE13	Pond at Toe of Slide AG B FF (Well)	00300	Dissolved Oxygen (2)	8 Apr 1992	10 Nov 1992
		31507	T coliform MPN (1)	8 Apr 1992	8 Apr 1992
		31615	Fecal coliform MPN (1)	8 Apr 1992	8 Apr 1992
		31639	Ent cocci (1)	8 Apr 1992	8 Apr 1992
MIC002	Cypher Truax Texaco (Well)	00010	Temp (1)	9 May 1994	9 May 1994
MIC003	Cypher Truax Texaco (Well)	00010	Temp (2)	9 May 1994	9 May 1994
WALDPORT 01	Waldport Landfill (Well)	00300	Dissolved Oxygen (1)	25 Oct 1994	25 Oct 1994
WALDPORT 02	Waldport Landfill (Well)	00300	Dissolved Oxygen (1)	25 Oct 1994	25 Oct 1994
WALDPORT 04	Waldport Landfill (Well)	00300	Dissolved Oxygen (1)	25 Oct 1994	25 Oct 1994
WALDPORT 05	Waldport Landfill (Well)	00300	Dissolved Oxygen (1)	25 Oct 1994	25 Oct 1994
WALDPORT 07	Waldport Landfill, Leachate (Well)	00010	Temp (1)	25 Oct 1994	25 Oct 1994
		31615	Fecal coliform MPN (1)	25 Oct 1994	25 Oct 1994
		31639	Ent cocci (1)	25 Oct 1994	25 Oct 1994
		00300	Dissolved Oxygen (1)	25 Oct 1994	25 Oct 1994
WALDPORT 08	Waldport Landfill, Leachate (Well)	31507	T coliform MPN (1)	25 Oct 1994	25 Oct 1994
		31615	Fecal coliform MPN (1)	25 Oct 1994	25 Oct 1994
		31639	Ent cocci (1)	25 Oct 1994	25 Oct 1994
		00300	Dissolved Oxygen (1)	25 Oct 1994	25 Oct 1994
		00010	Temp (1)	25 Oct 1994	25 Oct 1994
402921	Salmon River at Old Scenic Hwy (Ambient Stream)	31613	Fecal Coliform Agar (9)	19 Mar 1996	9 Dec 1997
		31613	Fecal Coliform Agar (9)	19 Mar 1996	9 Dec 1997
		31615	Fecal coliform MPN (14)	10 Mar 1993	12 Sep 1995
		31639	Ent cocci (14)	10 Mar 1993	12 Sep 1995
		31648	E. coli (9)	19 Mar 1996	9 Dec 1997
		00076	Turbidity (23)	10 Mar 1993	9 Dec 1997

Table 8.1. Summary of Water Quality Sample Stations found within the STORET database for the MidCoast Region.

Station	Name/ Type	Parameter No	Variables/ (No. Observations)	Dates of Records	
				Start	End
405059	Brush Creek (Ambient Stream)	00010	Temp (2)	19 Aug 1994	19 Aug 1994
		00300	Dissolved Oxygen (2)	19 Aug 1994	19 Aug 1994
		00076	Turbidity (2)	19 Aug 1994	19 Aug 1994
405072	Yaquina River US of Eddyville (Ambient Stream)	00010	Temp (7)	31 Aug 1994	18 Mar 1997
		00300	Dissolved Oxygen (2)	31 Aug 1994	12 Aug 1996
		00076	Turbidity (7)	31 Aug 1994	18 Mar 1997
405078	Gaper Station 11A (Yaquina Bay) (Ambient Estuary)	00010	Temp (37)	10 Aug 1994	28 Apr 1997
		31615	Fecal coliform MPN (18)	10 Aug 1994	21 Jun 1995
		31621	Fec Coli A (20)	18 Jul 1995	28 Apr 1997
405280	Salmon River at RM 21 (Ambient Stream)	00010	Temp (3)	7 Aug 1995	25 Sep 1996
		00300	Dissolved Oxygen (3)	7 Aug 1995	25 Sep 1996
		00076	Turbidity (3)	7 Aug 1995	25 Sep 1995
405093	Honey Grove Creek RM 1.2 (Ambient Stream)	00300	Dissolved Oxygen (3)	12 Sep 1994	3 Sep 1996
		00010	Temp (6)	12 Sep 1994	18 Mar 1997
		00076	Turbidity (6)	12 Sep 1994	18 Mar 1997
405281	Trout Creek RM 0.2 (Ambient Stream)	00300	Dissolved Oxygen (2)	8 Aug 1995	12 Sep 1996
		00010	Temp (2)	8 Aug 1995	12 Sep 1996
		00076	Turbidity (2)	8 Aug 1995	12 Sep 1996
405282	Drift Creek RM 7.3 (Ambient Stream)	00300	Dissolved Oxygen (3)	9 Aug 1995	11 Sep 1996
		00010	Temp (7)	9 Aug 1995	18 Mar 1997
		00076	Turbidity (7)	9 Aug 1995	18 Mar 1997
405283	Tenmile Creek (Ambient Stream)	00300	Dissolved Oxygen (3)	19 Jul 1995	4 Sep 1996
		00010	Temp (8)	19 Jul 1995	18 Mar 1997
		00076	Turbidity (8)	19 Jul 1995	18 Mar 1997
412377	Yaquina Bay South Beach Marina (Ambient Estuary)	00010	Temp (26)	18 Jan 1995	28 Apr 1997
		31615	Fecal coliform MPN (4)	18 Jan 1995	21 Jun 1995
		31621	Fec Coli A (22)	18 Jul 1995	28 Apr 1997
412403	Alsea Bay at Mouth (Ambient Estuary)	31621	Fec Coli A (9)	13 Feb 1997	16 Dec 1997
		00010	Temp (9)	13 Feb 1997	16 Dec 1997

Table 8.1. Summary of Water Quality Sample Stations found within the STORET database for the MidCoast Region.

Station	Name/ Type	Parameter No	Variables/ (No. Observations)	Dates of Records	
				Start	End
412404	Alsea Bay at Shepards Point (Ambient Estuary)	31621	Fec Coli A (9)	13 Feb 1997	16 Dec 1997
		00010	Temp (9)	13 Feb 1997	16 Dec 1997
412405	Alsea Bay at McKinney Slough (Ambient Estuary)	31621	Fec Coli A (9)	13 Feb 1997	16 Dec 1997
		00010	Temp (9)	13 Feb 1997	16 Dec 1997

In addition to the data listed in **Table 8.1**, we found data (older than 1990) for phosphorus (a nutrient which often limits freshwater primary production) from 10 sites. Only one site (402921) had more than 1 to 3 observations. We found very little data on metals or turbidity. There were pesticide data from station 44472312350400 (not listed above) dating from 1993, but observations were unreplicated.

Table 8.1 shows that water quality data were taken at many stations, but few stations had long-term data. Without replicated long-term data, it is impossible to determine water quality trends.

8.1.5 Water temperature

A number of water temperature monitoring projects have been conducted or are ongoing within the study area. However, the many different sampling protocols, dates, numbers of samples, and goals of these water temperature monitoring projects preclude their use for prioritizing 6th field watersheds in this assessment. Such prioritization across 217 6th field watersheds using the existing data would be inappropriate, given the fact that many 6th field watersheds would have either:

- no available data
- incomplete data
- data too old to be useful, or
- data collected using methods that were inconsistent with methods used in other watersheds.

In other words, for water temperature, as for other parameters, we sought consistent, comprehensive data covering the entire study area.

We recommend that MCWC use the available water temperature data at the stream reach and basin planning scale to prioritize project sites. Data gathered during this assessment can be combined with water temperature data to provide powerful tools for action planning. For example, where a monitoring program shows a consistently high water temperature, AHI data, DOQs or local knowledge should be investigated to determine where in the watershed streambank shading may be poor and riparian vegetation may be lacking. Riparian plantings and riparian fencing can then be planned for appropriate sites.

8.2 Hydrology

8.2.1 Gage data

When combined with data on water users, river gage data can help determine water availability. Such data can also be useful for prioritizing streams and watersheds for flow restoration. Through discussion with MCWC, we determined that the best way to approach this issue for this assessment was to use the streamflow restoration priorities developed jointly by ODFW and OWRD. The ODFW/OWRD flow restoration priorities reflect many factors that we could not address in this assessment (see **ODFW/OWRD streamflow restoration priorities** below). However, we provide information here on locations of USGS river gages to assist MCWC in future work.

8.2.1.1 USGS gage locations

Locations of USGS river gages in the study area can be obtained on the web at *http://oregon.usgs.gov/rt-cgi/gen_tbl_pg*.

Information is available from river gages currently in operation in the study area, as well as historical gage information. Due to the limited number of river gages, this information was not used in this assessment to prioritize 6th field watersheds. We provide the locations of these gages (**Table 8.2**) to facilitate sub-basin management actions.

Table 8.2. Current USGS stream gages.

Station Number	**Station Name**
14305500	SILETZ RIVER NR SILETZ
14306340	EAST FK LOBSTER CR NR ALSEA
14306500	ALSEA RIVER NR TIDEWATER

River gages are also identified in the STORET database. These include historical gages. There are 6 gages reported for the Siletz-Yaquina Basins (HUC 17100204) and 12 for the Alsea Basin (HUC 17100205).

8.2.2 Peak flows

8.2.2.1 Rain-on-snow

When rain falls on snow, water does not infiltrate the soil, as it normally does. Instead, water runs over the surface of the ground into the receiving stream network. This can result is high water levels in streams (high peaks on the hydrograph). Therefore, rain on snow (ROS) events can dramatically impact the pattern of water delivery to streams. As more water enters the stream network, water velocities increase, so does the capacity of the water to erode banks and down cut streambeds.

The OWEB watershed assessment manual (Watershed Professionals Network 1999) describes watersheds as having potential impact from ROS events if two conditions are met in 20% or more of the watershed area: (1) less than 30% crown closure and (2) elevations suitable for ROS events (not defined in OWEB manual). However, the manual does not have specific guidelines for mapping these areas in the Coast Range.

We used ARCView to locate areas of **potential** ROS impact, that is, areas where conditions exist that could *potentially* lead to ROS events. This is not to say that ROS events always occur in these zones. ROS events have a greater probability of occurring under certain conditions. In the Oregon Coast Range, ROS events can have return intervals of several years to tens of years.

To locate ROS areas, we first queried the CLAMS95^{W} land cover data for areas defined as "open" (areas lacking forest cover). Then, with input from the MCWC Tech Team, we defined four elevation zones: 0-1000 ft, 1001-2000 ft, 2001-3000 ft, and > 3000 ft. We determined the proportion of "open" areas within these four elevation zones for each 6th Field Watershed. Considering elevation only, approximately 66.8% of the study area fell within the 0-1000 ft elevation zone, 27.3% within the 1001-2000 ft zone, 5.4% within the 2001-3000 ft zone, and only 0.6% of the study area was above 3001 ft. ROS areas accounted for only 273 ha (ca. 0.01%) of the study area. In summary, using the OWEB manual methods, none of the 6th field watersheds are at risk for increased peak flow due to ROS events because none had more than 20% of their area both open and above 2000 ft (**Figure WR-2**).

8.2.2.2 Roads

As discussed in **Setting: Roads** above, the only comprehensive, consistent-scale roads coverage that was available for this assessment was the 100K roads layer (**minrds6**$^{\mathbf{M}}$). Although this layer was of uniform spatial scale and covered the entire study area, it was not at an appropriate scale for this study and probably underestimates the total length of roads in the study area by at least two thirds (see **Roads** above). Therefore, a better depiction of roads in the MidCoast Region is needed.

Despite the shortcomings of the 100K roads layer, we analyzed potential peak flow impacts from this roads layer roads within the study area. We reasoned that any watersheds at risk using the 100K roads layer would certainly be at risk using a more detailed roads layer.

The Watershed Assessment Manual details two methods for evaluating the impact of roads on peak flows:

1. Use of urban road density (expressed as miles of road per mi^2 of watershed) as a surrogate for Total Impervious Area;
2. Rural road density expressed as the percentage of total watershed area occupied by road surfaces.

We calculated both of these statistics for 6th field watersheds in the study area. We found that only a few 6th field watersheds had road densities in the high risk category (>5.5 mi roads/mi^2) using the urban road density method (Watershed Professionals Network 1999). The majority (n=182) of 6th field watersheds were in the 1-2 mi roads/mi^2 range. As the name implies, this screening tool is most appropriate for urban watersheds; therefore, non-urban watersheds that appear to be at risk using this approach should also be evaluated using the rural road density method (below).

We also calculated the percent of watershed area in roads using the rural road density method (Watershed Professionals Network 1999). We assumed that the average width of a road is 35 ft (Watershed Professionals Network 1999). We found that the total area occupied by road surface for the entire study area was 3,023.2 mi X 0.0066 mi = 19.95 mi^2. The proportion of the MidCoast study area occupied by roads is 19.95 mi^2 / 1,449.2 mi^2 = 0.014 or about 1.5 percent. This is well below the 4-8% threshold described above. Of course, what we really want to know is which, if any of the 6th field watersheds are above this threshold. The number of square miles of impervious surface per mi^2 of watershed ranged from 0.134 mi roads/mi^2 to 14.72 mi/mi^2. We did find several 6th field watersheds that were at risk for peak flow increases using the rural road density method. Detailed information is presented in separate sections for each basin planning team.

8.2.3 ODFW/OWRD streamflow restoration priorities

We obtained a GIS coverage of the streamflow restoration priorities maps developed by the Oregon Department of Fish and Wildlife (ODFW) and the Oregon Water Resources Department (OWRD). The maps were obtained from the ODFW website at *http://www.dfw.state.or.us/hcd/FlowRestore/index.htm*.

We clipped the streamflow restoration priorities coverage to the study area. In this coverage, flow restoration priority rankings and other attributes are assigned to Water Availability Basins (WABs) by OWRD and ODFW. Attributes for each WAB include: 1) flow restoration priorities; 2) OWRD assessment of flow restoration opportunities; and 3) the state priority for restoration activity (which incorporates both priority and opportunity rankings). Item 2 (OWRD assessment of flow restoration opportunities) is described as “WRD Waterhaster’s assessment of the flow restoration opportunities/optimism.” Each parameter is ranked separately for winter, spring, summer and fall seasons. As determined by discussion with the MidCoast Watersheds Council, for the purposes of this assessment we focused only on the streamflow restoration needs parameter. This priority is determined by ODFW and OWRD.

The ODFW/OWRD priority rankings range from 1 (low) to 4 (high) for each season. Since the rankings within a given WAB were always at least as high for summer as for fall, winter or spring (with only one exception), we used the summer ranking for this assessment.

We summarized the ODFW/OWRD flow restoration priorities for 6th fields in **flowrest_sum_by6th.shp**. As described above, WAB boundaries do not coincide with 6th or 5th field boundaries. WABS are generally much larger than 6th field watersheds and usually consist of a group of 6th field watersheds. Two hundred thirteen of the 217 6th field watersheds in our study area fell almost completely inside a single WAB (with only minor boundary discrepancies). For these 6th fields, we assigned the larger WAB's summer flow restoration priority ranking to the 6th field. This summer flow restoration priority ranking is shown as the field **dfwrank_summer** in the 6th field summary coverage (**flowrest_sum_by6th.shp**).

Only four out of 217 6th field watersheds lay across WAB boundaries, resulting in a relatively even split between two priority rankings. For these three 6th fields, we showed the second-most-prevalent ranking in the field "**other_rank**" in **flowrest_sum_by6th.shp**. All three "split" 6th fields were split between low and moderate priority rankings; none had any portion ranked "high." Two of the three "split" 6th fields (Rock Creek, in the Devil's Lake basin, and Middle Five Rivers) were split between a low ranking (1 on a scale of 4) and a medium-high ranking (3 on a scale of 4). The other two "split" 6th fields were split between rankings of 1 and 2 (low and medium-low).

The 6th field summer flow restoration priority rankings are a good starting point for making decisions on where to focus streamflow restoration activities. Within 6th fields ranked high priority, OWRD GIS layers showing points of water diversion, areas of water use, and instream water rights can be used to further focus efforts. Some of these layers were provided on the MCWC GIS CD, but the layers have since been updated. The most recent versions are available at: *http://www.wrd.state.or.us/index.shtml*.

8.2.3.1 Results

Table 8.3 shows the 6th field watersheds that were either uniformly or predominantly ranked "high" by ODFW for summer flow restoration.

Table 8.3. Sixth field watersheds with high priority for summer flow restoration (based on predominant ODFW/OWRD ranking in 6th field)

6th field watershed name	Major basin	6th field watershed code	ODFW/OWRD summer flow restoration priority (4=high)
U. DRIFT1	Siletz	40804	4
NORTH	Siletz	40805	4
SMITH	Siletz	40806	4
QUARRY	Siletz	40807	4
WILDCAT	Siletz	40808	4
SAMPSON	Siletz	40809	4
L. YACHATS	Yachats	50510	4
YACHATS	Yachats	50512	4
U. YACHATS	Yachats	50513	4
STUMP	Yachats	50514	4
L. SCHOONER	Siletz	40810	4
GORDY/L. DRIFT	Siletz	40811	4

Streamflow restoration priorities (by 6th field watershed) are shown in **Figure WR-1**.

8.2.3.2 Interpretation

The Oregon Plan website (http://*www.oregon-plan.org/ AnnRept/2-implement/ agency.reps/ imp-odfw.pdf*) describes some of the parameters that entered into the streamflow restoration priority rankings. These include fish resources (complexity, diversity, status), habitat conditions, risk factors (human impacts, endangered/threatened listings, streamflow restoration optimism (will fish respond?), water use, and water deficit status. According to information on the ODFW web page at http://*www.dfw.state .or.us/hcd/ FlowRestore/index.htm*, streamflow restoration priorities have been developed jointly by ODFW and OWRD in fulfillment of Oregon Plan Measure IV.A.8: Identify Instream Flow Priorities. A contact person is Rick Kruger at the ODFW Habitat Conservation Division.

8.2.3.3 Other water availability data

The OWRD website (*http://www.wrd.state.or.us*) has a water availability reporting system ("WARS") which provides data on the following:

1. stream flow
2. consumptive uses and net minimum flow prior to 1993
3. consumptive uses and net minimum flow as of the current date
4. instream water rights
5. net available flow as of the current date.

There are 166 streams in the study area for which water availability data are available. A listing of streams for which data are available was downloaded from the WARS site above. Unfortunately, the WARS system requires the user to request the actual data tables for every stream individually. The time commitment was high to work with the individual streams data. Therefore, in discussion with the MCWC Tech Team, we decided to use the ODFW streamflow restoration priorities in place of the WARS data (see **ODFW/OWRD streamflow restoration priorities** above).

8.2.3.4 Points of diversion

The original (1997) MCWC CD-ROM contained GIS coverages of points of water diversion and points of water use for the MidCoast watersheds. We reviewed these data and obtained updated coverages from OWRD, but without stream gage data for most of the streams in the study area, we did not feel the data would be suitable for prioritization of 6th fields. Through discussion with MCWC, we decided to use the ODFW/OWRD streamflow restoration priorities for this assessment in place of further analysis of points of diversion/points of use.

8.3 Wetlands

Wetlands are discussed in **Aquatic habitats: Wetlands** above.

9 Sediment sources

9.1 Landslides

9.1.1 Introduction

The coast range of Oregon is a dynamic region. Steep slopes and high amounts of precipitation are generally responsible for mass wasting (e.g., landslides and debris torrents) events throughout the region. Even the earliest accounts of the region's explorers describe large areas of landslides and debris torrents, which were visible from their vantage points on boats at sea. Thus, Oregon's Coast Range has been susceptible to mass wasting prior to the time of European settlement. Mass wasting is a natural process; it is the frequency and magnitude of events that are of concern. Many factors can contribute to an increased frequency of mass wasting events including, land use practices, road building, development, etc.

Mass wasting adds sediments (both fine and coarse) and organic material to the stream network. These natural stream components are neither good nor bad in themselves; it is the frequency, magnitude and duration of mass wasting events that may have undesired consequences on in-stream conditions, especially on salmonid habitat. After all, organisms like Pacific Northwest salmonids have evolved in these rapidly changing landscapes and they are adapted to the 'natural' (background) patterns of mass wasting.

9.1.2 SMORPH

We were interested in evaluating landslide risk throughout the study areas. Some landslide information is available as a landslide GIS layer on the MCWC CD-ROM and as ODF Hazard / Debris Flows GIS layers. Unfortunately, coverage was not complete, so the information contained in these data layers could not be used to prioritize 6th field watersheds. These layers, however, will be useful for sub-6th field site planning. They may also be useful in calibrating a landslide risk model, such as SMORPH (discussed below).

Spatial models are useful tools that are often used to produce risk assessments across large geographic areas based on extrapolations from a limited number of observations. Of course, there is always risk associated with data extrapolations. However, good models will generally give confidence intervals or an estimate of the degree of certainty associated with model outputs. Calibrating and implementation of a model was beyond the scope of this watershed assessment, so we turned to the literature. In a recent study (Shaw and Vaugeois, 1999) in Washington State, three modeling approaches were empirically tested to determine the best approach at modeling shallow landslides. The model (called SMORPH) was compared to two other shallow landslide risk models. Shaw and Vaugeois found that the SMORPH output correlated most closely to known landslide patterns in western Washington. The authors concluded that SMORPH was well suited for a landslide risk screening tool. We approached the authors of the 1999 study and described the needs of the MCWC. The authors suggested that default input variables of SMORPH were applicable to the MidCoast Region of Oregon. Therefore, we provide here a 'default' run of the SMORPH model to identify areas that may be at high risk for shallow landslides.

SMORPH appears to be a robust model. In SMORPH, landslide risk is based largely on slope and concavity, easily calculated from the 10 m DEMs. SMORPH should work well in areas where topographic factors drive shallow landslides, such as the MidCoast Region of Oregon. In the study by (Shaw and Vaugeois, 1999), SMORPH was found to be less sensitive to initial input variables than the other models tested and was determined to be more likely to accommodate greater error in initial condition selection than the other models tested.

In addition to being robust, another advantage of SMORPH is that mapped landslide inventory data can be used to easily calibrate and refine this model. We recommend that models, such as SMORPH, be used to extrapolate study area-wide risk from a limited number of observations.

We found that 6th field watersheds had, on the average, about 27.6% of their area rated as "high" risk for shallow landslides. As we expected, there was quite a bit of variability among the 217 6th field watersheds in the study area. On a watershed-by-watershed basis, areas determined to be "high risk" by SMORPH ranged from just over 1.0% of the total watershed area in some relatively flat coastal watersheds, to more than 40.0% of several watersheds in the Alsea River basin (**Figure SED-1**). In addition, high-risk watersheds are listed in each of the basin inserts in this report.

This analysis uses an uncalibrated landslide risk model. We recommend that landslide inventory data be collected, in a spatially explicit way, and used to calibrate this (or a similar) model.

9.1.3 ODF debris flow hazard maps

According to information available on the ODF web site (*http://www.odf.state.or.us*, 1-14-99), Western Oregon Debris Hazard Maps were prepared to depict areas that are subject to naturally occurring debris flows. They include initiation sites and paths of potential debris flows. These are coarse scale risk assessment maps and should not be used without on-the-ground verification. These maps were developed from the 30-m DEM and lithology data layers. Streams were represented by USGS digital raster graphic data. These maps were also developed using available historic information on debris flow from a variety of sources (e.g., ODF, USFS, DOGAMI, BLM and ODOT). These maps did not account for patterns in rainfall.

Briefly, the ODF debris hazard maps assign a risk category to 2-4 acres parcels based on steepness and lithology. Steep areas that occur on Tyee (and similar) geologic formations are rated higher (i.e., having a higher chance of sliding). Past landslide occurrence in an area resulted in a higher risk category being assigned to that area. ODF plans to develop additional guidance based on this work.

Because the ODF debris hazard mapping was coarse in scale compared to our SMORPH analysis, we do not provide a summary of the ODF maps in this assessment. A comparison of SMORPH and the ODF debris flow maps was beyond the scope of this project. However, if there is an interest in developing a better understanding of landslide and debris flow risk, especially how they relate to salmonid habitat, further analysis may be warranted.

9.1.4 USFS landslide inventory

A landslide inventory layer is present on the MCWC CD-ROM (**flood$^{\mathbf{M}}$**). The layer was obtained from the USFS and is at a scale of 1:12,000. However, the layer does not cover the entire study area, and brief examination of the layer indicates that it may not be a complete survey of landslides even in the area it does cover. Therefore, this layer did not meet the criteria of complete coverage required for this assessment, and it could not be used to prioritize the 217 6th field watersheds in the study area. However, this layer may be useful for local watershed groups planning watershed management actions. The layer may also provide a good starting point for further landslide mapping.

9.2 Streambank erosion

Streambank erosion can be a significant source of sediments entering streams. Bank erosion can cause sediment loading, which can cover gravel beds and make them unsuitable for salmonid spawning. Excessive fine sediments may also reduce the quality of in-stream habitat for other species such as lamprey, freshwater mussels and macroinvertebrates. The sediment input from streambank erosion can also provide gravel, which is needed for salmon spawning beds.

9.2.1 Actively eroding banks (AHI)

The only source of GIS data on bank erosion available for this assessment was Aquatic Habitat Inventory (AHI) data. We used aquatic habitat inventory data to determine the prevalence of actively eroding streambanks within the study area (for details on aquatic habitat survey data sources, see **Aquatic Habitats** above). The ODFW GIS data (**aqhab_odfw_final.shp**) and the Lincoln District data (**aqi_LD_final.xls**) used in this assessment show the percent of the total reach length composed of units that have some active bank erosion. USFS Stream Inventory data did not contain analogous data on bank erosion. The "measure" worksheet of the USFS Region 6 database (**REG6habs_final.xls**) contains a field called "bank_stability," but only 1,380 out of 6,486 reach records have data in this field, so it could not be used for the assessment.

We calculated a 6th field average of length of units with any active bank erosion (weighted by reach length) for each data source (**LD_bkeros** from the Lincoln District data, and **Dfw_bkeros** from the ODFW reach-level GIS data). We then calculated a 6th field average of the two data sources (weighting by surveyed length from each source) (**Bker_all** in **aqhab_sum_final.shp**).

Figure SED-2 shows the average percent of surveyed stream length composed of units that have some active bank erosion.

9.3 Surface erosion

9.3.1 Soils

(See **Setting: Soils: Erodible soils** above)

9.3.2 Combined soil erosion / shallow landslide risk

In this summary, we located areas where soils at high risk of erosion lie upon areas that may be prone to shallow landslides. These areas can potentially contribute coarse and fine sediments to stream networks.

We performed this multi-factor analysis by combining information from the erodible soils and shallow landslide risk assessments in a multifactor analysis. We used ARCView to create a shapefile depicting the “high risk” category from the SMORPH model. Over 60,724 ha in the study area were identified as being at “high risk” for shallow landslide by SMORPH. Similarly, we identified 137,000 ha classified as having “severe” soil erosion risk. Due to the size and complexity of these GIS layers, we used ARCView to intersect the SMORPH shapefile with highly erodible soils for each major river basin separately.

We found that, on the average, 6th Field Watersheds in the Alsea River Basin had the highest proportion of their area meeting shallow landslide and erodible soils conditions (described above). Sixth field watersheds in the Yachats and Yaquina River Basins were the least susceptible to the landslide/erodible soil combinations.

Table 9.1. Average percent of 6th field watershed area with both high landslide risk and erodible soils, by major basin

Major Basin	Average percent with landslide risk and erodible soils
Alsea	22
Ocean Tribs	12
Salmon	8
Siletz	15
Yachats	9
Yaquina	8

Individual 6th field watersheds ranged from 0 to 36 percent of their area occupied by erodible soil units in areas prone to shallow landslide. Only three of the six major river and tributary basins (Alsea, Siletz, and Ocean Tributaries) had 6th field watersheds that had 25 percent or more of their area in these erosion prone areas (see individual Basin Inserts). This information is useful in ranking 6th field watersheds for soil erosion potential. However, both the SMORPH model output and the soils maps have much more detail and may be very important data sets for site specific planning. We recommend that these data be field checked.

9.3.3 Roads

9.3.3.1 Roads on slopes greater than 60%

Roads passing over areas of steep slopes can fail, or act as chronic sources of sediments to streams. We were interested in ranking 6th field watersheds by the length of roads passing over steep slopes (> 60%). We calculated seven slope categories using the 10 m DEMs in ARCView (**Table 9.2**). We then used ARCView to determine the length of roads passing over these slope categories, using the most detailed roads information available to us from the MCWC CD-ROM (**minroads6^{M},** at a scale of 1:100K). We found that, on the average, about 7.9 percent of the total 1:100K road length in the study area (as depicted in the GIS roads layer) passed over areas that had slopes greater than 56.6 percent.

Table 9.2. Percent of 1:100K roads layer passing over various slope categories

Slope category	Degrees	% Slope	Percent of roads in category	Length of roads in category (m)
1	0.0-9.8	0-17.3	39.34%	1,912,526.1
2	9.8-19.7	17.3-35.8	35.52%	1,726,748.7
3	19.7-29.5	35.8-56.6	17.17%	834,846.2
4	29.5-39.3	56.6-81.8	6.58%	319,827.6
5	39.3-49.2	81.8-115.9	1.27%	61,845.4
6	49.2-59.1	115.9-167.1	0.10%	5,083.1
7	59.1-68.9	167.1-259.2	0.00%	130.3

We found eleven 6th field watersheds that had about 25 percent of their total road length passing over high slope areas (**Table 9.3**). Once more detailed roads information becomes available this approach can be used to located potential problem road segments.

Table 9.3. 6th field watersheds with highest percent of roads on steep slopes (over 60% slope).

6th field watershed name	Major Basin	6th field ID code	Fifth field watershed name	Percent of road length on high slopes
ROCK2	Alsea	50118	North Fork Alsea	48.8%
LOWER BOULDER	Siletz	40404	North Fork Siletz	39.9%
CAMP	Alsea	50209	Five Rivers - Lobster Creek	36.1%
DRIFT	Siletz	40409	North Fork Siletz	36.0%
BUCK	Siletz	40503	Middle Siletz	30.6%
U. PARKER	Alsea	50101	North Fork Alsea	26.6%
UPPER_LOBSTER	Alsea	50219	Five Rivers - Lobster Creek	26.1%
UPPER_FALL	Alsea	50404	Alsea River	25.8%
SLACK	Yaquina	40307	Lower Yaquina	25.6%
DRIFT	Alsea	50307	Drift Creek	24.7%
WILDCAT	Siletz	40808	Drift Creek (Siletz)	24.6%

10 Recommendations

For the recommendations outlined below, we advise that new data be collected at a spatial scale of 1:24,000 (on USGS topographic quads) or better, and that, if GPS units are used, spatial error (reported by the GPS instrument) as well as the map datum be documented. Whenever possible, we recommend that existing GIS layers be consulted prior to collecting new data and that new data or data corrections be entered into the GIS as soon as possible.

10.1 Data collection and monitoring recommendations

10.1.1 Land cover

- Develop or obtain up to date land cover information that reflects current conditions in the watershed.
- Ground-truth and update riparian vegetation information, especially in areas known to have spawning coho. Coordinate with DEQ's efforts for riparian vegetation monitoring.
- Locate and map exotic plant species.
- Ground-truth areas described as being "Open" in the CLAMS95 data; differentiate between grazed open areas and non-grazed open areas.
- Determine the condition of fences along riparian corridors.

10.1.2 Roads

- Acquire or develop a complete roads layer at a consistent spatial scale of 1:24,000 or better. Differentiate between paved and non-paved roads.

- Map road failures and the condition of roads that pass through riparian areas.
- Map roads that may confine streams.
- Map culvert locations and collect information on culvert features, including degree of blockage and if culverts are fish barriers. Use a standardized data sheet to collect this information, similar to the one prepared by ODFW.
- During or after heavy rainfall events, record locations where surface flow runs directly along roadways and into streams. These roads can be major sediment sources of streams.

10.1.3 Streams

- Stream locations and morphology derived from the DEMs should be ground truthed. Since a consistent scale streams layer was not available for this assessment, we used the DEMs to derive a streams layer. This layer, along with derived gradient and confinement, is meant to be a stand-in layer until better data become available. A good use of these coverages is to use them to guide ground truthing efforts. Teams should take the streams information from the GIS into the field and collect standardized observations. Field observations can then be compared to the DEM-derived stream characteristics and discrepancies noted. These spatially referenced observations will be valuable to future stream morphology work.
- Map active floodplains and wetland areas. Collect data from landowners on flood frequency, areas of inundation, alternate stream channels and backwater wetlands.
- Map areas of dynamic (frequently changing) stream channels.
- Map locations of channel modifications.
- Map locations where streams are entrenched.
- Map locations of exposed bedrock along streams.
- Map locations of algal blooms, indictors of nutrient enrichment and low dissolved oxygen concentration.

10.1.4 Biological data

- Use the results of this report to prioritize areas in which AHI surveys need to be conducted or updated. To improve spatial accuracy of AHI surveys, measure habitat unit lengths with hip chains from landmarks that are visible on the DOQ photographs or the USGS topographic base maps. Use GPS if possible. Calibrate observers to maximize spatial accuracy. Ensure that data are quickly processed and incorporated into the MCWC GIS at an appropriate spatial scale.
- Map the locations of exotic plants.
- Map the locations of beaver dams. Review the AHI data for locations of beaver dams and beaver activity (in the AHI comment columns). Consider beaver dam locations when planning riparian plantings, especially conifers.
- Work with ODFW and others to develop reliable estimates of the populations and distribution (including fish limit maps) for species of concern, such as salmon, lamprey, and mussels. Volunteers can be used to expand agency surveys provided that established protocols are followed. The lack of data on the

distribution and abundance of aquatic organisms is a major impediment to developing a successful watershed enhancement strategy.

- Design data collection strategies that include biological sampling. For example, water quality monitoring data should include sampling for benthic macroinvertebrates, which can be good indicators of water quality and environmental change.

10.1.5 Water resources and water quality

- Set up a systematic water quality monitoring program with strategically located sample stations. Set up a monitoring program to answer specific questions and to develop baseline information. For example, sample in areas known to have spawning salmon, downstream of rare species management areas, urban areas, and intensively managed forests. Know how the data will be used before they are collected.
- Expand continuous stream temperature monitoring and using collected data in a stream temperature model (GIS-based) to interpolate (spatially) between sampling points.
- Establish stream gaging stations, weather stations and rainfall gages to improve knowledge of water availability.
- Map points of water diversion.
- Map (or verify) spring and well locations.
- Document areas of ground water shortages and water quality problems from well logs.
- Begin to gather information on the location of the water table. Subsurface water flow entering streams may help to maintain cool water temperatures necessary for good salmonid habitat.
- Map locations of potential water contamination sources, i.e., underground storage tanks and agricultural chemical storage areas.

10.1.6 Land use

- Incorporate tax lot and building information into the GIS when it becomes available.
- Update and map changing land use information, e.g. timber harvest plans, pesticide application areas, construction projects.
- Update or map floodways along estuaries and rivers.

10.2 Recommendations for future analyses

- The **Data collection and monitoring recommendations** section above contains many suggestions for acquiring and improving data needed for watershed management. As watershed data are field-checked, updated, expanded, and improved, use these data to refine site selection for watershed management actions. In this assessment, we have provided many datasets that will be useful in site selection. However, these datasets need to be updated frequently, and many data gaps still need to be filled.

- In this assessment, we have provided several examples of multi-factor analyses which address site selection; these include the the **Large Woody Debris placement areas analysis**, and the **Potential floodplain restoration areas** analysis. Similar procedures can be used to intersect other factors of interest to locate action sites.
- The rankings provided in this report are only a subset of many possible rankings. MCWC may wish to re-rank 6th field watersheds (or other study units) using the data provided in this assessment, using different data, or using different weightings or groupings of data.
- When analyzing data from different agencies or groups that may have been collected using different protocols, consider analyzing rankings rather than absolute numeric values. Ranked lists offer advantages in being independent of the data distribution, an advantage since different data collection protocols often result in different distributions of resulting data.
- Use DEMS to locate small hollows that are located on 1st order streams. These hollows may be important sources for detrital material for streams (i.e., LWD, detritus).
- Use DEMS to distinguish between stream segments that function as sediment and bedload transport areas from those that are sediment and bedload sources.
- Use landslide inventories to calibrate the SMORPH shallow landslide risk model (or other models).

10.3 Watershed Enhancement Recommendations

10.3.1 Ecosystem context

Declining salmonid population trends have been apparent for several decades. During the past 60 years or so, natural resource managers have relied on fish harvest restrictions, hatcheries, and habitat enhancement/improvement as management tools to bolster moribund populations. The declines have continued. It is likely that our knowledge of the ecological process that maintain salmonid populations is incomplete. A watershed approach involves putting the valued resources, in this case, salmon, into an ecological perspective. This watershed assessment completes the first step in developing a watershed-based restoration plan. Using knowledge gained from the MCWC GIS and this report, it may be possible to apply some of the old management tools in ways that are more effective, or to develop completely new tools.

In a recent workshop that focused on habitat restoration in the Columbia River, guidelines were established by estuarine ecologist Dan Bottom to assist managers in restoring Columbia River salmonid populations (Bottom, 2001). These guidelines are also applicable for estuaries and watersheds in the MidCoast region.

1. Knowledge of the ecosystem is incomplete; therefore, restoration actions are largely experimental. Careful attention must be paid to the evaluation of restoration actions (through experimentation or monitoring).
2. Selection of restoration/enhancement sites should be for ecological reasons, rather than simply opportunistic.

3. Identify and conserve (or preserve) the high quality habitat that currently exists.
4. Where restoration is necessary, select historically important, high quality habitats (e.g., wetlands) or areas known to be important for sensitive life history stages of salmon (e.g., oligohaline-brackish water transition zones).
5. Give priority to passive restoration, rather than highly engineering solutions (active restoration).
6. Finally, adopt a landscape / watershed perspective. Avoid unlinked 'parcel-based' or 'postage stamp' restoration projects.

In this assessment, we used GIS to examine patterns in the factors believed to affect salmonid populations. We recommend that the MCWC use and refine this information to assist the council in locating and assessing all restoration projects.

The importance of relatively small, locally adapted populations of salmonids in stabilizing 'salmon runs' (i.e., decreasing fluctuations in those runs) is just beginning to be appreciated. Current thinking is that small populations of salmon are adapted to the unique local conditions of individual stream reaches. Environmental conditions like food availability, stream substrate, water temperature, flow (and flow pattern), etc. vary from stream reach to stream reach so that no two stream reaches are identical. The salmon that are best suited for conditions at a particular stream reach contribute more offspring to that local population than others do. Over time, the genetic makeup of that local population will become slightly different from the genetic makeup of nearby populations, even within the same watershed.

Historically, there were many small populations within a larger watershed, each adapted to its local conditions and varying slightly from one another. Differences may also have resulted in slightly different spawning and migration behaviors (timing). All of these populations existed within very dynamic coastal watersheds. From time to time, cataclysmic (i.e., landslides, floods, etc.) or biological (i.e., competition, disease) events would eliminate (or dramatically reduce) some of the locally adapted populations. However, if the change was not too great, other populations within the same watershed would not be affected. Consequently, the overall production of salmon for that watershed would remain fairly constant over time. In other words, the stability of the larger watershed's salmon population largely depended upon the diversity of the locally adapted populations.

Currently, genetic diversity in coastal salmonid populations is believed to be low. This may be due to the disappearance of many of the locally adapted populations or perhaps to environmental alterations that have all but eliminated environmental variability at the stream reach level. In the dynamic coastal environment, it is believed that the current salmon populations do not have the resiliency to quickly rebound after disturbance (natural or man-made) like the more diverse, historical populations. Consequently, salmon runs are observed to fluctuate widely. A successful restoration strategy will involve rebuilding the genetic diversity of salmonid populations. This involves creating and maintaining the conditions to which salmon populations can locally adapt.

10.3.2 Recommendations for aquatic habitat improvement

- Consult the GIS to determine if areas for planned projects or land use changes have potentially high erosion and/or landslide risk. Consider scheduling actions that disturb vegetation in these areas for times of low precipitation to avoid disturbing soils. Plan on leaving wide vegetated buffer strips to trap eroding sediments.
- Consult the results of multi-factor analyses in this assessment when planning watershed enhancement activities. For example, prioritize winter habitat enhancement projects like backwater wetland restoration, off-channel habitat creation, and floodplain restoration in 6th field watersheds that ranked high in the coho winter habitat multi-factor analysis. Use the stream-reach level data provided with this report (along with local knowledge and additional information like land ownership, landowner willingness, adjacent land use, existing anadromous migration barriers, etc.) to help pick specific sites for such actions. Similarly, prioritize summer habitat enhancement projects like riparian plantings in 6th field watersheds that ranked high in the coho summer habitat multi-factor analysis, and use the stream-reach level data (supplemented with local knowledge and additional information) to help choose project sites.
- Use the results of the **LWD Placement Areas** and **Potential Floodplain Restoration Sites** analyses (described below) to locate potential sites for these management actions. Of course, these analyses must be supplemented by local knowledge and more detailed site-specific information in choosing final locations for projects.

10.3.3 LWD placement areas

As a part of the Watershed Enhancement Recommendations section of this report, we conducted two multi-factor analyses designed to guide watershed enhancement actions at the stream reach level. The first of these is the LWD Placement Areas analysis. Unlike the majority of this assessment, this analysis does not rank 6th field watersheds, but is intended to provide an example of how the GIS data provided with this assessment could be used to answer a specific question at the stream reach level, namely: Where are some suitable locations for in-stream placement of large woody debris?

Priority areas for placement of large woody debris (LWD) would be low-gradient, mid-sized streams (coho rearing habitat) which are currently being used by coho, but which currently have low quantities of LWD. We used Rapid Bioassessment (RBA) survey results in combination with aquatic habitat survey data on LWD frequency. We did not directly search for low-gradient, mid-sized streams, since the RBA surveys are generally already focused on streams of this type. Since this is a sub-6th field analysis, we can only use the aquatic habitat survey data that are in GIS, because we need to identify specific stream reaches that are low in wood.

Data on LWD frequency were taken from a combination of the ODFW AHI GIS layer (**aqhab_odfw_final.shp**), and a partial GIS representation of the USFS stream survey data (see ***Aquatic Habitats: Data Sources: USFS GIS data*** above).

Using the combined ODFW/USFS aquatic habitat inventory GIS layers, we selected reaches with less than 10 pieces of LWD per 100m surveyed length. These are stream segments which are considered to have undesirably low LWD frequency using the ODFW habitat benchmarks (Watershed Professionals Network 1999). The selected group contained 468 reaches totaling about 520 km in length. In ARCView, we created a 100m buffer around each reach. We then intersected the RBA snorkel survey data with the buffer polygons and averaged 1998-99 RBA juvenile coho/sq m for each buffer unit. We then joined the summary layer to the buffer layer to allow symbolization of the buffer layer by coho/sq m. The resulting shapefile is **lowlwd_rba_15oct.shp**.

10.3.3.1 Results

The results of the LWD Placement analysis are discussed in the individual **Basin Inserts** and shown in individual major basin maps (**Figures REC-1AL, REC-1OT**, etc.). Since the intersection of RBA data and AHI data available in GIS form was quite limited, we did not consider this analysis suitable for ranking 6th fields. However, the basin-by-basin results may be useful in considering possible sites for LWD placement.

10.3.3.2 Interpretation

When using the results of this analysis, it is important to remember that both the RBA data and AHI data available in GIS form cover only limited portions of the stream network. It is possible that RBA and/or AHI data were missing for some areas that would benefit from LWD placement. Since many streams in the study area have low levels of LWD, the RBA data alone could be used to target LWD placement for areas lacking AHI data. Also, the RBA data could be used to select areas for further AHI data collection to improve data coverage (see **Data Recommendations**). Collection of additional AHI and RBA data would improve the analysis, as would entry of existing tabular AHI data into GIS.

This analysis was affected by the scale of available GIS data layers. The aquatic habitat inventory data are placed in GIS on a 1:100K stream layer (**mc_rivs.shp**), while the RBA data are on the densified streams layer, which is a 1:24K layer. We needed to use a method that would allow intersection of the RBA data points with the 100K stream reaches in the AHI data layer. The solution was creating a 100m buffer around each AHI reach; this buffer was wide enough to include nearly all of the RBA pools for each reach. (A wider buffer might capture all of the pools for a specific reach, but would also incorporate too many pools on adjacent tributaries).

10.3.4 Potential floodplain restoration sites

The second of the Watershed Enhancement multi-factor analyses conducted for this section of the report was the Potential Floodplain Restoration Sites analysis. Unlike the majority of this assessment, this analysis does not rank 6th field watersheds, but is intended to provide an example of how the GIS data provided with this assessment could be used to answer a specific question at the stream reach level, namely: Where in the watershed are some potential floodplain restoration sites? Potential floodplain restoration sites would be former floodplains (diked, drained, or otherwise altered) that do not have land uses incompatible with floodplain restoration. To locate potential floodplains, we used the DEM-derived slope GIS layer as described below. To locate areas that do not have incompatible land uses, we used the DLCD generalized zoning layer as described below.

In this multi-factor analysis, we used ARCView to perform a series of GIS layer "intersections" (a command available in the Geoprocessing Wizard of ARCView) to combine information from zoning and slope GIS layers onto the derived streams layer (**st1400-c.shp**). This produced a single streams layer containing all of the information from the single factor analyses.

Before summarizing information in this newly created GIS layer, we manually removed stream segments where there was a lot of "flagging" on the derived streams layer (see **Appendix A: Supplemental methods**).

To address the issue of incompatible land uses, we removed from consideration all stream segments that passed through property zoned as "urban", "rural residential", rural industrial", "rural commercial", and "rural service center" since these are unlikely areas for restoration projects.

To locate potential floodplains, we selected stream segments that flow through 'flat' areas (areas that had less than 5% slope). The 5% slope threshold was determined during the stream confinement analysis (**Main Report**, **Aquatic habitats: Stream confinement from DEMs**). Since it probably would not be practical to attempt to restore floodplains along very short segments of streams, we then selected those stream segments longer than 500m that flowed through these 'flat areas.' (In case the Council wishes to conduct further analyses using these data, we retained the shorter segments in the layer, but simply selected those longer than 500m for summarization and display on the maps.)

Information from this analysis is presented for each basin separately in the **Basin Inserts**, as sub-6th field maps showing stream segments identified as having potential floodplain restoration sites (**Figures REC-2AL**, **REC-2OT**, etc.). Please note that stream lengths should be used as a relative measure of the amount of suitable (potential) floodplain restoration sites because stream lengths may be exaggerated, especially in low relief areas (e.g., along the coast) where the stream derivation algorithms had trouble placing the stream channel and stream “flagging” occurred.

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MidCoast Sixth Field Watershed Assessment Appendix A: Supplemental Methods

Prepared for the MidCoast Watersheds Council
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APPENDIX A: Supplemental Methods

1 Streams Layers

Many types of spatial analyses require data that are of consistent scale. Furthermore, in order to set restoration and monitoring priorities on a site-by-site basis, it is best to have uniform datasets that extend across the entire area of concern. We are conducting an analysis for the entire MidCoast region of Oregon at a spatial scale of 1:24,000. Until recently, a digital streams layer did not exist that was at an appropriate spatial scale.

A densified streams layer containing important information on stream channel confinement, stream gradient and fish distribution has been developed by USFS (Siuslaw National Forest). However, during the analysis phase of this assessment, we were unable to use the USFS densified layer for many of our analyses because it did not yet have gradient and confinement attributes for most of the study area. Also, the USFS densified layer incorporated data created by different agencies (e.g., BLM and USFS) using somewhat different methods for their respective areas. Agency staff report that analysis of these different areas did not show major inconsistencies (Diane Rainesford, personal communication), but inconsistent methodologies can create problems for analytical use of such data in GIS.

Perhaps more importantly, we were interested in defining gradient and confinement at a finer resolution than the reaches for which these characteristics are defined in the densified streams layer (reaches in that layer average about 200m in length). Therefore, we derived a streams layer for the study area from the 10m DEMs (Digital Elevation Model) (see **DEM-derived streams** below).

To help meet the goals of the current assessment, we conducted a suite of comparisons to see if we could develop a digital stream network that covered the entire study area, captured the detail necessary to serve as a useful planning tool, and was of uniform spatial scale.

1.1 Generating a Uniform Scale Streams Layer from 10 m DEMs

We used an ARCView extension (txdo0409.apr) developed by David Maidment's group at the University of Texas, Austin. The extension is available on the WWRI web site (*http://www.ce.utexas.edu/prof/maidment/)* or on the Hydro98 CD-ROM (available from Environmental Systems Research Institute, Inc. (ESRI)).

We acquired 10 m DEM files from researchers at Oregon State University (*http://www.fsl.orst.edu/clams/*). We mosaicked the DEM files into one coverage using ERDAS Imagine software. We used txdo0409.apr to fill sinks, and to create flow direction and flow accumulation grids from the original DEM files.

Next, we created multiple digital streams layers by varying the 'Stream Threshold.' Stream threshold, a user-supplied parameter in txdo0409.apr, defines the drainage area necessary for a grid cell to be considered part of the stream network. That is, stream threshold is the area on the DEM that corresponds to the minimum number of cells (threshold) which will contribute to a stream. For a single grid cell to be defined as a stream, it must drain an area that is equal to or greater than the stream threshold.

For comparison, we selected stream thresholds of 10,000, 5,000, 2,500, 1,500, and 1,400 cells. The ARCView extension failed to work for the entire study area when the stream threshold was smaller than 1,400 cells, so smaller stream thresholds could not be considered (unless the study area was split into smaller units). This resulted in the stream thresholds shown in **Table 1.1**.

Table 1.1. Stream Threshold Selections

Grid Cell Threshold	Km^2	Acres
10,000	1.0	247
5,000	0.5	123
2,500	0.25	61
1,500	0.15	37
1,400	0.14	34
750	0.075	18.5
300	0.03	7.4

Generated streams layers were then clipped to the study area using ARCView, and compared to two existing streams layers: (1) the USFS densified streams layer and (2) the 1:24 K USGS DLG Streams layer.

1.2 Densified Streams Layer

The Densified Streams Layer was obtained from Diane Rainsford at the Siuslaw National Forest office in Corvallis. The following description applies to the version of the layer that was available to us during our data analysis phase. The layer has since been updated and is available in a more complete form (for example, the finalized layer contains gradients and stream confinement information for the entire layer).

There are 74,611 segments (records) in the data layer and lengths are reported in meters. There are stream order designations for each segment in this layer. The ARCView extension (**XTOOLS**) ‘Table Frequency’ was used to summarize the length of streams by stream order for the entire study area. We found that there were 15,240.9 km (9,470.3 mi) of streams in the study area. Most of the streams were 1st order streams (**Table 1.2**). Stream gradient and stream confinement information was given in this data layer for several watersheds in the study area. (After completion of our analysis phase for this assessment, the densified layer the gradient and confinement information was extended to cover the entire densified layer.) We used the gradient and confinement data in the densified layer to our DEM-derived stream gradient and stream confinement in lieu of spatially explicit field observations.

Table 1.2. Length of streams by stream order in USFS densified layer

Stream order	Length (km)	Proportion (%)	Number of segments
1	8,673	56.9	38,869
2	3,094	20.3	16,886
3	1,579	10.4	9,083
4	897	5.9	5,191
5	459	3.0	2,277
6	301	2.0	1,178
7	197	1.3	993
8	40	0.3	134

1.3 USGS DLG Comparison

The 1:24K USGS DLG streams layer did not cover the entire study area. Many arcs (lines) in the USGS DLG coverage were shoreline segments and were removed from the coverage. As we expected, there were other differences between the USGS DLG coverage and the densified streams layer. Most notably, the USGS DLG coverage did not capture many of the first order streams. Because USGS DLG coverage was not available for the entire study area, we compared the total stream length for three of the 5th field watersheds where both coverages were available. The areas compared were the Lower Siletz, Rock Creek, and Upper Yaquina 5th field watersheds. We found that the USGS DLG files accounted for approximately 50% of the total stream length of the USFS densified streams layer (**Table 1.3**).

Table 1.3. Comparison of total stream length captured by USGS DLG for three 5th field watersheds

Basin	USFS Densified streams (km)	USGS DLGs (km)	% of Densified Streams Contained in USGS
Rock Creek	432.6	203.7	47.1
Lower Siletz	1,336.8	665.1	49.8
Upper Yaquina	684.3	377.9	55.2

1.4 DEM-derived streams versus densified streams

In order to capture more stream detail and to develop a uniform stream coverage that was of consistent spatial scale, we 'grew' a streams layer (**st1400-c.shp**) from the 10 m digital elevation models (DEM). As the stream initiation threshold got smaller, the total stream length increased (**Figure 1**). The following comparisons show the stream network and the derived catchment sizes for several different stream initiation thresholds. As the stream threshold gets smaller, we captured more of the 1st order streams (**Table 1.4**). An important consideration is that the derived stream network is based on the DEMs. The computer defines stream channels from the topography; therefore, 'streams' will include both streams and less well-defined drainageways. Whether a 'stream' is actually a stream depends on factors in addition to topography, e.g., precipitation, soils, underlying rock formations, and infiltration rates.

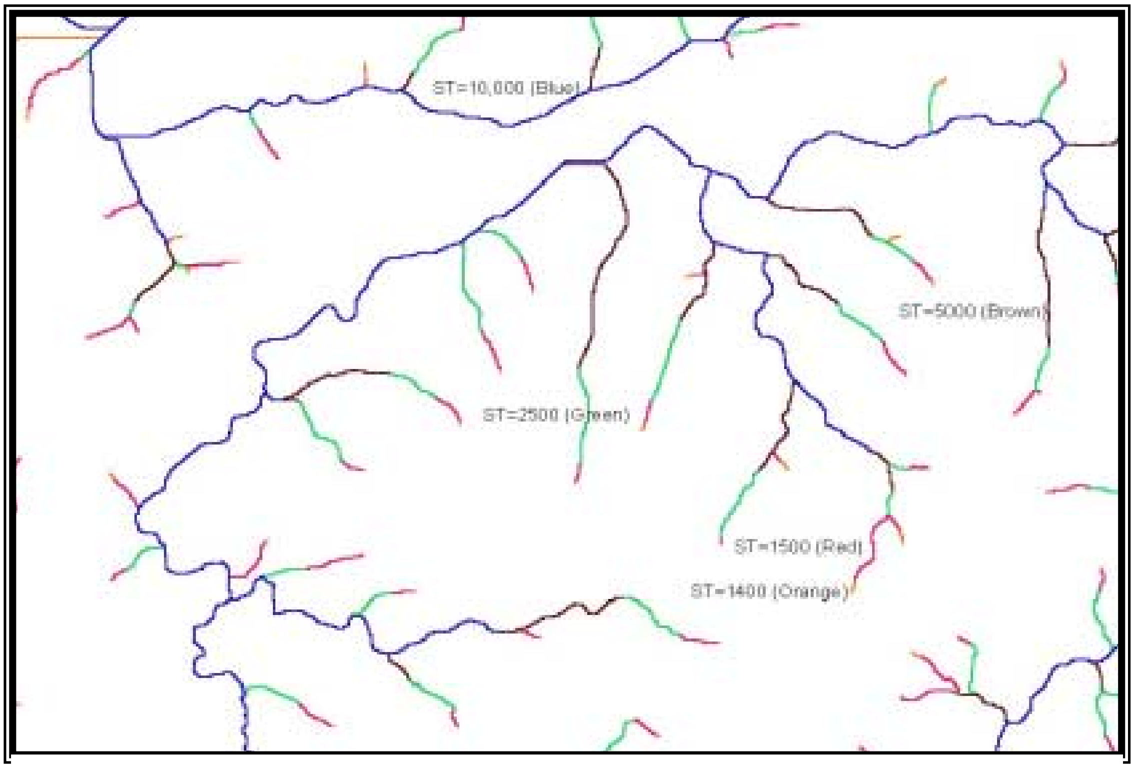

Figure 1. Overlapping stream networks derived using five different stream initiation thresholds. The blue lines were derived using the largest stream initiation threshold (ST). As the ST decreased the total length of streams appearing in the data layer increased. This process worked up to the point where the topographic relief was not sufficient for the computer to place a channel (about 1,400 cells), shown in red and orange.

We finally selected a stream initiation threshold of 1,400 grid cells (about 34 acres). This means that we considered a stream to be any point within the study area that drained _at least_ 34 acres. This stream initiation threshold resulted in a 6,293.8 km (3,910.8 mi) long stream network for the entire study area. One of the drawbacks of applying a single stream initiation threshold to the entire study area is that at smaller stream initiation thresholds a large amount of 'flagging' is evident. Flagging is the result of the computer program not being able to correctly place the stream channel because the topographic relief was too flat. This occurs in coastal areas and in relatively flat river valleys. In these cases, the computer simply drew a straight line across the area.

The overall stream density for the study area is 6,293.8 km / 375,341.0 ha = 0.017 km stream ha^{-1} (2.7 mi stream mi^{-2}). Interestingly, this value for stream density is very close to the density of the 1:24 K USGS streams layer in the area it covered. This suggests that the 1,400 cell stream threshold produced a stream network similar to that present on the 7.5 min USGS topographic maps. We calculated that only 20% of the first order streams identified in the USFS densified stream layer were captured as first order streams in the derived streams layer (Table 1.4). This shows that our 1,400 cell stream initiation threshold was too large to delineate many first order streams in the study area and suggests that photo interpretation may be more accurate. An advantage in using DEM-derived streams is that the stream network is coupled to the topographic data in the GIS: this is an important step in developing any GIS based models. However, if more detailed stream information is needed, it may be possible to break the study area up into sub-basins and use smaller stream initiation thresholds (in some areas) to derive a more detailed stream network. This may be possible in the upper watersheds where topographic relief is much more pronounced. Future work should include a ground truthing component to ensure that the computer-generated streams accurately represent stream location.

Table 1.4. Proportion of densified streams layer captured by each iteration of stream derivation from digital elevation models

Stream Initiation Threshold (grid cells)	**Total stream length (m) for derived coverage**	**Length of densified streams layer (m)**	**Proportion of densified streams layer captured (%)**
10,000	2,724,605	15,240,889.9	17.9
5,000	3,686,250	15,240,889.9	24.2
2,500	4,940,885	15,240,889.9	32.4
1,500	6,115,270	15,240,889.9	40.1
1,400	6,293,803	15,240,889.9	41.3

2 Stream Confinement

In this section, it is important to distinguish between the terms "stream confinement" and "stream entrenchment." Stream entrenchment refers to areas where stream down-cutting has led to a separation of the stream from its floodplain. Confinement refers to the width of a streams' floodplain in comparison to the width of the stream. Both entrenchment and confinement determine the extent to which a stream is free to move laterally (i.e., meander). The channel of an unconfined stream is likely to be more dynamic, with frequently-changing meander locations. Dynamic, unconfined stream channels often have more off-channel and backwater wetland habitats of high value to salmonids. In the OWEB Watershed Assessment Manual (Watershed Professionals Network, 1999), a stream is considered unconfined if the floodplain width is more than 4 times the stream width.

Using the GIS to derive stream confinement was rather problematic and we made a number of assumptions. For example, we assumed that the stream width was approximately the width of a DEM grid cell, or 10 m. This may be true for some of the higher order streams, but it is not true for 1st and 2nd order streams, which may only be 1-2 m in width (Naiman and Anderson, 1997).

To derive stream confinement we used ARCView to calculate the slope from the DEM GRID. We assumed that riparian valleys were separated from confining hillsides at slope breaks. Recall that in ARCView, each GRID cell in the output theme contains a slope value represented in degrees. Slope is calculated as the rate of maximum change for each cell to its neighbors is using a 3 by 3 window. We determined the optimal value to use for separating riparian valleys from confining hillsides using an iterative process.

Three different sets of values were evaluated to determine the best slope variables to use to delineate riparian valleys and floodplains. In this evaluation valley floors or "flat areas" were defined as (1) 0-2 degrees (0.0-1.1%), (2) 0-5 degrees (0.0-8.8%), and (3) 0-10 degrees (0.0- 17.6%). After consideration, we selected slope values of 0-5 degrees to represent "flat" areas along valley floors and slope values > 5 degrees (up to 90 degrees) to represent hillsides. Selection was qualitative and was based on our ability to delineate stream valleys using the three slope categories. The first (0-2 degrees) category created many small "hillside" areas within the stream valleys and the third (0-10 degrees) produced relatively small riparian valleys.

Once values were selected to distinguish between "flat areas" and "hillsides" we used ARCView to reclassify the slope grid into a two-category grid, which represented the two slope classes (0-5 =1 and >5-90=2). ARCView was then used to convert the GRID file to an ARCView shapefile.

We also considered that streams are not always centered in their valleys. Using the GIS we removed small (<1.5 ha), isolated 'flat areas.' Therefore, stream segments must flow through 'flat areas' greater than 1.5 ha to be considered as 'unconfined' stream segments in our analysis. We considered stream segments flowing through 'steep areas' or flowing through 'flat areas' less than 1.5 ha in size to be confined.

We used ARCView to intersect the DEM derived streams coverage with the 'flat areas' coverage. All of the stream segments that fell within the 'flat area' polygons over 1.5 ha in size were labeled as "U", or unconfined. All other stream segments were labeled as "C" or confined.

This data layer (**der_st_confinement.shp**) was created because a study area wide confinement layer did not exist for this assessment. Stream confinement portrayed in this data layer has not been field verified. We recommend that field crews verify this information as soon as possible. We expect that the DEM will be more successful in defining stream segments constrained by bedrock or hillslopes as "confined" than stream segments bordered by more gradual hill slopes. We also expect that the spatial resolution of the DEMs is not adequate for separation of terrace-constrained channels from unconstrained channels where elevational differences may be only 1-2 m. We recommend that field crews make detailed observations on stream morphology at specific locations along the derived streams network so that the GIS process can be refined.

3 Stream Gradient

Stream gradient information was not available for the entire study area. We used the digital elevation model (DEM) data to develop a computer-generated representation of stream gradient (**der_stream_gradient.zip**, shapefile name **der_gradient_4.shp**). This layer is meant to be used as a study area wide surrogate for stream gradient information until a better representation of stream gradient can be produced.

We acquired digital elevation model (DEM) data from the CLAMS group at Oregon State University (*http://www.fsl.orst.edu/clams/menu.htm*). The DEMs were mosaicked as previously described. Recall that the elevation value assigned to an individual DEM cell represents the elevation of a $100m^2$ area as a single value. For relatively flat areas that extend for hundreds of meters, the DEM value is probably a good representation of elevation, at least within the vertical error associate with the original data. However, in areas with variable terrain on a spatial scale of a few meters, DEM values may not capture topographic variability. These factors should be considered when evaluating the results of DEM based analyses.

Ideally, a 10 X 10 m grid, such as the DEM, would produce a stream gradient value for every cell along a stream, based on the elevation change between the cell immediately above and below it. However, most of the slope calculation routines in GIS generate a slope value from the elevation change measured within 1 grid cell (in our case, 10 m) in any direction around the cell. In other words, the slope of a single cell is determined by the maximum elevation change from any two of the 9 cells immediately surrounding each cell. This has the effect of smoothing out the terrain. In deeply incised valleys, such as those found in the upper watersheds within the study area, stream gradient may be overestimated by this procedure because steep valley walls may be included in the determination of stream channel cells. In addition, stream widths may be only a few meters across compared to the relatively coarse grid cell size of 10 m.

Therefore, there are at least two potential sources of error in using GIS to calculate stream gradients: (1) the possible incorporation of valley wall elevations into the stream channel slope calculations; and (2) the relatively coarse DEM grid compared to the relatively narrow stream widths. **We recommend that field teams validate this stand-in data layer as soon as possible.**

Initially, we used a public domain version of an ArcInfo AML (a command language instruction file) to calculate stream gradient from the DEM (available from *http://www.cwu.edu/~rhickey/slope/slope*). We were able to generate a slope grid, but the range of gradient values produced by the AML was not complete, i.e., the AML did not produce any slope values of 1, 3, or 5 degrees. Since we were particularly interested in low gradient streams, we abandoned this AML. We learned that there would be a stream gradient ARCView Spatial Analyst routine released in early 2000. We recommend that the new AML be investigated at a future date to see if there is any advantage in using it to produce a stream gradient layer.

We used the slope function in ARCView to create a slope grid of the entire study area from the 10 m DEMs. The slope function in ARCView identifies the maximum rate of change in elevation within a 3 X 3 cell neighborhood. This means that for each cell, ARCView examines the elevation of the surrounding cells, selects the cells with the maximum and minimum values, calculates the difference in elevation and then calculates the slope as the change in elevation (rise) over horizontal distance (run). ARCView returns the slope in degrees, which has to be converted to percent slope. We used the following formula to convert degrees to percent slope:

Equation 1. **tan (degree slope) * 100 = percent slope**

One of the drawbacks in using the slope function in ARCView Spatial Analyst is that slope values are returned as integers. Salmon biologists are interested in 1-percent differences in stream gradient, especially in low gradient streams. Calculating whole number values for stream gradient in degrees of slope, it was impossible (for example) to separate a 1% gradient from a 2% gradient, or a 2% from 3% gradient. Conversions are given in **Table 3.1**.

We then used ARCView to intersect the newly created slope grid with the **ST1400** derived stream layer. This transferred the gradient attributes onto each of 440,000 stream segments in the study area. This stream layer was then intersected with the 6th field watershed [**6th_field.shp**] coverage to produce a coverage that could be used to summarize the stream gradient classes for each 6th field.

Table 3.1. Stream gradient classes: Shown are expected stream gradient classes in percent slope, the actual slopes calculated by ARCView, and the degree slope equivalent.

Gradient Class	Expected %	Actual Percent Slope	Degrees Slope
1	0-1	0	0
2	1-2	1.75	1
3	2-4	3.5	2
4	4-8	5.24-8.75	3-5
5	8-14	10.51-14.1	6-8
6	14-20	≥ 15.8	≥9

The question is how to represent stream gradient in watershed assessments. Measuring stream gradient directly from USGS topographic maps has been criticized because the technique may miss biologically important discontinuities in stream gradient by assigning one stream gradient value to a reach. Using the DEMS to derive stream gradient produces a stream gradient value for every 10 m section of stream. However, for reasons discussed, the derived gradient may not be an accurate representation of actual stream gradient, especially in areas where the streams are narrow (< 5 m) and the topographic variability within a 100 X 100 m area is high. The best way to answer this question would be to field check the computer generated DEM-derived stream gradients. Since this was not possible for this study we used two sources of stream gradient information to check our results: (1) the USFS/ BLM stream gradient information within the densified streams layer [**dens_str_final**] and (2) a point file generated by the NOAA, Northwest Fisheries Science Center (Contact: Cara Campbell or Pete Lawson *http://www.nwfsc. noaa.gov/*).

3.1 Comparison of Stream Gradients

As mentioned, during the analysis phase of this study, the USFS densified streams layer did not contain stream gradient information for the entire study area. Therefore, we could only compare information for 13 of the 217 6th field basins. The densified stream layer contained gradient information for each stream reach, measured from USGS topographic maps by Forest Service staff. Stream gradient determinations were made by measuring the number of topo map contour intervals within a given linear distance with a plastic template. Only stream gradient classes were recorded, not actual gradient values. The gradient classes were 0-1%, 1-2%, 2-4%, 4-8%, 8-20% and > 20% (D. Rainsford, personal communication, 1999).

We were unable to make point-by-point comparisons between the gradient data we derived from the DEM and the gradients in the USFS densified streams layer, due to differing stream gradient units, i.e., degrees *vs*. percent slope, and the different physical locations of streams in the two layers. Instead, we developed ranked lists of the 13 6th field basins. Basins were ranked in decreasing order according to the proportion of stream lengths falling in each stream gradient class. We reasoned that although the units and stream coverages may differ, both approaches should produce the same sort of pattern at the 6th field basin level. When considering low gradient streams (0-1%), we found that 10 out of the top 20 appeared on both lists. This suggests that patterns in the ranked list of derived stream gradients were close to (but not the same) as patterns produced in the densified streams ranked list. However, when the higher gradient streams were summarized, we found that only 2 basins appeared on both ranked lists. Of course, the stream gradient information in the densified layer was summarized in gradient categories and along stream segments that were very different from those used in the derived stream gradient layer. For this reason, we made a second comparison.

We obtained a spatial database from the National Marine Fisheries Service (*http://www.nmfs.noaa.gov/*) (Cara Campbell, personal communication, 2000) containing spatially referenced points of observations for stream gradient. Data points in this layer were developed from ODFW AHI field surveys and GIS modeled stream gradients. However, we did not find ODFW stream gradient data in the file that we received, although there was a field for those data. The NMFS data contained two stream gradient values with which we compared ours:

1. P.STEEP, stream steepness generated in the GIS software program, GRASS; and
2. DEMSLOPE, the average slope for a stream point calculated by taking the average DEM elevation over 2 points along the stream, one point above and one point below with 100 m between the points (not using 3 X 3 grid like our method).

To make the comparison between an ARC coverage (our DEM derived streams layer) and a point coverage (the NMFS DEMSLOPE data), we used the 26,149 points in the DEMSLOPE data to generate 10 m buffer areas around each point. This was done to account for differences in the stream position. Using the buffered points, we captured and compared over 33, 000 individual stream segments (10 m sections). The stream segments were exported to Excel and a summary (pivot) table created that summarized the proportion of the total stream lengths correctly identified by the derived stream gradient coverage. Since the units (degrees) were the same between the two coverages and the stream segments were similar in size, this is a more appropriate comparison than the comparison between the DEM derived gradient and the USFS gradient data.

Tables 3.2 and **3.3** summarize the proportion of correctly identified stream segments in the derived stream gradient layer, by gradient category, when compared to P.STEEP and DEMSLOPE. (Note that gradients of 1 degree were missing from the P.STEEP layer obtained from NMFS.) We also considered those stream segments that were close, but off by one category. For example, if the DEMSLOPE value was ‘4’, but the derived stream gradient value was ‘3’, we included it in the column labeled ‘Minus 1 Category.’

We found that the derived stream gradient correctly identified 14-25% of the stream gradients. If the stream gradient misclassifications (“off by one” categories) are considered, we correctly classified 50-60 % of the stream segments. Unfortunately, the NMFS data did not include very many points from first order steams. Therefore, the higher stream gradients are not compared.

Table 3.2. Proportion of stream lengths correctly identified by derived stream gradient (as compared with DEMSLOPE)

Slope (degrees)	No. Records	Correct (%)	Minus 1 Category (%)	Plus and Minus 1 Category (%)
0	1,405	14.3		
1	3,444	20.3	44.5	63.3
2	4,710	25.9	50.0	71.8
3	3,858	18.0	34.7	55.6
4	2,564	12.5	21.7	38.5
5	3,122	15.5	27.4	45.6
14	655	4.0	7.5	11.0
15	481	2.8	6.4	10.3
20	184	1.4	2.9	4.1

Table 3.3. Proportion of stream lengths correctly identified by derived stream gradient (as compared with P.STEEP)

Slope (degrees)	No. Records	Correct (%)	Minus 1 Category (%)	Plus and Minus 1 Category (%)
0	1,405	24.3		
1 (missing)	3,444			
2	4,710	28.2		61.7
3	3,858	16.4	32.4	49.7
4	2,564	7.3	13.3	20.0
5	3,122	6.6	12.1	21.8
14	655	1.5	2.1	3.5
15	481	0.7	1.2	1.8
20	184	0.4	< 1.0	< 1.0

In summary, we used the DEMs to generate a streams coverage and stream gradient. This was necessary because data of appropriate spatial scale that covered the whole study area were not available at the time of this study. We used these data layers as surrogate data layers until better spatial data sets become available. We strongly recommend that these data layers be validated by field teams.

4 Stream Channel Types

Stream channel types were designated in the following ways:

(1) Large Estuarine (EL) and Small Estuarine (ES) streams were manually coded. We used the Estuary Plan Book (Cortright, 1987) to determine the extent of tidal influence

for the large mainstem rivers. We used ARCView to measure distances of 8.5 km for the Salmon River, 7.7 km for the Siletz, 23.2 km for the Yaquina, and 10 km for the Alsea; for all others we used a value of 2.5 km. We used the DEMs to determine if rivers had a broad floodplain. Those that did were designated as Large Estuarine (EL) and those that were smaller, unconfined and low gradient were designated as Small Estuarine (ES).

(2) Very Steep Headwater (VH) channels were selected as 1st order streams that had stream gradients greater than 16%.

(3) All other channel types were defined using the channel type categories shown in **Table 4.1** below, taken from the Oregon Watershed Assessment Manual (Watershed Professionals Network, 1999).

Table 4.1. OWEB Manual stream channel types (Watershed Professionals Network 1999)

Code	Channel Type	Gradient	Confinement	Size
ES	Small Estuary	<1%	Unconfined to moderately confined	Small to medium
EL	Large Estuary	<1%	Unconfined to moderately confined	Large
FP1	Low Gradient Large Floodplain	<1%	Unconfined	Large
FP2	Low Gradient Medium Floodplain	<2%	Unconfined	Medium to large
FP3	Low Gradient Small Floodplain	<2%	Unconfined	Small to medium
AF	Alluvial Fan	1-5 %	Variable	Small to medium
LM	Low Gradient Moderately Confined	< 2%	Moderately confined	Variable
LC	Low Gradient Confined	< 2%	Confined	Variable
MC	Moderate Gradient Moderately Confined	2-4%	Moderately confined	Variable
MC	Moderate Gradient Confined	2-4%	Confined	Variable
MH	Moderate Gradient Headwater	1-6%	Confined	Small
MV	Moderately Steep Narrow Valley	3-10%	Confined	Small to medium
BC	Bedrock Canyon	1>20%	Confined	Variable
SV	Steep Narrow Valley	8-16 %	Confined	Small
VH	Very Steep Headwater	> 16%	Confined	Small

5 Aquatic habitat survey (AHI) data

5.1 Initial GIS coverage manipulations

ODFW Aquatic Habitat Inventory GIS data obtained from the ODFW website included reach-level and habitat-unit-level ArcInfo coverages for each 4th field watershed. The reach-level coverages were merged into a single ArcView shapefile. We then intersected the merged ODFW reach-level GIS coverage with the 6th field coverage to create a theme containing all of the original aquatic habitat data plus 6th field identifiers (**aqhab_odfw_final.shp**). As a result of analyses performed during this assessment, we added many parameters not found in the original attribute table to the shapefile. Parameters added are described in the metadata for the shapefile **aqhab_odfw_final.shp**.

In general, we used the reach-level summaries prepared by ODFW, but for some parameters (substrates and length of riffle units), we needed to use habitat-unit level data because the data we needed were not available in the reach-level GIS layer. For these parameters, we summarized within the ODFW habitat-level GIS coverage by stream reach, then joined the summaries to the reach coverage for summarization by 6th field in the aquatic habitats summary shapefile (**aqhab_sum_final.shp**).

5.2 Region 6 tabular data manipulations -- general

The USFS Region 6 tabular stream inventory data were provided to us as several files in delimited text format. We combined the files in a single Excel workbook (**REG6habs_final.xls**). We used the Excel **concatenate** function to merge the original USFS watershed codes from the ***master*** worksheet into a single 6th field ID code. We then used the **vlookup** function to assign the resulting HUC code and stream reach name to each reach and to each habitat unit (called an "NSO" or Natural Sequence Order in USFS protocol) in the ***habitat*** worksheet. The merged HUC codes corresponded to the field **SNF_LET_ID** in the sixth field coverage provided to us on the MCWC CD -ROM (**6th_field**).

Since measurements in the Region 6 database were in SAE units (feet and inches), we converted all measurements to the metric system to allow comparison to ODFW data and ODFW habitat benchmarks. In addition, we calculated unit area (length times width) for each NSO. Other data manipulations are described in the main report.

5.3 Calculating sixth field watershed averages and totals

Since some of the data for our AHI analyses were not available in GIS form, we manipulated, converted and compiled data to make the results of our analyses as comparable as possible from the three separate data sources. The specific method used for each parameter is described in the **Main Report**. To calculate summaries for 6th field watersheds, we used length-weighted numeric averages in some cases and summed lengths in others. All numeric averages were weighted by the length of the streams surveyed by each source (i.e., not calculated from the map length in the GIS layer) to avoid biasing the results towards sources with less survey data in a given 6th field. For parameters summarized by length, we simply added together the lengths from all three sources.

5.4 Interpreting the results of AHI analyses

5.4.1 Protocol differences and rankings versus averages

A great deal of effort was put into combining tabular stream survey data from several different sources into a single spreadsheet for this assessment. However, before summaries can be interpreted, differences in data collection methods must be understood. A protocol is a standardized method used to make an observation or measurement. Field personnel follow a set protocol when recording survey data. Protocols can vary from agency to agency and even within a single agency from year to year. It is important to note that protocols differed between the two main aquatic habitat survey data sources (agencies) used in this assessment (ODFW AHI *versus* USFS Stream Inventory). These protocol differences, described in the individual analysis sections of the **Main Report**, can make it harder to interpret numeric averages.

We investigated data distributions from the three different AHI data sources and determined that protocol differences did not appear to create serious problems for combining the sources in our analysis (for the parameters we analyzed). We combined data from all sources to create an index (which retained the original units) from numeric parameters across all data sources. Retaining the original units in this step of the analysis will help people to interpret the results (e.g., LWD pieces/100m or % pools by area). However, recognizing the differences in protocols, we ranked the 6th field watersheds for each numeric parameter analyzed (i.e., LWD/100m, key pieces/100m, % pools, channel widths per pool, percent shade, and % of units with active bank erosion) to assist in interpretation of the aquatic habitat analysis. All of the **Multi-factor analyses of salmonid habitat** (see **Main Report**) use rankings rather than absolute numeric averages. Use of rankings minimizes possible errors due to combining data that may not be equivalent due to protocol differences. We provide rankings in the aquatic habitat summary shapefile (**aqhab_sum_final.shp**).

In the aquatic habitat summary shapefile (**aqhab_sum_final.shp**), we indicated all 6th fields that had averages falling in the top quarter of the ranking from any single data source (**topq** in spreadsheet/table). Not all of these 6th fields had average numeric values in the top quarter of their range, illustrating the possible pitfalls of using numeric averages from different data sources. For example, protocol differences might mean that if two different agencies measured the same parameter in the same location, the measurements from one agency might range from 1 to 10, while the measured values from the other agency ranged from 1 to 15. If we simply averaged the data together, a top-ranked value from the first source (10) would be treated as equivalent to a middle-ranked value from the 2nd data source. By ranking results separately from each data source, and by highlighting values that were in the top quarter from any single data source, we allow users to be aware of possible errors that could result from comparing data from different sources.

Fortunately, in general, rankings were in close agreement from one data source to another. There were only 4 cases out of over 600 where a parameter had a 6th field average ranked in the top 25% from one data source, but in the bottom 25% from another data source. These cases were marked in "check" fields labeled **Zpls_ck**, **cwpl_ck**, **lwd_ck**, and **key_ck** in the summary shapefile **aqhab_sum_final.shp**.

5.4.2 Absolute lengths versus proportion of surveyed lengths

As requested by MCWC, we prioritized 6th fields by using the absolute length of stream reaches with certain AHI characteristics (riffles, substrates) in both single-factor and multi-factor analyses. Given that the proportion of the stream network surveyed varied greatly from one 6th field to another, it is worth considering the relative advantages and disadvantages of using absolute lengths and proportional lengths in such analyses. Further discussion of this issue is found in the **Main Report** in the **Interpretation** section for each AHI parameter.

The following scenario illustrates the issues involved: Suppose we are comparing absolute lengths of riffle habitat units with gravel substrate dominant in two 6th fields, both of which had about two-thirds of the major streams surveyed. Suppose both 6th fields had 3 km of gravel-dominated riffle habitat. But imagine one of those 6th fields had a total of only 6 km surveyed, while the other 6th field had 30 km surveyed. Should the 6th field with 3 km of gravel-dominated riffles out of 6 km surveyed (50%) be ranked higher, lower, or the same as a 6th field with 30 km surveyed, of which "only" 3 km (10%) had desirable habitat characteristics? In the first case, 50% of the surveyed length had the desirable habitat characteristics, while in the second case, only 3% of the surveyed length had those desirable habitat characteristics. Depending on the intended use of the data, either proportional (% of surveyed length) or absolute lengths might be more useful. Whichever ranking system is used, the other ranking system should be compared to get a complete picture of watershed conditions.

In fact, several analyses requested by MCWC illustrate a practical problem with using absolute lengths instead of proportional lengths. These are the analyses of length of riffle habitats, length of riffle habitats with gravel substrate dominant, and length of riffle habitats with gravel-to-boulder substrate dominant. The MidCoast Tech Team requested we use absolute lengths (rather than proportions of the stream network) for these analyses. When the resulting maps are viewed, it becomes apparent that the lengths of riffles and riffles with the substrates of interest (**Figures AQ-6**, **Figure AQ-14**, and **Figure AQ-16**) are very closely correlated to the length of AHI survey data (**Figure AQ-4**). The reason is obvious -- length of survey varied far more from 6th field to 6th field than did the proportion of each of these habitat types within surveyed streams.

In other words, ranking 6th fields by the length of riffle units, or by the length of riffle units with gravel substrate dominant, etc., may be misleading, because it is essentially equivalent to ranking 6th fields by the length of streams surveyed -- not a parameter that influences the quality of salmonid habitat. (Of course, professionals decide which streams to survey, and in that sense survey effort may reflect at least a number of professional’s opinions on the amount of good habitat within a basin -- but this may not be the most desirable metric for prioritizing action sites!) For these reasons, we recommend supplementing the absolute lengths analyses we conducted with proportional lengths analyses. Each method will provide specific advantages and disadvantages.

The scenario described above shows that interpretation of existing data is not always straightforward. Further interpretation challenges will arise in the future, as MCWC attempts to track watershed change. As explained above, when absolute lengths are used, it can be harder to track watershed change because results will be greatly influenced not only by habitat characteristics, but also by the length of streams surveyed. This can make it difficult in the future to determine if improvements that are seen are due to actual environmental change, or instead due to a change in sampling effort.

The problems described above can be overcome simply by analyzing *both* proportional and absolute lengths when making decisions on watershed management (or even ranked lists). This is our recommended approach. Each type of data has its advantages, and both can be used in conjunction for the most complete understanding of watershed conditions.

5.4.3 Proportional extent of survey data

For both numeric averages and absolute lengths, evaluation of assessment results requires consideration of the proportion of the stream network surveyed (**Survey Extent**, above). As the surveyed proportion of a watershed decreases, there is less certainty that data collected are representative of that watershed. In other words, if only a small proportion of a 6th field's stream network has been surveyed, it is possible that the numeric average values for aquatic habitat characteristics (like LWD pieces/100m, or %shade) may not be characteristic of the 6th field as a whole. To help eliminate this possible source of error, we excluded from our rankings those 6th fields where less than 5% of the total 1:100K stream length had been surveyed. Still, results from a 6th field where only 10% of the 1:200k stream length was surveyed should be interpreted differently from results from a 6th field where 90% of the length was surveyed. This consideration also applies to absolute lengths (see **Absolute lengths surveyed** in **Main Report**).

5.4.4 GIS length versus field-measured length

For the ODFW aquatic habitat survey data already in GIS format, two different types of length measurements are available. One set of length measurements originates from field measurements and is subsequently corrected in the office to produce “corrected channel length.” The other set of length measurements are the lengths of the GIS features representing the surveyed stream segment (“GIS feature length”). The corrected channel length, in turn, consists of two different parameters in the ODFW reach-level GIS: **prichnll** and **secchnll**. **Prichnll** is the total length of primary channel units (main stream channel) for the reach; **secchnll** is the total length of secondary channel units (side channels). The map length (GIS length) was generally about 12% shorter than the recorded primary channel length **prichnll**; the secondary channel length comprised about 7% of the total surveyed length (**prichnll+sechnll**). Each time we made a calculation based on reach length for a GIS AHI layer, we had to decide which of these length variables to use.

Two main factors influenced our decision on which length variable to use for each calculation:

1) Due to scale mismatch, intersection of the ODFW AHI GIS layer with the 6th field coverage results in duplication of records where a given reach cross a 6th field boundary. Most reaches would logically end at a 6th field boundary. However, the ODFW AHI GIS coverage is placed in GIS on a 1:100K stream layer, and the 6th field watershed boundaries (at a scale of 1:24K) do not match up exactly with the stream confluences. Each ODFW reach that is duplicated is stored with identical parameters in each 6th field into which it was divided, i.e., values are not weighted by stream length (GIS feature length). The result is duplication of field-estimated and corrected length fields, which are not updated as a result of the intersection process since they are not recognized by ArcView as lengths. The result of this duplication is an overall 19% increase in the sum of the fields "prchnll" (primary channel length) and "sechnll" in the intersected ODFW reach-level GIS layer.

2) The GIS length (feature length) is an artifact of the GIS data layer used as a base map for data entry. It is not the same as the sum of primary and secondary channel lengths for a given surveyed stream reach. The total GIS length for the study area is about 100 km shorter than the sum of the primary plus secondary channel lengths, a difference of about 12%. GIS feature length will generally be shorter than field-measured length, because a GIS map does not show every bend that is measured on the ground. The effect is heightened when data are placed on a coarse-scale base map, as is the case with the ODFW GIS data (entered on a 1:100K stream layer rather than a 1:24K streams coverage).

We made the following decisions on which length variable to use:

1) For purposes of calculating length-weighted averages of numeric habitat data (LWD, percent pools, channel widths per pool, percent shade and bank erosion), we used primary channel length as the weighting factor since it best represents the actual length of stream surveyed. Secondary channel length totals only about 7% of the surveyed length, across the entire study area.

2) For purposes of determining total length surveyed from the three different data sources, we decided to use the sum of principal channel length and secondary channel length (ignoring the duplication of lengths caused by intersection with the 6th field layer). We chose this procedure because it was analogous to the procedures used for the USFS Region 6 and Lincoln District data. Inclusion of the duplicated values of primary and secondary channel length exaggerates the total length of the ODFW survey data by about 19%. On the other hand, use of the GIS length would underestimate the length surveyed by about 12%. Since the total length surveyed was not used in any 6th field rankings, we felt that using an analogous procedure justified the larger error rate.

3) For purposes of determining total length of surveyed stream reaches with desirable habitat characteristics (e.g., length of riffle habitat units, length of riffle units with gravel-

dominated substrate, etc.), we used the GIS length. The advantage of using the GIS length instead of the primary channel length was that the GIS length was not duplicated during the process of intersecting surveyed reaches with sixth field watersheds (see item 1 above). These lengths were totaled in the habitat level GIS layer, then joined to the reach-level layer, then summarized by 6th field and joined to the final summary layer. We conducted a brief analysis of the effect of using GIS length versus corrected length from the habitat level layer, and found that there was generally only about a 10% reduction in length of "desirable" stream habitat using GIS length instead of primary channel length. Since these data would be used for ranking 6th fields, we felt that it was better to use the method with the lower error (about 10% for GIS length, compared to about 19% error using the duplicated primary channel lengths).

5.4.5 Spatial accuracy

For this assessment, we sought out GIS data at a scale of 1:24K or better. However, the ODFW Aquatic Habitat Inventory GIS data were available only at a scale of 1:100K. Because these data were so important to the assessment, we decided to use the data and provide information on the limitations of its spatial accuracy. Three factors influence the spatial accuracy of the ODFW GIS layer: 1) Use of the 1:100K streams layer as a base map; 2) Estimated *versus* measured habitat unit lengths; and 3) Transfer of data to GIS. These factors are not unique to the ODFW dataset, but are common issues that arise whenever data are placed in a GIS. Our protocol for handling these issues is described below.

1) Use of the 1:100K streams layer as a base map. The ODFW AHI GIS data are placed in GIS on a 1:100K streams layer base map, which lacks detail and is less spatially accurate than a 1:24K streams layer. The spatial accuracy of a map produced at a scale of 1:100,000 is about ±167 feet (if the map is produced using National Map Accuracy Standards, US Bureau of the Budget, 1947). No doubt the ODFW decision to place the data on a 1:100K layer was influenced by the lack of a suitable streams layer at the 1:24K scale -- the same problem that led us to derive our own streams layer from the 10m DEMs, which only became available this year. The main problem with presenting the AHI data on a 1:100K streams base is the lack of spatial correspondence between the 1:100K layer (and associated AHI data) and more detailed streams layers such as the **USFS densified layer** and the **DEM-derived streams layer** (both of which are at a scale of 1:24K or better). It is difficult to determine what segment of 1:24K stream has the characteristics described by the 1:100K data. Since 1:24K is the appropriate scale for watershed assessment below the 5th field level (Watershed Professionals Network 1999), this scale discrepancy presents a challenge in assessing stream reach conditions and creating watershed action plans.

2) Estimated and measured habitat unit lengths. Under the AHI protocol, one member of the field crew estimates the length of each habitat unit, and the other crew member measures the length of every tenth unit. In the office during data analysis, the measured lengths are compared to the estimated lengths for measured habitat units, producing a correction factor that is then applied uniformly across a group of habitat units to produce a corrected length. The corrected length is the length shown in the habitat-level GIS layer and summarized in **prichnll** and **sechnll** in the reach-level GIS layer. **Lengths used in our analyses were the corrected lengths, not the field-estimated lengths.** (In some cases, we used GIS feature lengths instead of primary and secondary channel lengths; see "**Transfer to GIS**" below and "**GIS length *versus* field-measured length**" above.)

Since the correction factor is applied uniformly across many units, the exact location of each individual habitat unit in the GIS is not known. This uncertainty creates challenges in interpreting the habitat-level GIS data on a site-by-site basis. Individual habitat units are mapped in this layer, and therefore appear to have an exact location on the map, but may in fact be in a different location due to the inherent uncertainty involved in applying the correction factor as well as the other factors described in this section. In fact, ODFW staff do not recommend making management decisions based on precise locations of habitat units, because habitat unit characteristics are expected to be dynamic (pools form and re-form each season; logs move during winter high flow periods; etc.) (Becky Flitcroft, personal communication, 2001).

3) Transfer to GIS. Additional uncertainty in location is added when the entire surveyed length is placed in the GIS, requiring adjustment of the total length to fit the map length of the surveyed segment as depicted in the 1:100K streams layer. The new, adjusted length of the GIS feature is called the "GIS length" or "GIS feature length" in this report. We used GIS feature length in analyses where intersecting AHI data with 6th field watersheds produced duplicated corrected lengths (see "**GIS length *versus* field-measured length**" above).

None of these spatial uncertainties are unique to the ODFW AHI GIS layer -- in fact, Therefore, it is important to be aware of these limitations to avoid misinterpretation of data.

MidCoast Sixth Field Watershed Assessment

Appendix B:
Ecosystem processes in watershed development

Prepared for the MidCoast Watersheds Council
July 2001

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1 The Watershed as an Ecosystem

Ecosystems are open systems, that is, they rely on inputs from other ecosystems and from the sun, and they export materials (i.e., nutrients) and energy (contained in organic materials). Although recycling and storage may help to stabilize ecosystems, energy and materials must constantly be replenished in order to keep ecosystems going (Pomeroy et al. 1988). The storage and recycling of materials and the flow of energy is determined by the ecosystem components (abundance and distribution of organisms) and the way in which the components relate to each other and to their abiotic environment.

The term 'ecosystem' was coined by Tansley (1935) although the concept of a higher level of organization of biological systems was in use since the late 1800s (Pomeroy et al. 1988). The notion of the ecosystem is that "living organisms and their non-living environment are inseparably interrelated and interact upon each other" (Odum 1971). Like watersheds, ecosystems can be large or small. For example, a rotting log in a forest can be considered to be an ecosystem, if there is interaction between the living and non-living components of that log. Watersheds in the Midcoast Region of Oregon can also be thought of as ecosystems, if certain conditions are met. By definition watersheds are areas of the landscape that collect water and drain to a stream, river, bay, lake or ocean. Ecosystems are defined as areas in which living organisms interact (i.e., competition, predation, etc.) with each other and their non-living (abiotic) environment. Since watersheds have identifiable boundaries, it is convenient to think of watersheds as ecosystems; however, the concepts are not interchangeable. While watersheds can be ecosystems (i.e., if you're considering interactions between a watershed's biotic and abiotic components), not all ecosystems are watersheds!

1.1 Flow of energy and materials

The flow of water dictates how energy and materials move through the coastal watersheds in Oregon. Management of watersheds can be thought of in ecosystem terms, i.e., to maximize the production of valued resources (i.e., salmon, timber, crabs, etc.) while minimizing loss of desired properties or functions (timber losses due to disease; reductions in water quality; flooding; etc.). An ecosystem approach uses knowledge of energy and material movement to help us evaluate approaches for resource management.

Physical laws limit what can be accomplished by management actions. For example, the transfer of energy between predator and prey is not perfect and energy is lost with each link in the food web. Therefore, the food web in an ecosystem cannot be infinitely long. For example, although it may be desirable to have higher trophic level organisms (e.g., salmon) in the watershed, if food web support is not present, consumers cannot exist.

In a sense, a resource-based economy depends on maximizing the production of desirable species such as salmon, Douglas-fir and oysters. Watershed management is the process of ensuring that human actions upon all components of the ecosystem have the desired effect of increasing target resource production, without excess negative impact to other, nontarget resources.

Odum (1971) describes ecosystems as having identifiable trophic structure and material cycles (the movement of materials and energy between living and non-living ecosystem components). He identifies the components of an ecosystem as (1) inorganic substances, (2) organic compounds, (3) climatic regime, (4) producers, (5) microconsumers (transformers), and (6) consumers. Human activities can alter both inorganic and organic components of ecosystems through actions such as burning, fertilization, timber harvest, increasing erosion, etc. Human activities can also affect the types of organisms in the ecosystem (producers and consumers) through such activities as sylvaculture, aquiculture, agriculture, or through the introduction of non-native organisms.

Within ecosystems, food energy is transferred from producers (plants) through a series of consumers and transformers (animals, bacteria, fungi) by eating and being eaten (Odum 1975). A trophic level is a group of organisms that all obtain their nourishment the same number of steps from producers; for example, plants are the first step and constitute the first trophic level. Consumers that eat plants (e.g., cows, caterpillars, Black Brandt geese) are all one step away from the producer (the plant) and all belong to the same trophic level although they are very different organisms. The next trophic level would be composed of organisms that eat cows, caterpillars and Black Brandt. The trophic structure of an ecosystem is a functional description of how organisms interrelate (in this case by eating each other) and how energy moves through the ecosystem.

Energy is lost at each transfer between trophic levels. The trophic structure in an ecosystem cannot be infinitely long: the types of organisms and their interactions (predation, competition, etc.) determine how energy moves into and through the food web. Therefore, expectations of desired management action outcomes must occur within certain limits. For example, although it may be desirable to have higher trophic level organisms (e.g., salmon) in the watershed, if food web support is not present, consumers cannot exist.

Ecosystems can be structured by the interactions between living and non-living components. Inorganic substances are ecosystem components (Odum 1971). Several of these inorganic substances, phosphorus (P), nitrogen (N), oxygen (O), carbon (C), carbon dioxide (CO_2), and water (H_2O) are essential to living organisms. Of these substances, N and P most often limit plant growth in aquatic and marine ecosystems (Hutchinson 1973; Wetzel 1983; Schelske et al. 1974). Inorganic substances are taken up by organisms directly from their environment (often through the action of bacteria or fungi) or as food. Inorganic substances are used by organisms as building blocks for proteins, carbohydrates, lipids, or other organic compounds. Organic compounds, another ecosystem component, are produced by organisms. Examples of organic compounds include sugars, the cellulose and lignins that make up wood, proteins, etc. Organic compounds constitute an important structural ecosystem component and function to store energy since many organisms can digest and use organic compounds for food.

1.2 Land cover

Vegetation, both living and dead, provides structure to the terrestrial ecosystem. For example, trees form a substrate for epiphytic plants, slow the wind, reduce rainfall impact to the soil surface, provide shade to the forest floor and streams, bind soils to slow erosion, and provide obstacles to slow the overland flow of water. Undisturbed old growth forests are stable and conservative in terms of sediment movement; root systems, protective canopy and a highly organic soil layer mitigate the effect of intense precipitation in the area (Proctor 1980). Even the structure of unmowed fields and riparian areas can slow soil loss. Alterations to slope and to vegetation can accelerate erosion (see Proctor 1980 for discussion).

Vegetation slows down the movement of water. The pool of organic material in forest, shrublands, and agricultural fields holds moisture during dry periods by slowing down evaporation. The importance of large woody debris is recognized in Pacific Northwest forests. Woody debris acts as a food source for some organisms. In addition, woody debris and other organic material slows down water velocities over the forest floor and in streams, thereby decreasing the flushing of materials from the watershed and establishing the complex in-stream environments favorable for many organisms, such as salmon. Of all the structural components in the terrestrial ecosystem, woody debris is one of the slowest components of the forest ecosystem to recover after disturbance (Spies et al. 1988).

Terrestrial ecosystems, forests, are the upper end of a continuum that extends from the ridge tops to the sea. Most of the materials and energy move down the elevational gradient. The time that it takes for materials to move depends on how land cover has been modified. Energy and materials leave the terrestrial subsystem when resources are harvested, as animals migrate out of the area or when dissolved and particulate organic materials are transported into the stream network.

2 Sediment Transport: A Conceptual Model

Humans influence sediment production rates in many ways, such as vegetation removal for agriculture, timber harvest, roadbuilding, stream channel modifications, and gravel mining. Sediments are produced through various types of erosion, including sheet and rill, gully, road, trail, streambank, and roadside erosion; landslides; and debris flows.

Landslides (mass wasting) are one source of upper watershed sediments. Landslides occur naturally due to instability of soils and geologic formations. The frequency of landslides may also be influenced by human-induced land use changes . Soil and organic debris that break loose from the hillside may be temporarily stopped by vegetation (trees and riparian areas) before entering into the stream. For any point on a stream course, sediments entering at that point are a combination of those sediments entering from upstream and those that enter from sources on the hillside. Land use practices can dramatically affect the frequency and timing of pulses of sediments that enter the stream by exacerbating slumping and removing vegetation, which may promote hillside sediment deposition. Sediments can be temporarily removed from a stream by deposition. Sediments may also enter the stream *via* bank erosion. Precipitation patterns and geomorphology determine the quantity and timing of sediment movement.

As sediments are transported down gradient, they eventually enter the estuaries, or directly enter the sea. Once in the estuary, sediments can be permanently lost from the system as deep sediments (those sediments that do not interact with the water column under normal circumstances) or lost to the ocean. Sediments can also be temporarily removed from the water column by settling to shallow sediments; however, resuspension of shallow sediments can occur under a variety of circumstances (wind, heavy precipitation events, etc.). Sediments that end up as deep sediments remain within the bay and may change processes that occur within the bay. For example, as sediments accrete, deep water habitat may be replaced by mudflats and water circulation patterns and temperature can be altered.

2.1 Erosion and Sedimentation

Erosion is the detachment and transport of material from a surface.

Surface erosion is characterized by lack of channels or rills. Consequences of erosion are many and are not confined to source areas. Much of the concern about steepland erosion is not so much over the loss of soil but over the degradation of stream resources. Steepland erosion is the result of numerous interactions between climate, soil, geology, topography and vegetation. There are also interactions between different types of erosion, that is, one type of erosion can increase or decrease the rate of another type (after Ziemer undated). For example, high rates of runoff and erosion on steep, cleared slopes with roads can result in areas of **mass wasting** (Reckendorf 1994).

In undisturbed forested areas, surface erosion is usually insignificant due to the high infiltration rates of soil (Ziemer undated) and because living and dead plant material intercepts and dissipates raindrop and wind energy (Pimentel et al. 1995). However, logging, road construction, wildfires or mass erosion can expose mineral soil or otherwise decrease soil permeability (Ziemer undated).

Immediate effects of erosion by water and wind include loss of soil quality and productivity by reducing infiltration rates, water-holding capacity, nutrient and organic content, soil biota and soil depth. Vegetation regenerates poorly on these low-quality soils, creating a cycle in which eroded areas remain prone to further erosion due to poor vegetation establishment and the consequent higher runoff rates (Pimentel et al. 1995).

2.2 Mass erosion

Mass erosion (or mass wasting) is the downslope movement of soil or rock in response to gravitational stress. This movement can be slow and subtle to rapid failures of hillsides and stream channels: in undisturbed forested areas, mass erosion is the dominant mechanism by which soil gets into stream channels (Ziemer undated).

Debris flows, **debris avalanches** or **debris torrents** (mass erosion) are generally found in shallow noncohesive soils on steep slopes. Debris flows can be a significant source of sediments and woody debris to streams and rivers. Plant roots can reduce the frequency of these shallow failures. In marginally stable areas, debris avalanches frequency can increase after trees are cut and their roots decompose. Road building activities can also increase the frequency of debris avalanches because road cuts can undercut shallow failure surfaces and road fills can increase the weight of overburden on slope surfaces.

Creep, a type of mass erosion, is the slow downslope movement of soil. In Pacific Northwest forests annual creep rates are generally less than 10 mm yr^{-1};

Earthflow, also a type of mass erosion, can be considered to be accelerated creep where shear stress exceeds the strength of the soil mantle resulting in discrete failures. The movement of overburden during earthflow can be imperceptibly slow or it can exceed a meter day^{-1}. Failures due to earthflow can range in size from less than a hectare to square kilometers.

Mass wasting, such as debris flows, can be responsible for large inputs of sediment into stream systems. Mass wasting can result from natural disturbances, such as floods and fires, but is exacerbated by human land use activities. High rates of runoff and erosion on steep cleared slopes with roads are a prime source of mass wasting. Forest road building and maintenance failures make the most significant contribution to the mass wasting process and sediment (especially gravel) production. On United States Department of Agriculture Bureau of Land Management (BLM) lands, sediment production and delivery are primarily a result of past timber harvest and road construction activities.

Debris flows are a major source of disturbance to riparian vegetation in humid mountainous areas (Swantson 1978, Veblen and Ashton 1978). Landslides, debris flow, and erosion are ultimately the source of terrestrial sediments that arrive in the bay. In addition to supplying organic material and sediments to streams and rivers, these types of disturbances can have a profound effect on the structure and function of ecosystems.

Intense debris flows can remove all vegetation and remove soils down to bedrock (Costa 1984). Lack of upland forest cover and riparian vegetation can lead to chronic sedimentation problems. For example, in areas where vegetation, which would have trapped sediment movement, is no longer present even small rainfall events can lead to significant sediment movement. Surface deposit characteristics and earth flow intensity are the most important influences on revegetation (Gecy and Wilson 1990). Mass movement of earth can also alter landscape successional patterns by promoting the growth of disturbance-adapted species. For example, in Oregon streams, red alder (Alnus rubra) seedlings can quickly become established in debris flow zones (Gecy and Wilson 1990).

In addition to removing vegetation and increasing the potential for chronic sedimentation, debris flows can quickly move woody debris from the forest into aquatic ecosystems. Once in aquatic ecosystems, and depending on the stream, woody debris can either become trapped in the stream where it can reduce erosion by dissipating energy in flowing water, store moisture, serve as a seedbed or provide energy, nutrients and structure to the stream channel that can be used by a variety of aquatic organisms (Franklin et al. 1981, Harmon and Hua 1991) or woody debris can be quickly exported from the stream. Dead trees trapped in streams can persist for centuries (Triska and Cromack 1980); therefore, the influence of the dead tree upon the forest-stream ecosystem can be as long lasting as the live tree (Harmon and Hua 1991), provided the tree stays in the stream.

2.3 Sediments and Stream Channels

The morphology or physical form of a stream channel at any point is a dynamic expression of the climate (as it affects stream flows) and the geology (as it affects sedimentation) of a stream basin. Other variables, such as resistance to flow (friction) and bed particle size, also influence important channel variables, such as width, depth, velocity, slope, and pattern. Perturbations (both human and natural) to a fluvial (river) system can result in site-specific channel changes (e.g., changes in cross-sectional geometry at the point of disturbance) and/or channel morphology adjustments longitudinally over an area of stream downstream or upstream from the point of disturbance (after M. Reiter, 1995).

Human modifications of channels can cause an array of effects depending on the inherent characteristics of a system. In larger river systems these modifications rarely occur in isolation, but interact with other upstream and downstream alterations to channel morphology.

Channel erosion is the detachment and transport of material from a gully or stream channel. The material may be derived from the channel itself or material that has been deposited within the channel by surface or mass erosion. The size, complexity (sinuosity) and transport capability of channels is determined by the energy of the water, which flows through the channel. High gradients, low friction and unimpeded water flow characterize high-energy channel systems.

Channels are unique; therefore their responses to natural factors and human-induced modifications are also unique. Changes in channel form and process occur longitudinally along a stream. In the downstream direction, the gradient decreases, sinuosity ("curviness") increases, the ratio of **bedload** to **total sediment load** decreases, the grain size of material which can be transported decreases, and the total **discharge** or **streamflow** increases. Large-scale determinants of channel morphology include the following factors; climate, geology/topography, vegetation and soils, land use practices, and in-channel modifications.

Fluvial processes are structured by hydrology, sediment load and movement, and the resistance of the channel to flow and sediment movement. Components of hydrology include the type of flow (baseflow, **bankfull flow**, and highflow), **stream power**, and the hydrological disturbance regime. Sediments can differ in their source, type (suspended load, bedload, turbidity), and size. Changes in sediment load that occur through land use practices can result in sediment accumulation (**aggradation)** or loss (**degradation**) in portions of the stream. Channel resistance is determined by the bank and bed material, vegetation (large wood, riparian vegetation, and roots), and physical form of the channel. Adjustments of channels include a number of factors. Channels have four degrees of freedom or ways in which the form can change: 1) **the longitudinal profile**, 2) **channel sinuosity**, 3) roughness of bed or bank, and 4) **the hydraulic radius**.

3 Aquatic and riparian habitats

There are several models used to describe and inventory riverine areas. These models are useful to resource managers because models promote an understanding of factors that control the abundance and distribution of organisms. First, the River Continuum Concept (Vannote et al. 1980) recognized that there are predictable patterns in the physical characters of stream channels to which organisms adapt. Briefly, the River Continuum Concept (summarized in Table 2.3) can provide resource managers with expectations and an understanding for certain stream reaches. For example, insectivorous fish distribution in the watershed may be controlled by fish passage issues alone, but also by the availability of prey items in the upper reaches of the stream network. Different species of salmonids have specific requirements for current, streambed substrate and temperature. The Oregon Department of Fish & Wildlife recognizes the relationship between salmonids and Oregon streams and has spent considerable effort to inventory salmonid habitats (ODFW 1994). Indeed, management actions aimed at increasing salmonid populations in Oregon target instream areas. For example, the lack of off-channel alcoves and deep dam pools are thought to limit coho salmon production (Solazzi 1995).

Stream velocity also structures riverine ecosystems. The stream network in the Oregon Coast Range occurs along a steep elevational gradient, reaching from the peaks of the Coast Range to the sea. Water velocity in the stream channel is a primary organizing factor for the riverine ecosystem, both the abiotic components (Hynes 1970, Cummins 1988) and the biotic components (Hynes 1970, Merritt and Cummins 1984). At high velocities, water is capable of eroding away the stream substrate and carrying away suspended solids. As the water slows, suspended solids settle; therefore, water velocity affects the stream bed depth (pools), patterns in stream meander, the distribution of sediment sizes along the stream bed (boulders, gravel bars, silt or clay deposits) and the type of organic material (coarse vs. fine). Suspended sediments in turn affect the amount of light reaching the streambed (important for algal production) and the availability of some nutrients (phosphorus sorbs to particulates). Fast moving, turbulent water has the potential to have more dissolved oxygen than still water due to mixing. Since different types of organisms have different ecological requirements for current, light, temperature, oxygen, food particle size and substrate, it is easy to see that water velocity can be important in structuring the biological communities within riverine ecosystems

Following the River Continuum Concept, aquatic macroinvertebrates may be used as indicators for instream conditions. Since these organisms may have specific ecological requirements for temperature, dissolved oxygen concentration, current and food particle size, the presence and abundance of these organisms can be related to environmental conditions within a stream. Table 2.3 shows how the composition of the invertebrate community (by feeding / functional group) is expected to change along the river continuum. At higher elevations, in lower order streams, the invertebrate community is dominated by organisms that use coarse particulate organic material (shredders, such as caddisflies [family *Phyrganeidae*]. In higher order streams, shredders are eventually replaced by organisms that use fine particulate organic material in streams (such as freshwater mussels). This demonstrates that the stream network functions to transform organic materials: coarse material is degraded into fine or dissolved materials by biological (invertebrate) and abiotic (i.e., fragmentation, leaching) mechanisms. The processing of organic material within the stream network is fundamental to the biological productivity of the stream.

Table 2.3. General characteristics of streams along the River Continuum of Stream Order (after Cummins 1988).

Stream Order	Description	Width (m)	P/R ratio	light	Organic Material*	Invert. Func. Group	Fish
0	intermittent	0.5-1	hetero or autotrophic	with or without	CPOM periphyton	shredders, collectors, scrapers	none
1-3	headwater	0.5-8	heterotrophic	shading	riparian CPOM & derived FPOM	shredders (25-50%); collectors (50-60%); scrapers (< 10%)	eat invert
4-6	mid size river	10-50	autotrophic	open; low sed load	transported FPOM periphyton CPOM	shredders (<5%); collectors (50-75%); scrapers (25-50%)	eat invert. and other fish
7-12	large river	75-500	heterotrophic	heavy sed load	transported FPOM	collectors (75-90%);	eat plankton and inverts

* CPOM: coarse particulate organic material; FPOM: fine particulate organic material

MidCoast Sixth Field Watershed Assessment
Appendix C: GIS Layers

Prepared for the MidCoast Watersheds Council
July 2001

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APPENDIX C: GIS Layers

	web/zip name	shapefile/coverage name	Description	Source	Data directory	Comments
1	aqhab_odfw_final.zip	aqhab_odfw_final.shp	ODFW AHI Reach Data with summary variables added during this assessment	This Assessment	bio	
2	aqhab_sum_final.zip	aqhab_sum_final.shp	6th field summary of AHI surveys, plus potential and functioning salmonid habitat multi-factor analyses	This Assessment	bio	
3	rba9899_sum_final.zip	rba9899_sum_final.shp	6th field summary of average juvenile coho density, 1998-99	This Assessment	bio	
4	rba98_by6th.zip	rba98_by6th.shp	1998 Rapid Bioassessment Survey individual pools data	This Assessment	bio	contact Siuslaw N.F. (Diane Rainsford)
5	rba98_distrib_by6th.zip	rba98_distrib_by6th.shp	1998 Rapid Bioassessment Survey individual pools data, within observed coho distribution	This Assessment	bio	for current files
6	rba99_by6th.zip	rba99_by6th.shp	1999 Rapid Bioassessment Survey individual pools data	This Assessment	bio	

7	rba99_distrib_by6th.zip	rba99_distrib_by6th.shp	1999 Rapid Bioassessment Survey individual pools data, within observed coho distribution	This Assessment	bio
8	salmonid_types.zip	salmonid_types_by_6th.shp	6th field summary of number of salmonid biotypes	This Assessment	bio
9	fp_rest_sites.zip	fp_rest_sites.shp	Potential Floodplain Restoration Sites	This Assessment	edc-gpc-analyses (multi-factor)
10	fzone_smorph.zip	fzone_smorph.shp	Large wood source areas	This Assessment	edc-gpc-analyses (multi-factor)
11	lowlwd_rba.zip	lowlwd_rba_15oct.shp	LWD placement areas	This Assessment	edc-gpc-analyses (multi-factor)
12	SMORPH_er_risk_by_6th.zip	SMORPH_er_risk_by_6th.shp	6th field summary of Landslide/ Erosion Risk	This Assessment	edc-gpc-analyses (multi-factor)
13	303_98_by_6th.zip	s303_98_by6th.shp	303(d) listed streams	This Assessment	envqual
14	303_sum_by_6th.zip	s303_sum_by6th.shp	6th field summary of 303(d) listed stream length	This Assessment	envqual
15	geo62500_m6.zip	geo62500_m6.shp	Lithology (Geology), coded with formation type	This Assessment	geomorph
16	SMORPH.ZIP	SMORPH.shp	SMORPH Output GRID	This Assessment	geomorph
17	Smorph-6thfield.zip	Smorph-6thfield.shp	(? 6th field summary of ??) SMORPH results by 6th Field	This Assessment	geomorph
18	soils_mc6.zip	soils_mc6.shp	NRCS soils, with hydric & erodible mapping units marked	This Assessment	geomorph
19		flood	ODF debris flow/landslide inventory study	MCWC CD-ROM	geomorph
20	1964dam2.zip	1964_dam2.shp	Dams and proposed	This Assessment	infra

			dams		
21	6thfield.zip	a_6th_field.shp	6th field watersheds	This Assessment	hydro
22	der_channel_types.zip	der_channel_types.shp	DEM Derived Stream Channel Types	This Assessment	hydro
23	der_stream_gradient.zip	der_gradient_4.shp	DEM derived Stream Gradient	This Assessment	hydro
24	derived_st_confinement.zip	der_st_confinement.shp	DEM derived Stream Confinement	This Assessment	hydro
25	derived_streams.zip	st1400-c.shp	DEM-Derived Streams	This Assessment	hydro
26	flowrest_sum.zip	flowrest_sum_by6th.shp	6th field summary of predominant summer flow restoration priority ranking	This Assessment	hydro
27	ROSby6th.zip	ROSby6th.shp	6th field summary of total Rain on Snow risk area	This Assessment	hydro
28	springs1.zip	springs1.shp	Springs	This Assessment	hydro
29	1400streamdensity.zip	Stream_Density.shp	6th field summary of stream density	This Assessment	hydro
30	USGSstreams.zip	clip_usgshydro.shp	1:24,000 USGS Streams	This Assessment	hydro
31		mc_rivs	1:100,000 streams	MCWC CD-ROM	hydro
32		mvbdams	Dams	MCWC CD-ROM	hydro
33	100KRoad_Densities.zip	100KRoad_Density.shp	6th field summary of 100K Road densities	This Assessment	infra
34	usgs24K_roads.zip	cl_mcwc_roads.shp	USGS Roads 1:24K	This Assessment	infra
35		minrds6	roads	MCWC CD-ROM	infra
36		nwi_mc	NWI wetland maps (coastal strip only)	MCWC CD-ROM	landcov
37	zoning_m6.zip	zoning_m6.shp	DLCD generalized land use zoning	This Assessment	polit
38		own_osu	Ownership	MCWC CD-ROM	polit
39	CLAMS95		Land Cover	Worldwide Web	n/a

			(Vegetation)			
40	multiple files		10m DEMs (Digital Elevation Model)	Worldwide Web	n/a	
41	multiple files		Digital Ortho Quads	MCWC Office	n/a	
42	multiple files	contact Siuslaw Natl. Forest	Siuslaw National Forest DOQ	Worldwide Web	n/a	
43		contact Siuslaw Natl. Forest	USFS Densified Streams	Siuslaw Natl. Forest	n/a	contact Diane Rainsford, Siuslaw NF
44		contact Siuslaw Natl. Forest	Siuslaw National Forest roads	Worldwide Web	n/a	
45		contact Bureau of Land Mgmt.	Bureau of Land Management Roads	Worldwide Web	n/a	
46			ODFW/OWRD Stream Flow Restoration Priorities (WABs)	Worldwide Web (ODFW)	n/a	

spreadsheets

47	aqi_LD_final.xls	aqi_LD_final.xls	Lincoln District AHI data (tabular data only)	This Assessment	bio
48	REG6habs_final.zip	REG6habs_final.xls	USFS Region 6 Stream Inventory data (tabular data only)	This Assessment	bio

Alsea Basin Insert

Important: This Basin Insert is a part of the MidCoast Sixth Field Watershed Assessment and is intended for use only with the full report. Please contact the MidCoast Watersheds Council at (541) 265-9195 for information on how to obtain the full report.

Table of Contents

1 Introduction

This basin insert is a supplement to the MidCoast Sixth Field Watershed Assessment and is intended for use only with the full report. This insert focuses on basin-specific results for a subset of the analyses conducted in the assessment, but provides little background, setting, methods or interpretation. Therefore, it is important to read the **Main Report** before using this Insert. If this basin insert has been separated from the **Main Report**, contact the MidCoast Watersheds Council (MCWC) at (541) 265-9195 for information on how to obtain the full report.

2 Setting

Setting for the MidCoast Sixth Field Watershed Assessment is described in the **Main Report**, as are summaries that compare the different basins. To provide details useful to local watershed groups, this basin insert contains several maps depicting features at a scale below that of the sixth field watershed.

2.1 Location

General features of the Alsea Basin are shown in **Figure SET-2AL**. Not all stream names are shown; names shown are those contained in the 100K streams layer (**mc_rivs^{M}**). The location of the basin relative to the rest of the study area is shown in the general locator map (**Figure SET-1** in the **Main Report**).

2.2 Sixth field watershed boundaries

Boundaries of sixth field watersheds, and the watershed codes used in this analysis, are shown in **Figure SET-3AL**. The source of these boundaries, and the way we used them, are described in the **Main Report** (**Setting: 6th field watersheds**).

2.3 Zoning

DLCD generalized land use zoning categories are shown in **Figure SET-4AL**. Categories are described in the **Main Report** (**Setting: Land use zoning**).

Most of the basin is zoned for Forestry use, with Agriculture the next most prominent use. Agricultural use is concentrated in the valleys of the mainstem Alsea River (particularly near the town of Alsea); the North Fork Alsea River, Lobster Creek (Lobster Valley), lower Five Rivers, and Buck Creek. The towns of Alsea and Waldport are the only urban areas. Several areas zoned Rural Residential are scattered along the mainstem Alsea River.

2.4 Land ownership

Major land ownership categories, and a breakdown of major private industrial landowners, are shown in **Figure SET-5AL**. The major industrial landowners shown separately are the top five ranked by acreage owned within the entire study area.

The largest landowner in the basin is the U.S. Forest Service, which owns most timberland in the west half of the basin. The other major public owner is BLM, which owns over half of the timberland in the east half of the basin. The remainder of the eastern timberland is owned by Willamette Industries, Starker Forests, and other Private Industrial landowners. Georgia-Pacific owns a substantial portion of the Drift Creek watershed and some areas to the southeast; Boise Cascade ownership is mainly just south of Waldport; Simpson Timber Company owns some areas near Alsea Bay. Private non-industrial owners predominate in the main river valleys.

2.5 Hydric soils

Hydric soils mapped by NRCS and provided in GIS digital soils coverages are shown in **Figure SET-7AL**. Further information on the nature of hydric soils and why they are important to the watershed assessment is found in the **Main Report** (**Setting: Hydric soils** and **Aquatic habitats: Wetlands**).

Hydric soils are located in the Alsea estuary (Brophy 1999) and along river valleys in the watershed. These are areas likely to be suitable for restoration of wetlands, backwater and off-channel aquatic habitats, meandering channels, active floodplains, and similar landscape components.

2.6 Lithology

General lithology is shown in **Figure SET-8AL**, with underlying formations color-coded by major types (sedimentary, igneous, and quaternary). These formations (and the importance of lithology in watershed assessment) are described in the **Main Report** (Setting: Lithology).

Most of the Alsea basin is underlain by sedimentary formations, predominantly the Tyee formation. Portions of the North Fork and South Fork Alsea River are underlain by igneous formations. Quaternary formations (usually alluvium) are found mainly in river valleys.

3 Salmon and salmonid habitat

3.1 Rapid Bioassessment juvenile coho density

The Rapid Bioassessment (RBA) project (begun in 1998) provides data on distribution and abundance of juvenile coho, based on snorkel surveys of pools in the study area (see

Main Report, **Species of concern: Rapid bioassessment**). We analyzed the RBA data to determine average number of coho per square meter for each 6th field watershed, based on snorkeled pools within the observed distribution of coho in each stream in 1998 and 1999 (see methods described in **Main Report**). We weighted the average values by the number of pools snorkeled in each year to normalize results. We also summed the number of pools surveyed in 1998 and 1999 for each 6th field. Sixth fields with less than 10 pools snorkeled during 1998 and 1999 are indicated with a red outline on the map showing coho per square meter (**Figure SOC-8** in the **Main Report**). Caution should be exercised when interpreting results from basins with a limited number of observations.

The Rapid Bioassessment reports describe the year-to-year variability in fish counts and density when the same stream is snorkeled two years in a row (Bio-Surveys 1998, 1999). Understanding this variability is important to interpreting the data.

Average juvenile coho densities by 6th field watershed across the entire study area are discussed in the **Main Report** (**Species of concern: Salmonids: Distribution**); these average densities are shown on **Figure SOC-8**. **Table 3.1** shows the Alsea Basin 6th field watersheds that had the highest average juvenile coho densities in 1998-99 (excluding those watersheds that had less than 10 pools snorkeled). The 6th field watershed names and codes shown are those found in the MCWC 6th field watershed coverage, **6th_field.shp**.

Table 3.1. 6th field watersheds within the Alsea Basin that had highest average juvenile coho densities during 1998-99 Rapid Bioassessment surveys

6th field watershed name	6th field ID code	# of pools surveyed, 1998-99	Average coho/sq m, 1998-99
SLIVER	50218	14	1.1218
HORSE	50301	142	0.9234
LOBSTER	50203	83	0.6918
CAMP	50209	145	0.6527
U. FIVE	50217	101	0.5984
U. LOBSTER	50206	71	0.5918
CRAB	50212	121	0.5726
U. BUCK	50214	50	0.5182
SKUNK	50414	29	0.5024
ALDER2	50105	30	0.4967

Figure SOC-9AL shows the locations of surveyed pools for 1998 and 1999, color-coded by average juvenile coho density in each pool. This map can be used to locate individual stream segments that had juvenile coho "hot spots," for use in action planning below the 6th field watershed level.

Rapid Bioassessment data provide the most comprehensive field-based data available on coho distribution and population in the study area. However, not all streams have been surveyed and, therefore, 6th field watersheds cannot be evaluated on Rapid Bioassessment data alone. The RBA data should be used to focus restoration efforts on those streams which are currently used by coho. The RBA data can also be used to focus further monitoring efforts. For example, where watershed conditions appear to be suitable for juvenile coho production and rearing, but RBA data show that coho are absent, further investigation is recommended to determine possible reasons for their absence such as migration barriers. Repeated RBA surveys on the same stream segments will be very useful for determining year-to-year variability in coho distribution and populations, which will help interpret the results of individual years' data.

3.2 Multi-factor analyses of salmonid habitat

As described in the **Main Report**, we conducted several multi-factor analyses of coho and winter steelhead habitat. Please read the **Main Report** for important details on the methods used for these analyses. The analyses were conducted using combinations of stream channel characteristics (derived from DEMs), AHI data, soils data, and coho juvenile survey data.

As described in the **Main Report**, no GIS data on anadromous migration barriers appropriate for ranking 6th field watersheds were available for this assessment, so we were not able to incorporate effects of barriers into these multi-factor analyses. Therefore, a limitation of this analysis is the fact that some top-ranked watersheds (or portions thereof) may be inaccessible to anadromous fish. In the sections below, we note the 6th field watersheds that ranked high, but are inaccessible to salmonids according to information provided to us by MCWC. However, other 6th field watersheds or portions thereof are no doubt inaccessible, due to either natural and artificial barriers. **We recommend that when MCWC uses the results of these analyses for prioritizing management actions, they should refine the prioritization by adding local knowledge to the discussion.** Such local knowledge should include locations of fish barriers and other factors influencing choice and siting of management actions. MCWC should also seek to acquire new data on such factors to fill data gaps, as described in **Data collection and monitoring recommendations** in the **Main Report**.

3.3 Coho winter habitat

3.3.1 Potential coho winter habitat

The Potential Coho Winter Habitat analysis is an example of a multi-factor analysis that answers a specific question at the stream reach level. This analysis is designed to answer the question, "Where are stream segments with physical characteristics that make them potentially suitable for coho winter habitat?" As requested by MCWC, we included the following components in our analysis of potential coho winter habitat:

1. Gradient (criterion: low-gradient, 0 - 2 degrees = 0 - 3.5% slope)
2. Confinement (criterion: unconfined)
3. Soils (criterion: hydric)

Working with the DEM-derived streams layer (**DEM_Derived.zip**), we used ARCView to query the attributes of stream segments that met the criteria of low gradient and unconfined. We then selected those low-gradient, unconfined segments that flow over hydric soils (**soils_m6.zip**) as shown in the NRCS digital soil survey data.

Table 3.2 shows the ten 6th field watersheds in the Alsea Basin that ranked highest for length of potential coho winter habitat (low-gradient, unconfined streams flowing through hydric soils). Although they ranked high in this analysis, two of the 6th fields in the table are currently inaccessible to anadromous fish: The Upper South Fork Alsea watershed is above Alsea Falls, and passage to the Upper North Fork Alsea is blocked by a dam at the North Fork Hatchery (Wayne Hoffman, personal communication).

Table 3.2. 6th field watersheds in the Alsea Basin with greatest length of potential coho winter habitat

6th field watershed name	Major basin	6th field ID code	Length of potential coho winter habitat (m)
UPPER_SF_ALSEA[1]	Alsea	50119	6,244
GREEN RIVER	Alsea	50216	5,625
UPPER_NF_ALSEA[1]	Alsea	50102	5,357
HONEYGROVE	Alsea	50113	5,071
BUMMER	Alsea	50116	4,975
L. BUCK	Alsea	50208	4,464
M. DRIFT	Alsea	50303	4,432
LINT	Alsea	50409	3,897
CRAB	Alsea	50212	3,889
MIDDLE_LOBSTER	Alsea	50211	3,787

[1] Anadromous migration barriers affect this watershed and may affect other watersheds. See text for details.

The specific stream reaches identified as potential habitat in this analysis are shown in **Figure AQ-18AL**. The figure also shows coho habitat as mapped by ODFW. Due to lack of appropriate GIS data (as described above), it was not possible to incorporate information on natural barriers into this analysis. Therefore, the potential habitat map may show areas that are inaccessible to fish. The ODFW habitat map may be useful in locating such areas; local knowledge should also be used to supplement the mapping.

3.3.2 Functioning coho winter habitat

The Functioning Coho Winter Habitat Analysis is a 6th field ranking described in detail in the **Main Report** (**Aquatic habitats: Functioning coho winter habitat**). This analysis is designed to answer the question, "Which 6th field watersheds have average conditions most suitable for overwintering coho juveniles?" Briefly, we ranked 6th fields using factors that influence coho winter habitat. As requested by MCWC, we included the following factors: percent pools, channel widths per pool, large woody debris frequency, length of side channels, and length of potential habitat (low-gradient, unconfined streams flowing through hydric soils). All of the data except potential habitat were taken from aquatic habitat surveys conducted within the past 10 years.

Sixth field watersheds ranked highest for functioning coho winter habitat *across the entire study area* are described in the **Main Report** and shown in **Figure AQ-21**. In this basin report section, we present the highest-ranked 6th fields *within the basin.* Data that led to the rankings are found in the 6th field aquatic habitats summary shapefile (**aqhab_sum_final.shp**).

The Alsea Basin contains 75 sixth field watersheds. **Table 3.3** shows the 15 sixth field watersheds that were ranked highest in the basin for functioning coho winter habitat. Possible ranks range from 1 (best) to 100 (worst) across the entire study area (all basins). Sixth field watershed names and codes shown are those found in the MCWC 6th field layer (**6th_field.shp**).

Although they ranked high in this analysis, two of the 6th fields in the table are currently inaccessible to anadromous fish: The Upper South Fork Alsea and South Fork Alsea Headwaters watersheds are above Alsea Falls (Wayne Hoffman, personal communication).

Table 3.3. 6th field watersheds ranked highest for functioning coho winter habitat within the Alsea basin.

6th field watershed name	6th field ID code	Rank (scale of 100, 1 is best)
HONEYGROVE	50113	7.52
UPPER_SF_ALSEA[1]	50119	13.03
GREEN RIVER	50216	15.81
SF_ALSEA_HEADWATERS[1]	50120	20.29
PEAK	50111	30.64
MIDDLE_SF_ALSEA	50114	30.91
L. BUCK	50208	32.54
U. FIVE	50217	33.70
CRAB	50212	33.93
SEELY	50112	37.66
U. DRIFT2	50304	38.45
PREACHER	50213	38.77
CANAL	50419	39.24
MILL	50413	39.76
M. DRIFT	50303	39.88

[1] Anadromous migration barriers affect this watershed and may affect other watersheds. See text for details.

In general, for the Alsea basin, 6th field watersheds that ranked high for functioning coho winter habitat achieved that ranking mainly through high percent pools and/or high pool frequency (low channel widths/pool). Large woody debris frequency was also important for Honeygrove, Upper South Fork Alsea, and particularly South Fork Alsea Headwaters, which ranked highest in the study area for LWD frequency with an average of about 37 pieces of LWD per 100m. Length of side channels contributed to the high ranking for Honeygrove, Upper South Fork Alsea, Peak, and Middle South Fork Alsea. Length of potential habitat was a moderately important factor for many of the high-ranked 6th field watersheds, particularly for Green River, Upper South Fork Alsea, Lower Buck, and Honeygrove.

3.4 Coho summer habitat

3.4.1 Potential coho summer habitat

The potential coho summer habitat analysis is an example of a multi-factor analysis that answers a specific question at the stream reach level. This analysis is designed to answer the question, "Where are stream segments with physical characteristics that make them potentially suitable for coho summer habitat?" As requested by MCWC, we included the following components in our analysis of potential coho summer habitat:

1. Gradient (criterion: low-gradient, 0 - 2 degrees = 0 - 3.5% slope)
2. Confinement (criterion: unconfined)

Working with the DEM-derived streams layer (**derived_streams.zip**, shapefile name **st1400-c.shp**), we used ArcView to query the attributes of stream segments to find those that met the criteria of low gradient and unconfined.

Table 3.4 shows the ten 6th field watersheds in the Alsea Basin that ranked highest for length of potential coho summer habitat (low-gradient, unconfined streams). The Upper South Fork watershed ranked high for these types of streams, but is inaccessible to anadromous fish because it lies above Alsea Falls (Wayne Hoffman, personal communication).

The specific stream reaches identified as potential habitat in this analysis are shown in **Figure AQ-19AL**. The figure also shows coho habitat as mapped by ODFW. Due to lack of appropriate GIS data (as described above), it was not possible to incorporate information on natural barriers into this analysis. Therefore, the potential habitat map may show areas that are inaccessible to fish. The ODFW habitat mapping may be useful in locating such areas; local knowledge should also be used to supplement the mapping.

Table 3.4. 6th field watersheds with greatest length of potential coho summer habitat

6th field watershed name	Major basin	6th field code	Length of potential coho summer habitat (m)
BUMMER	Alsea	50116	14,968
BIRCH	Alsea	50420	14,906
RYDER	Alsea	50110	13,864
M. FIVE	Alsea	50210	12,590
MIDDLE_LOBSTER	Alsea	50211	12,537
UPPER_SF_ALSEA[1]	Alsea	50119	11,750
DIGGER	Alsea	50417	9,309
L. FIVE	Alsea	50202	9,195
LYNDON	Alsea	50306	8,893
RISLEY	Alsea	50412	8,425

[1] Anadromous migration barriers affect this watershed and may affect other watersheds. See text for details.

3.4.2 Functioning coho summer habitat

The Functioning Coho Summer Habitat Analysis is a 6th field ranking described in detail in the **Main Report** (**Aquatic habitats: Functioning coho summer habitat**). This analysis is designed to answer the question, "Which 6th field watersheds have average conditions most suitable for coho summer habitat?" Briefly, we ranked 6th fields using a several factors that are important to coho juveniles during the summer. As requested by MCWC, we included the following factors: percent pools, channel widths per pool, large woody debris frequency, percent shading of stream channels, length of riffle habitats with gravel substrate dominant, length of riffle habitats with bedrock substrate dominant (this factor reduced the ranking), length of potential habitat (low-gradient, unconfined streams flowing through hydric soils), and juvenile coho densities from Rapid Bioassessment surveys. Data on pools, LWD, shade, and substrates were taken from aquatic habitat surveys conducted within the past 10 years.

Sixth field watersheds ranked highest for functioning coho summer habitat *across the entire study area* are described in the **Main Report** and shown in **Figure AQ-22**. In this basin report section, we present the highest-ranked 6th fields *within the basin.* Data that led to the rankings are found in the 6th field aquatic habitats summary shapefile (**aqhab_sum_final.shp**).

Table 3.5 shows the 15 sixth field watersheds that were ranked highest (out of the 75 in the basin) for functioning coho summer habitat. Possible ranks range from 1 (best) to 100 (worst) across the entire study area (all basins). Sixth field watershed names and codes shown are those found in the MCWC 6th field layer (**6th_field.shp**).

The Upper South Fork Alsea and South Fork Alsea Headwaters watersheds ranked high in this analysis, but both are inaccessible to anadromous fish because they lie above Alsea Falls (Wayne Hoffman, personal communication).

Table 3.5. 6th field watersheds ranked highest for functioning coho summer habitat within the Alsea basin.

6th field watershed name	6th field ID code	Rank (scale of 100, 1 is best)
GREEN RIVER	50216	21.06
HONEYGROVE	50113	22.57
RYDER[2]	50110	26.73
CRAB	50212	29.19
LYNDON	50306	31.38
U. LOBSTER	50206	31.73
SF_ALSEA_HEADWATERS[1]	50120	34.16
U. FIVE	50217	34.95
ALSEA	50422	35.59
SEELY	50112	36.11
UPPER_SF_ALSEA[1]	50119	37.58
LOBSTER	50203	38.25
CASCADE	50205	38.42
BEAR3	50201	39.22
HORSE	50301	39.79

[1] Anadromous migration barriers affect this watershed and may affect other watersheds. See text for details.

[2] The Ryder Creek 6th field ranked high for functioning coho summer habitat, but had only 720m of stream length surveyed (on Hayden Creek). Results may not be representative of the entire 6th field.

Factors that led to high rankings for coho summer habitat varied from 6th field to 6th field watershed. High percent pools and high pool frequency (low channel widths/pool) were prominent for Green River, Honeygrove, South Fork Alsea Headwaters, Seely, and Bear. The other sixth field watersheds were ranked high due to various other combinations of low channel widths/pool, high LWD frequency, substantial lengths of gravel substrate, low amounts of bedrock substrate, and substantial lengths of potential habitat (low-gradient unconfined streams as determined from DEMs). LWD frequency was an important factor for Honeygrove, S. Fork Alsea Headwaters, Alsea, and Upper South Fork Alsea. Gravel substrate was important for Green River, Crab, Lobster, Cascade, Bear, and Horse 6th field watersheds.

3.5 Winter steelhead Habitat

3.5.1 Potential winter steelhead habitat

The potential winter steelhead habitat analysis is an example of a multi-factor analysis that answers a specific question at the stream reach level. This analysis is designed to answer the question, "Where are stream segments with physical characteristics that make them potentially suitable for winter steelhead habitat?" As requested by MCWC, we included the following components in our analysis of potential winter steelhead habitat:

1. Gradient (criterion: moderate gradient, 1-5 degrees = 1.75 - 8.75% slope)
2. Confinement (criterion: confined)

We used the 1.75 - 8.75% slope gradient because it was the closest we could come to the 2 - 8% slope range requested by MCWC, using the ***DEM-derived stream gradient coverage***. Working with the ***DEM-derived streams layer***, we used ARCView to query the attributes of stream segments to locate those that met the criteria of moderate gradient and confined.

Table 3.6 shows the ten 6th field watersheds in the Alsea Basin that ranked highest for length of potential winter steelhead habitat (moderate-gradient, confined streams).

Although it ranked high in this analysis, the Upper South Fork Alsea watershed is currently inaccessible to anadromous fish since it is above Alsea Falls (Wayne Hoffman, personal communication).

The specific stream reaches identified as potential habitat in this analysis are shown in **Figure AQ-20AL**. The figure also shows winter steelhead habitat as mapped by ODFW. Due to lack of appropriate GIS data (as described above), it was not possible to incorporate information on natural barriers into this analysis. Therefore, the potential habitat map may show areas that are inaccessible to fish. The ODFW habitat mapping may be useful in locating such areas; local knowledge should also be used to supplement the mapping.

Table 3.6 6th field watersheds with greatest length of potential winter steelhead habitat.

6th field watershed name	Major basin	6th field ID code	Length of potential winter steelhead habitat (m)
UPPER_SF_ALSEA[1]	Alsea	50119	8,368
CANAL	Alsea	50419	6,137
BUMMER	Alsea	50116	6,105
PEAK	Alsea	50111	5,906
MIDDLE_LOBSTER	Alsea	50211	5,498
U. DRIFT2	Alsea	50304	5,326
MIDDLE_SF_ALSEA	Alsea	50114	5,316
LOWER_NF_ALSEA	Alsea	50106	5,012
U. FIVE	Alsea	50217	4,701
GREEN RIVER	Alsea	50216	4,378

[1] Anadromous migration barriers affect this watershed and may affect other watersheds. See text for details.

3.5.2 Functioning winter steelhead habitat

The Functioning Winter Steelhead Habitat Analysis is a 6th field ranking described in detail in the **Main Report** (**Aquatic habitats: Functioning winter steelhead habitat**). This analysis is designed to answer the question, "Which 6th field watersheds have average conditions most suitable for winter steelhead?" Briefly, we ranked 6th fields using a several factors that are important to winter steelhead during the summer and winter. As requested by MCWC, we included the following factors: length of riffle habitat; length of riffle habitat with gravel-to-boulder-sized substrate dominant; and length of potential habitat (moderate-gradient, confined streams). Data on riffle length and substrates were taken from aquatic habitat surveys conducted within the past 10 years.

Sixth field watersheds ranked highest for functioning winter steelhead habitat *across the entire study area* are described in the **Main Report** and shown in **Figure AQ-23**. In this basin report section, we present the highest-ranked 6th fields *within the basin.* Data that led to the rankings are found in the 6th field aquatic habitats summary shapefile (**aqhab_sum_final.shp**).

Table 3.7 shows the 15 sixth field watersheds that were ranked highest (out of the 75 in the basin) for functioning winter steelhead habitat. Possible ranks range from 1 (best) to 100 (worst) across the entire study area (all basins). Sixth field watershed names and codes shown are those found in the MCWC 6th field layer (**6th_field.shp**).

Table 3.7. 6th field watersheds ranked highest for functioning winter steelhead habitat within the Alsea basin.

6th field watershed name	6th field ID code	Rank (scale of 100, 1 is best)
CANAL	50419	5.37
PEAK	50111	8.72
GREEN RIVER	50216	13.52
GRASS	50423	18.88
U. FIVE	50217	19.83
U. BUCK	50214	21.00
LOBSTER	50203	23.33
TROUT2	50305	23.99
PREACHER	50213	25.68
CASCADE	50205	26.69
CRAB	50212	27.15
HORSE	50301	27.24
BULL RUN	50401	29.90
SCOTT	50405	34.76
L. BUCK	50208	37.63

In general, sixth field watersheds that ranked high for winter steelhead habitat in the Alsea basin achieved their rankings through substantial lengths of riffle habitat and riffle habitat with gravel-to-boulder-sized substrates dominant.

4 Erosion and shallow landslide risk

Although debris and sediments have been entering the streams of Oregon Coast Range since before the time of European settlement, the frequency, duration and intensity of mass wasting events is of concern. Mass wasting events (such as landslides and debris flows) add both coarse and fine sediments to streams along with organic debris (i.e., LWD). The quality of in-stream conditions, especially salmonid habitat, can be dramatically affected by patterns in material transport to streams (see **Appendix B: Ecosystem Processes**). We performed a series of risk assessments that identify 6th field watersheds that are 'at risk' for three types of mass wasting events: (1) soil erosion risk, (2) shallow landslide risk, and (3) debris flows that could potentially transport LWD from riparian zones to streams.

4.1 Soil erosion risk

Erosion risk was determined for most soil types occurring in the study area (see Soil Erosion Risk). We then used ARCView to measure the area of each 6th field watershed covered by soils determined to have a "severe" risk of erosion. In general, 6th field watersheds in the Alsea River basin were the most prone to soil erosion of all the river basins and ocean tributaries in the study area. The following eighteen 6th field watersheds had more than 75% of their area occupied by the most severe soil erosion risk category: 50103, 50104, 50109, 50117, 50118, 50201, 50204, 50212, 50215, 50216, 50218, 50219, 50305, 50308, 50309, 50311, 50402, and 50422. One way to use this information in planning is to avoid disturbing soils at times when precipitation would wash soils into streams or plan on leaving wide vegetated buffer strips to trap eroding sediments. Another way to use this information is to combine risk of soil erosion with other factors such as risk of shallow landslides (see below), in a multi-factor analysis.

4.2 Shallow landslide risk

Aside from the ODF debris flow hazard maps and a few mapped landslides, there was no information with which to rank 6th field watersheds for shallow landslide risk (see **Main Report**, **Sediment Sources: Landslides**). We relied on work done by team in the State of Washington that compared several models that predicted landslide risk. Discussions with the authors of that report (L. Vaugeois, personal communication, 1999, see **Appendix A: Supplemental Methods**) suggested that the default settings of the SMORPH model should provide a good approximation of landslide risk in the northern section of the Oregon Coast Range, especially at the 6th field watershed level. Indeed, the first step in model calibration is to run the model without calibration and then compare model output with spatially explicit landslide inventories. SMORPH ranks each 10 X 10 m grid cell as having a "low", "medium" or "high" risk of shallow landslides. The model is influenced primarily by slope and topographic concavity, both derived from the DEM grid. Therefore, we used an uncalibrated model to assess landslide risk in the study area. We strongly suggest that the model output be used only in a general sense (i.e., on a 6th field watershed basis) and that model calibration be performed before using SMORPH to assess particular sites.

As with the soil erosion risk analysis, we ranked each 6th field watershed by the proportion of its area occupied by the 'high' risk category. Surprisingly, areas occupied by 'high' risk grid cells did not account for more than 50% of any of the 6th field watersheds. The 6th field watersheds with the highest proportions, 40.3% (50219), (50204) 40.4% and (50218) 41.3%, all occurred in the Alsea River basin. Another fifty-eight 6th field watersheds in the Alsea River basin had more than 25% of their area at "high" risk for shallow landslide.

This information is useful in helping to identify 6th field watersheds that may have large areas prone to shallow landslides. We recommend that detailed landslide information be collected and used to calibrate this model. A calibrated model would be useful in identifying specific locations within the watershed that may be prone to shallow landslide. Land use actions could then be planned so that they avoid these areas whenever possible.

4.3 Combined soil erosion / shallow landslide risk

Finally, we performed a multi-factor analysis by combining information from the erodible soils and shallow landslide risk assessments. We used ARCView to create a shapefile depicting the "high risk" category from the SMORPH model. Due to the size and complexity of this layer, we used ARCView to intersect the SMORPH shapefile with highly erodible soils for each major river basin separately. This resulted in a single shapefile that contained both risk of soil erosion and of shallow landslide. The final step in this analysis was to rank each 6th field by the proportion of its area that met these two criteria.

Table 4.1 shows the 6th field watersheds in the Alsea Basin that had more than 25% of their area in erodible soils prone to shallow landslides.

TABLE 4.1. 6th Field Watersheds in the Alsea Basin with more than 25% of their area having high risk for both soil erosion and shallow landslides

6th field watershed name	6th field ID code	Proportion of 6th field area
ELK1	50204	0.36
EASTER_CR	50109	0.32
SLIVER	50218	0.32
BOULDER2	50310	0.31
COUGAR	50311	0.31
ALSEA	50422	0.31
UPPER_LOBSTER	50219	0.31
BEAR	50402	0.30
TABLE	50309	0.30
EF_LOBSTER	50215	0.30
U. FIVE	50217	0.30

TABLE 4.1. 6th Field Watersheds in the Alsea Basin with more than 25% of their area having high risk for both soil erosion and shallow landslides

6th field watershed name	6th field ID code	Proportion of 6th field area
YEW	50103	0.29
PARKER	50104	0.29
BULL RUN	50401	0.28
GOLD	50308	0.28
UPPER_FALL	50404	0.28
TOBE	50117	0.28
HATCHERY	50410	0.27
CAMP	50209	0.27
GREEN RIVER	50216	0.27
U. DRIFT2	50304	0.26
TROUT2	50305	0.26
LOWER_NF_ALSEA	50106	0.26
WEST SCOTT	50406	0.26
SKUNK	50414	0.26
BEAR3	50201	0.26
LOBSTER	50203	0.26
MILL	50413	0.25
U. LOBSTER	50206	0.25
L. BUCK	50208	0.25
CRAB	50212	0.25
TOBE	50117	0.28
HATCHERY	50410	0.27
CAMP	50209	0.27
GREEN RIVER	50216	0.27
U. DRIFT2	50304	0.26
TROUT2	50305	0.26
LOWER_NF_ALSEA	50106	0.26
WEST SCOTT	50406	0.26
SKUNK	50414	0.26
BEAR3	50201	0.26
LOBSTER	50203	0.26
MILL	50413	0.25
U. LOBSTER	50206	0.25
L. BUCK	50208	0.25
CRAB	50212	0.25

Both the SMORPH model output and the soils maps contain a great deal of detail and may be very important data sets for site specific planning. We have provided these data to MCWC, and we recommend that these data be field checked.

5 Peak flow impact

Water movement is an important factor in structuring ecosystems in the Oregon Coast Range. Water arrives in the watershed as precipitation (rain or snow), then moves across the land surface and into the stream network. Many factors affect the water's capacity to erode and transport soils, sediments and pollutants. For example, vegetation can reduce the impact of rain on soils, or increase water storage capacity by slowing the movement of water as it moves down slope. Vegetation can also affect snow accumulation at higher elevations. In areas of higher elevation, snow can accumulate in treeless areas. The snow can prevent infiltration of rainfall, so that if rain then falls on the snow, water can move quickly across the watershed into the stream network. This can result in high peak stream flows. Just as snow prevents rain from infiltrating soils in the upper watershed, impervious surfaces (roads and parking lots) can quickly route water into stream networks during precipitation events. Thus, both rain-on-snow and roaded areas can affect peak stream flows.

5.1 Rain-on-snow

Rain-on-Snow analysis identifies those areas within the watershed that ***could potentially*** experience increases in peak-flows under certain weather conditions. The Alsea River Basin had the third greatest potential for Rain-on-Snow events from the six MidCoast sub-regions. Eleven of the 75 6th field watersheds in the Alsea River sub-region have potential for Rain-on-Snow events (50103, 50104, 50107, 50303, 50308, 50402, 50414, 50116, 50207, 50211, and 50215) and nine of these 6th field watersheds have areas where the elevation exceeds 3,000 ft. Fortunately, the CLAMS95 data show that only one 6th field watershed (50116) has open areas within high elevation zone, and these areas comprise less than 10% of the watershed area, so the risk of peak flow impact from rain-on-snow events is low (Watershed Professionals Network 1999).

5.2 Roads

The impact of roads on peak flows can be assessed in several ways. Most important is to have a good map representation of where the roads actually are. Our assessment is based on the 100K roads layer because it was the best roads layer that was available for the entire study area. We estimate that the 100K roads layer may under-represent the actual frequency of roads in the watershed by about 38%, so the impact of roads on peak flows may also be underestimated using this dataset.

We used two methods for determining possible peak flow impacts from roads: a method that uses urban/residential road density as a surrogate for total impervious area, and a method that analyzes rural roads as a percent of watershed area (Watershed Professionals Network 1999) (see **Main Report**, **Hydrology: Peak flows: Roads**). We found that the seventy-five 6th field watersheds in the Alsea Basin had relatively low average total impervious area, and the rural road densities were among the lowest of all the sub-regions in this study (ranked No. 5 out of the 6 basins or sub-regions). There were no 6th field watersheds at risk for peak-flow impact from roads.

6 Restoration

6.1 Large Woody Debris placement areas

In this analysis, we used Rapid Bioassessment (RBA) data and aquatic habitat survey data (AQI data) to answer a specific question: What are some suitable locations for in-stream placement of large woody debris? This question is one of MCWC's top priorities for the next phase in watershed assessment and action planning using GIS.

Priority areas for placement of large woody debris (LWD) would be low-gradient, mid-sized streams (coho rearing habitat) which are currently being used by coho, but which currently have low quantities of LWD. It makes sense to look for reaches with high average juvenile coho densities (not just individual pools with high densities).

Using the ODFW habitat benchmarks (Watershed Professionals Network 1999) and ODFW and USFS aquatic habitat inventory data, we first selected stream reaches with undesirably low levels of LWD (less than 10 pieces of LWD per 100m). We then created 100m buffers around each selected stream reach. We then intersected the RBA snorkel survey data (**rba98_distrib_by6th.shp** and **rba99_distrib_by6th.shp**) with the buffer polygons and averaged 1998-99 RBA juvenile coho/sq m for each buffer unit. We then joined the summary layer to the buffer layer to allow symbolization of the buffer layer by coho/sq m. The resulting shapefile is **lowlwd_rba_15oct.shp**.

Figure REC-1AL shows the results for the Alsea Basin. Red stream segments had the highest juvenile coho densities, plus low LWD levels. Blue segments had somewhat lower coho densities (but still above average for the basin), and low LWD levels. The sections of Horse Creek and Flynn Creek (tributaries to Drift Creek) that are shown in red on the map had average RBA coho densities above 1 coho/sq m when surveyed in 1999, and also had low LWD levels from AQI surveys. Portions of Bear Creek and West Creek (tributaries to Canal Creek), and portions of Wilkinson Creek (tributary to Lobster Creek) had average RBA coho densities between 0.6 coho/sq m and 1 coho/sq m in 1998-1999, and also had low LWD levels from AQI data. These segments are shown in blue on the map. AQI data for all of these segments is from 1995 or earlier, so new AQI surveys are needed. Many other stream segments in the basin had high RBA coho densities but lacked AQI data in GIS form, so they could not be analyzed using the techniques in this section. AQI surveys (or placement of existing AQI data into the GIS) are recommended for these streams (see below).

When using the results of this analysis, it is important to remember that both the RBA data and the AQI data available in GIS format cover only limited portions of the stream network. It is likely that RBA and/or AQI data were missing for some areas that would benefit from LWD placement. Since many streams in the study area have low levels of LWD, the RBA data alone could be used to target LWD placement for areas lacking AQI data; or the RBA data could be used to select areas for further AQI data collection to improve data coverage (see **Data Recommendations** in **Main Report**). Collection of additional AQI and RBA data would improve the analysis.

6.2 Potential floodplain restoration sites

This analysis was designed to answer the question, "Where in the watershed are some potential floodplain restoration sites?" Potential floodplain restoration sites would be former floodplains (diked, drained, or otherwise altered) that do not have land uses incompatible with floodplain restoration. To locate potential floodplains, we used the DEM-derived slope GIS layer as described below. To locate areas that do not have incompatible land uses, we used the DLCD generalized zoning layer as described below

In this multi-factor analysis, we used ARCView to perform a series of GIS layer "intersections" (a command available in the Geoprocessing Wizard of ARCView) to combine information from zoning and slope GIS layers onto the derived streams layer (**ST-1400**). This produced a single streams layer containing all of the information from the single factor analyses.

Before summarizing information in this newly created GIS layer, we manually removed stream segments where there was a lot of "flagging" on the derived streams layer (see **Appendix A: Supplemental Methods**).

To address the issue of incompatible land uses, we removed from consideration all stream segments that passed through property zoned as "urban", "rural residential", rural industrial", "rural commercial", and "rural service center" since these are unlikely areas for restoration projects.

To locate potential floodplains, we selected stream segments that flow through 'flat' areas (areas that had less than 5% slope). The 5% slope threshold was determined during the stream confinement analysis (**Main Report**, **Aquatic habitats: Stream confinement from DEMs**). Since it probably would not be practical to attempt to restore floodplains along very short segments of streams, we then selected those stream segments longer than 500m that flowed through these 'flat areas.' (In case the Council wishes to conduct further analyses using these data, we retained the shorter segments in the layer, but simply selected those longer than 500m for summarization and display on the maps.)

Information from this analysis is presented in two forms, as a summary showing the total stream length per 6th field meeting our selection criteria and as a sub-6th field map showing actual locations for stream restoration projects. Please note that stream lengths should be used as a relative measure of the amount of suitable (potential) floodplain restoration sites because stream lengths may be exaggerated, especially in low relief areas (e.g., along the coast) where the stream derivation algorithms had trouble placing the stream channel and stream “flagging” occurred.

Figure REC-2AL shows the stream segments identified as having potential floodplain restoration sites. There were four 6th field watersheds (50116, 50420, 50119, and 50211) in the Alsea River basin that had more than 20 km of stream identified as potential floodplain restoration sites.

7 References

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Ocean Tributaries Basin Insert

Important: This Basin Insert is a part of the MidCoast Sixth Field Watershed Assessment and is intended for use only with the full report. Please contact the MidCoast Watersheds Council at (541) 265-9195 for information on how to obtain the full report.

Table of Contents

1 Introduction

This basin insert is a supplement to the MidCoast Sixth Field Watershed Assessment and is intended for use only with the full report. This insert focuses on basin-specific results for a subset of the analyses conducted in the assessment, but provides little background, setting, methods or interpretation. Therefore, it is important to read the **Main Report** before using this Insert. If this basin insert has been separated from the **Main Report**, contact the MidCoast Watersheds Council (MCWC) at (541) 265-9195 for information on how to obtain the full report.

2 Setting

Setting for the MidCoast Sixth Field Watershed Assessment is described in the **Main Report**, as are summaries that compare the different basins. To provide details useful to local watershed groups, this basin insert contains several maps depicting features at a scale below that of the sixth field watershed.

2.1 Location

General features of the Ocean Tributaries Basin are shown in **Figure SET-2OT**. Not all stream names are shown; names shown are those contained in the 100K streams layer (**mc_rivs^{M}**). The location of the basin relative to the rest of the study area is shown in the general locator map (**Figure SET-1** in the **Main Report**).

2.2 Sixth field watershed boundaries

Boundaries of sixth field watersheds, and the watershed codes used in this analysis, are shown in **Figure SET-3OT**. The source of these boundaries, and the way we used them, are described in the **Main Report** (**Setting: 6th field watersheds**).

2.3 Zoning

DLCD generalized land use zoning categories are shown in **Figure SET-4OT**. Categories are described in the **Main Report** (**Setting: Land use zoning**).

Most of the basin is zoned for Forestry use, except for the coastal strip which is zoned urban (Lincoln City, Newport, Waldport, Yachats) and Rural Residential. Only small areas are zoned for agriculture in these steep coastal watersheds.

2.4 Land ownership

Major land ownership categories, and a breakdown of major private industrial landowners, are shown in **Figure SET-5OT**. The major industrial landowners shown separately are the top 5 ranked by acreage owned within the entire study area.

Most land along the west edge of these coastal watersheds is held by private non-industrial landowners, but much of the eastern portion is in forestry use, with Boise-Cascade and GP major owners in the north portions and USFS in the south.

2.5 Hydric soils

Hydric soils mapped by NRCS and provided in GIS digital soils coverages are shown in **Figure SET-7OT**. Further information on the nature of hydric soils and why they are important to the watershed assessment is found in the **Main Report** (**Setting: Hydric soils** and **Aquatic habitats: Wetlands**).

Concentrations of hydric soils are found behind the foredune along the ocean's edge, on the south side of Devil's Lake, and along stream valleys, particularly Fogarty Creek and Beaver Creek (6th field number 50501). The wetlands behind the foredune are particularly susceptible to development pressure; these wetlands may contain unique plant communities in the deflation plain habitats (Weidemann 1974).

2.6 Lithology

General lithology is shown in **Figure SET-8OT**, with underlying formations color-coded by major types (sedimentary, igneous, and quaternary). These formations (and the importance of lithology in watershed assessment) are described in the **Main Report** (**Setting: Lithology**).

Lithology is noticeably different between the northern Ocean Tributaries watersheds (from Salmon River south to Newport) versus the southern watersheds (Yachats to Cape creek). The northern watersheds are primarily underlain by sedimentary formations, with a strip of quaternary (often unconsolidated, sandy) formations along the coast. The southernmost watersheds are underlain by extensive igneous formations; Cape Perpetua and Heceta Head are the western prominences of these formations.

3 Salmon and salmonid habitat

3.1 Rapid Bioassessment juvenile coho density

The Rapid Bioassessment (RBA) project (begun in 1998) provides data on distribution and abundance of juvenile coho, based on snorkel surveys of pools in the study area (see **Main Report**, **Species of concern: Rapid bioassessment**). We analyzed the RBA data to determine average coho per square meter for each 6th field watershed, based on pools within the observed distribution of coho in each stream in 1998 and 1999 (see methods described in **Main Report**). We weighted the average values by the number of pools snorkeled in each year to normalize results. We also summed the number of pools surveyed in 1998 and 1999 for each 6th field. Sixth fields with less than 10 pools snorkeled during 1998 and 1999 are indicated with a red outline on the map showing coho per square meter (**Figure SOC-8** in the **Main Report**). Caution should be exercised when interpreting results from basins with a limited number of observations.

The Rapid Bioassessment reports describe the year-to-year variability in fish counts and density when the same stream is snorkeled two years in a row (Bio-Surveys 1998, 1999). Understanding this variability is important to interpreting the data.

Average juvenile coho densities by 6th field watershed across the entire study area are discussed in the **Main Report** (**Species of concern: Salmonids: Distribution**); these average densities are shown on **Figure SOC-8**. **Table 3.1** shows the Ocean Tributaries Basins 6th field watersheds that had the highest average juvenile coho densities in 1998-99 (excluding those watersheds that had less than 10 pools snorkeled). The 6th field watershed names and codes shown are those found in the MCWC 6th field watershed coverage, **6th_field.shp**.

Table 3.1. 6th field watersheds within the Ocean Tributaries Basins that had highest average juvenile coho densities during 1998-99 Rapid Bioassessment surveys

6th field watershed name	**6th field ID code**	**# of pools surveyed, 1998-99**	**Average coho/sq m, 1998-99**
NORTH BEAVER2	50502	110	1.0536
ROCK1	41012	55	0.8435
BEAVER	50501	26	0.2381
ELKHORN	50503	23	0.2148
BLODGETT	50507	52	0.1623

Figure SOC-9OT shows the locations of surveyed pools for 1998 and 1999, color-coded by average juvenile coho density in each pool. This map can be used to locate individual stream segments that had juvenile coho "hot spots," for use in action planning below the 6th field watershed level.

Rapid Bioassessment data provide the most comprehensive field-based data available on coho distribution and population in the study area. However, not all streams have been surveyed and, therefore, 6th field watersheds cannot be evaluated on Rapid Bioassessment data alone. The RBA data should be used to focus restoration efforts on those streams which are currently used by coho. The RBA data can also be used to focus further monitoring efforts. For example, where watershed conditions appear to be suitable for juvenile coho production and rearing, but RBA data show that coho are absent, further investigation is recommended to determine possible reasons for their absence such as migration barriers. Repeated RBA surveys on the same stream segments will be very useful for determining year-to-year variability in coho distribution and populations, which will help interpret the results of individual years' data.

3.2 Multi-factor analyses of salmonid habitat

As described in the **Main Report**, we conducted several multi-factor analyses of coho and winter steelhead habitat. Please read the **Main Report** for important details on the methods used for these analyses. The analyses were conducted using combinations of stream channel characteristics (derived from DEMs), AHI data, soils data, and coho juvenile survey data.

As described in the **Main Report**, no GIS data on anadromous migration barriers appropriate for ranking 6th field watersheds were available for this assessment, so we were not able to incorporate effects of barriers into these multi-factor analyses. Therefore, a limitation of this analysis is the fact that some top-ranked watersheds (or portions thereof) may be inaccessible to anadromous fish. In the sections below, we note the 6th field watersheds that ranked high, but are inaccessible to salmonids according to information provided to us by MCWC. However, other 6th field watersheds or portions thereof are no doubt inaccessible, due to either natural and artificial barriers. **We recommend that when MCWC uses the results of these analyses for prioritizing management actions, they should refine the prioritization by adding local knowledge to the discussion.** Such local knowledge should include locations of fish barriers and other factors influencing choice and siting of management actions. MCWC should also seek to acquire new data on such factors to fill data gaps, as described in **Data collection and monitoring recommendations** in the **Main Report**.

3.3 Coho winter habitat

3.3.1 Potential coho winter habitat

The Potential Coho Winter Habitat analysis is an example of a multi-factor analysis that answers a specific question at the stream reach level. This analysis is designed to answer the question, "Where are stream segments with physical characteristics that make them potentially suitable for coho winter habitat?" As requested by MCWC, we included the following components in our analysis of potential coho winter habitat:

1. Gradient (criterion: low-gradient, 0 - 2 degrees = 0 - 3.5% slope)
2. Confinement (criterion: unconfined)
3. Soils (criterion: hydric)

Working with the DEM-derived streams layer (**derived_streams.zip**, shapefile name **st1400-c.shp**), we used ARCView to query the attributes of stream segments that met the criteria of low gradient and unconfined. We then selected those low-gradient, unconfined segments that flow over hydric soils as shown in the NRCS digital soil survey data.

Table 3.2 shows the ten 6th field watersheds in the Ocean Tributaries Basin that ranked highest for length of potential coho winter habitat. The specific stream reaches identified as potential habitat in this analysis are shown in **Figure AQ-18OT**. The figure also shows coho habitat as mapped by ODFW. Due to lack of appropriate GIS data (as described above), it was not possible to incorporate information on natural barriers into this analysis. Therefore, the potential habitat map may show areas that are inaccessible to fish. The ODFW habitat map may be useful in locating such areas; local knowledge should also be used to supplement the mapping.

Table 3.2. 6th field watersheds in the Ocean Tributaries Basins with greatest length of potential coho winter habitat

6th field watershed name	Major basin	6th field ID code	Length of potential coho winter habitat (m)
BEAVER	Ocean Tribs	50501	10953
FOGARTY	Ocean Tribs	41001	7067
THIEL	Ocean Tribs	50515	4937
LINCOLN CITY/DEVIL'S LAKE	Ocean Tribs	41011	4668
BLODGETT	Ocean Tribs	50507	4008
SEAL ROCK	Ocean Tribs	50504	2202
BIG	Ocean Tribs	50709	1625
SPENCER	Ocean Tribs	41007	1601
CAPE	Ocean Tribs	50711	1553
TENMILE	Ocean Tribs	50705	1512

3.3.2 Functioning coho winter habitat

The Functioning Coho Winter Habitat Analysis is a 6th field ranking described in detail in the **Main Report** (**Aquatic habitats: Functioning coho winter habitat**). This analysis is designed to answer the question, "Which 6th field watersheds have conditions most suitable for overwintering coho juveniles?" Briefly, we ranked 6th fields using factors that influence coho winter habitat. As requested by MCWC, we included the following factors: percent pools, channel widths per pool, large woody debris frequency, length of side channels, and length of potential habitat (low-gradient, unconfined streams flowing through hydric soils). All of the data except potential habitat were taken from aquatic habitat surveys conducted within the past 10 years.

Sixth field watersheds ranked highest for functioning coho winter habitat *across the entire study area* are described in the **Main Report** and shown in **Figure AQ-21**. In this basin report section, we present the highest-ranked 6th fields *within the basin.* Data that led to the rankings are found in the 6th field aquatic habitats summary shapefile (**aqhab_sum_final.shp**).

The Ocean Tributaries basins contain 35 sixth field watersheds. **Table 3.3** shows the 5 sixth field watersheds that were ranked highest in the basin for functioning coho winter habitat. Possible ranks range from 1 (best) to 100 (worst) across the entire study area (all basins). Sixth field watershed names and codes shown are those found in the MCWC 6th field layer (**6th_field.shp**).

Although it ranks high in this analysis, Rocky Creek is currently blocked to all anadromous passage by a fill and perched culvert under Highway 101, at the creek's mouth.

Table 3.3. 6th field watersheds ranked highest for functioning coho winter habitat within the Ocean Tributaries basins.

6th field watershed name	6th field ID code	Rank (scale of 100, 1 is best)
SPENCER	41007	24.47
BEAVER	50501	30.31
ROCKY[1]	41005	32.14
CAPE	50711	32.71
ROCK1	41012	32.96

[1] A perched culvert and fill at Highway 101 currently block anadromous fish passage to Rocky Creek

For the Ocean Tributaries basins, sixth field watersheds ranked high for coho winter habitat usually achieved that ranking mainly through high LWD frequency and length of side channels. Percent pools were high for the Spencer Creek 6th field watershed, and large quantities of potential habitat contributed strongly to the high ranking for the Beaver Creek 6th field watershed, which contains an unusual concentration of wetlands. The Beaver Creek 6th field had a total of 10.9 km of low-gradient unconfined streams flowing through hydric soils.

3.4 Coho summer habitat

3.4.1 Potential coho summer habitat

The potential coho summer habitat analysis is an example of a multi-factor analysis that answers a specific question at the stream reach level. This analysis is designed to answer the question, "Where are stream segments with physical characteristics that make them potentially suitable for coho summer habitat?" As requested by MCWC, we included the following components in our analysis of potential coho summer habitat:

1. Gradient (criterion: low-gradient, 0 - 2 degrees = 0 - 3.5% slope)
2. Confinement (criterion: unconfined)

Working with the DEM-derived streams layer (**derived_streams.zip**, shapefile name **st1400-c.shp**), we used ArcView to query the attributes of stream segments to find those that met the criteria of low gradient and unconfined.

Table 3.4 shows the ten 6th field watersheds in the Ocean Tributaries Basin that ranked highest for length of potential coho summer habitat.

The specific stream reaches identified as potential habitat in this analysis are shown in **Figure AQ-19OT**. The figure also shows coho habitat as mapped by ODFW. Due to lack of appropriate GIS data (as described above), it was not possible to incorporate information on natural barriers into this analysis. Therefore, the potential habitat map may show areas that are inaccessible to fish. The ODFW habitat mapping may be useful in locating such areas; local knowledge should also be used to supplement the mapping.

Table 3.4. 6th field watersheds with greatest length of potential coho summer habitat.

6th field watershed name	Major basin	6th field ID code	Length of potential coho summer habitat (m)
BEAVER	Ocean Tribs	50501	36150
LINCOLN CITY/DEVIL'S LAKE	Ocean Tribs	41011	27408
THIEL	Ocean Tribs	50515	12312
FOGARTY	Ocean Tribs	41001	11599
SEAL ROCK	Ocean Tribs	50504	10968
BLODGETT	Ocean Tribs	50507	7063
MOLOCH	Ocean Tribs	41008	6771
LITTLE	Ocean Tribs	50506	5551
SPENCER	Ocean Tribs	41007	5154
NORTH BEAVER2	Ocean Tribs	50502	5059

3.4.2 Functioning coho summer habitat

The Functioning Coho Summer Habitat Analysis is a 6th field ranking described in detail in the **Main Report** (**Aquatic habitats: Functioning coho summer habitat**). This analysis is designed to answer the question, "Which 6th field watersheds have average conditions most suitable for coho summer habitat?" Briefly, we ranked 6th fields using a several factors that are important to coho juveniles during the summer. As requested by MCWC, we included the following factors: percent pools, channel widths per pool, large woody debris frequency, percent shading of stream channels, length of riffle habitats with gravel substrate dominant, length of riffle habitats with bedrock substrate dominant (this factor reduced the ranking), length of potential habitat (low-gradient, unconfined streams flowing through hydric soils), and juvenile coho densities from Rapid Bioassessment surveys. Data on pools, LWD, shade, and substrates were taken from aquatic habitat surveys conducted within the past 10 years.

Sixth field watersheds ranked highest for functioning coho summer habitat *across the entire study area* are described in the **Main Report** and shown in **Figure AQ-22**. In this basin report section, we present the highest-ranked 6th fields *within the basin.* Data that led to the rankings are found in the 6th field aquatic habitats summary shapefile (**aqhab_sum_final.shp**).

Table 3.5 shows the five 6th field watersheds that were ranked highest (out of the 35 in the basin) for functioning coho summer habitat. Possible ranks range from 1 (best) to 100 (worst) across the entire study area (all basins). Sixth field watershed names and codes shown are those found in the MCWC 6th field layer (**6th_field.shp**).

Table 3.5. 6th field watersheds ranked highest for functioning coho summer habitat within the Ocean Tributaries basins.

6th field watershed name	6th field ID code	Rank (scale of 100, 1 is best)
MOLOCH	41008	25.79
SPENCER	41007	27.54
ROCKY[1]	41005	29.90
ROCK1	41012	37.42
NORTH BEAVER2	50502	37.45

[1] A perched culvert and fill at Highway 101 currently block anadromous fish passage to Rocky Creek.

For the Ocean Tributaries basins, sixth field watersheds ranked high for coho summer habitat usually achieved that ranking mainly through high LWD frequency and low amounts of bedrock substrate. Pool area and frequency were also important for Moloch, Berry, and Rocky Creek 6th field watersheds.

3.5 Winter steelhead habitat

3.5.1 Potential winter steelhead habitat

The potential winter steelhead habitat analysis is an example of a multi-factor analysis that answers a specific question at the stream reach level. This analysis is designed to answer the question, "Where are stream segments with physical characteristics that make them potentially suitable for winter steelhead habitat?" As requested by MCWC, we included the following components in our analysis of potential winter steelhead habitat:

1. Gradient (criterion: moderate gradient, 1-5 degrees = 1.75 - 8.75% slope)
2. Confinement (criterion: confined)

We used the 1.75 - 8.75% slope gradient because it was the closest we could come to the 2 - 8% slope range requested by MCWC, using the ***DEM-derived stream gradient coverage***. Working with the ***DEM-derived streams layer***, we used ARCView to query the attributes of stream segments to locate those that met the criteria of moderate gradient and confined.

Table 3.6 shows the ten 6th field watersheds in the Ocean Tributaries Basin that ranked highest for length of potential winter steelhead habitat (moderate-gradient, confined streams).

The specific stream reaches identified as potential habitat in this analysis are shown in **Figure AQ-20OT**. The figure also shows winter steelhead habitat as mapped by ODFW. Due to lack of appropriate GIS data (as described above), it was not possible to incorporate information on natural barriers into this analysis. Therefore, the potential habitat map may show areas that are inaccessible to fish. The ODFW habitat mapping may be useful in locating such areas; local knowledge should also be used to supplement the mapping.

Table 3.6. 6th field watersheds with greatest length of potential winter steelhead habitat.

6th field watershed name	Major basin	6th field ID code	Length of potential winter steelhead habitat (m)
MOLOCH	Ocean Tribs	41008	6617
NORTH BEAVER2	Ocean Tribs	50502	6127
BEAVER	Ocean Tribs	50501	6069
CAPE	Ocean Tribs	50711	5605
U. TENMILE	Ocean Tribs	50704	5070
BLODGETT	Ocean Tribs	50507	4857
U. BIG	Ocean Tribs	50708	4308
THIEL	Ocean Tribs	50515	4009
SPENCER	Ocean Tribs	41007	3862
TENMILE	Ocean Tribs	50705	3860

3.5.2 Functioning winter steelhead habitat

The Functioning Winter Steelhead Habitat Analysis is a 6th field ranking described in detail in the **Main Report** (**Aquatic habitats: Functioning winter steelhead habitat**). This analysis is designed to answer the question, "Which 6th field watersheds have average conditions most suitable for winter steelhead?" Briefly, we ranked 6th fields using a several factors that are important to winter steelhead during the summer and winter. As requested by MCWC, we included the following factors: length of riffle habitat; length of riffle habitat with gravel-to-boulder-sized substrate dominant; and length of potential habitat (moderate-gradient, confined streams). Data on riffle length and substrates were taken from aquatic habitat surveys conducted within the past 10 years.

Sixth field watersheds ranked highest for functioning winter steelhead habitat *across the entire study area* are described in the **Main Report** and shown in **Figure AQ-23**. In this basin report section, we present the highest-ranked 6th fields *within the basin.* Data that led to the rankings are found in the 6th field aquatic habitats summary shapefile (**aqhab_sum_final.shp**).

Table 3.7 shows the 5 sixth field watersheds that were ranked highest (out of the 35 in the basin) for functioning winter steelhead habitat. Possible ranks range from 1 (best) to 100 (worst) across the entire study area (all basins). Sixth field watershed names and codes shown are those found in the MCWC 6th field layer (**6th_field.shp**).

Table 3.7. 6th field watersheds ranked highest for functioning winter steelhead habitat within the Ocean Tributaries basins.

6th field watershed name	6th field ID code	Rank (scale of 100, 1 is best)
BLODGETT	50507	6.58
CAPE	50711	6.75
ROCK1	41012	26.73
NORTH BEAVER2	50502	30.13
BOB	50703	32.73

The Cape Creek watershed had the 2nd-highest ranking in the entire study area for length of riffle habitat with gravel-to-boulder-sized substrate dominant (13.8 km). In general, all three factors (riffles, gravel-to-boulder substrate, and potential habitat) were important in creating the high rankings for the sixth fields listed above. Exceptions are: the North Beaver 6th field watershed did not have particularly high rankings for riffle length or gravel-to-boulder-sized substrate, so length of potential habitat (moderate-gradient, confined streams) was important for this watershed. By contrast, length of potential habitat was not important for the Rock Creek and Bob Creek sixth field watersheds; these watersheds had relatively high rankings for riffle length and gravel-to-boulder-sized substrate.

4 Erosion and shallow landslide risk

Although debris and sediments have been entering the streams of Oregon Coast Range since before the time of European settlement, the frequency, duration and intensity of mass wasting events is of concern (see **Appendix B: Ecosystem Processes**). Mass wasting adds both coarse and fine sediments to streams along with organic debris (i.e., LWD). The quality of in-stream conditions, especially salmonid habitat, can be dramatically affected by patterns in material transport to streams (see **Appendix B: Ecosystem Processes**). We performed a series of risk assessments that identify 6th field watersheds that are 'at risk' for three types of mass wasting events: (1) soil erosion risk, (2) shallow landslide risk, and (3) debris flows that could potentially transport LWD from riparian zones to streams.

4.1 Soil erosion risk

Erosion risk was determined for most soil types occurring in the study area (see Soil Erosion Risk). We then used ARCView to sum the area of each 6th field watershed covered by soils determined to have a "severe" risk of erosion. The following eight of the Ocean Tributary 6th field watersheds had more than 75% of their area occupied by the most severe risk category of soils: 50701, 50702, 50703, 50704, 50705, 50706, 50707, and 50711. One way to use this information in planning is to avoid disturbing soils at times when precipitation would wash soils into streams or plan on leaving wide vegetated buffer strips to trap eroding sediments. Another way to use this information is to combine risk of soil erosion with other factors such as risk of shallow landslides (see below), in a multi-factor analysis.

4.2 Shallow landslide risk

Aside from the ODF debris flow hazard maps and a few mapped landslides, there was not much information with which to rank 6th field watersheds for shallow landslide risk (see **Main Report**, **Sediment Sources: Landslides**). We relied on work done by team in the State of Washington that compared several models that predicted landslide risk. Discussions with the authors of that report (Vaugeois, personal communication, 1999, see **Appendix A: Supplemental Methods**) suggested that the default settings of the SMORPH model should provide a good approximation of landslide risk in the northern section of the Oregon Coast Range, especially at the 6th field watershed level. Indeed, the first step in model calibration is to run the model without calibration and then compare model output with spatially explicit landslide inventories. SMORPH ranks each 10 X 10 m grid cell as having a “low”, “medium” or “high” risk of shallow landslides. The model is influenced primarily by slope and topographic concavity, both derived from the DEM grid. Therefore, we used an uncalibrated model to assess landslide risk in the study area. We strongly suggest that the model output be used only in a general sense (i.e., on a 6th field watershed basis) and that model calibration be performed before using SMORPH to assess particular sites.

As with the soil erosion risk analysis, we ranked each 6th field watershed by the proportion of its area occupied by the ‘high’ risk category. Surprisingly, areas occupied by ‘high’ risk grid cells did not account for more than 50% of any of the 6th field watersheds. In the Ocean Tributaries basins sixteen 6th field watersheds had more than 25% of their area identified by SMORPH as being “high” risk for a shallow landslide. The top three 6th field watersheds in terms of proportion of their area at “high” risk were 50707 (37.8%), 50703 (37.5%), and 50705 (37.4%).

This information is useful in helping to identify 6th field watersheds that may have large areas prone to shallow landslides. We recommend that detailed landslide information be collected and used to calibrate this model. A calibrated model would be useful in identifying specific locations within the watershed that may be prone to shallow landslide. Land use actions could then be planned so that they avoid these areas whenever possible.

4.3 Combined soil erosion/shallow landslide risk

Finally, we performed a multi-factor analysis by combining information from the erodible soils and shallow landslide risk assessments. We used ARCView to create a shapefile depicting the “high risk” category from the SMORPH model. Due to the size and complexity of this layer, we used ARCView to intersect the SMORPH shapefile with highly erodible soils for each major river basin separately. This resulted in a single shapefile that contained both risk of soil erosion and of shallow landslide. The final step in this analysis was to rank each 6th field by the proportion of its area that met these two criteria.

Table 4.1 shows watersheds in the basin that have high risk of both soil erosion and shallow landslides.

TABLE 4.1. 6th Field Watersheds in the Ocean Tributaries Basin with more than 25% of their area having high risk for both soil erosion and shallow landslides.

6th field watershed name	6th field ID code	Proportion of 6th field area
BOB	50703	0.33
CUMMINS	50702	0.32
TENMILE	50705	0.32
ROCK2	50707	0.32
BIG	50709	0.30
PERPETUA	50701	0.29
SQUAW	50706	0.28
CAPE	50711	0.26

Both the SMORPH model output and the soils maps contain a great deal of detail and may be very important data sets for site specific planning. We have provided these data to MCWC, and we recommend that these data be field checked.

5 Peak flow impact

Water movement is an important factor in structuring ecosystems in the Oregon Coast Range. Water arrives in the watershed as precipitation (rain or snow), and then moves across the land surface and into the stream network. Many factors affect the water's capacity to erode and transport soils, sediments and pollutants. For example, vegetation can reduce the impact of rain on soils or increase water storage capacity by slowing the movement of water as it moves down slope. Vegetation can also affect snow accumulation at higher elevations. In areas of higher elevation snow can accumulate in treeless areas. The snow can prevent infiltration of rainfall, so that if rain then falls on the snow, water can move quickly across the watershed into the stream network. This can result in high peak stream flows. Just as snow prevents rain from infiltrating soils in the upper watershed, impervious surfaces (roads and parking lots) can quickly route water into stream networks during precipitation events. Thus, both rain-on-snow and roaded areas can affect peak stream flows.

5.1 Rain-on-snow

Rain-on-Snow analysis identifies those areas within the watershed that ***could potentially*** experience increases in peak-flows under certain weather conditions. The Ocean

Tributary Basins have no potential for Rain-on-Snow events because of their relatively low elevations.

5.2 Roads

The impact of roads on peak flows can be assessed in several ways. Most important is to have a good map representation of where the roads actually are. Our assessment is based on the 100K roads layer because it was the best available for the study area. We estimate that the 100K roads layer may under-represent the actual frequency of roads in the watershed by about 38%, so the impact of roads on peak flows may also be underestimated using this dataset. As described in the **Main Report** (**Water Resources: Hydrology: Peak flow: Roads**), we used two methods for determining possible peak flow impacts from roads: a method that uses urban/residential road density as a surrogate for total impervious area, and a method that analyzes rural roads as a percent of watershed area (Watershed Professionals Network 1999).

We found that for the thirty-five 6th field watersheds in the Ocean Tributaries basins, the overall average potential for peak-flow impact to stream from roads was the greatest calculated in this study (the basin ranked No. 1 out of the 6 basins). Seven 6th field watersheds were at risk for potential peak-flow impacts from roads (41001, 41004, 41006, 41010, 41011, 50408, and 50505) using the Total Impervious Surface benchmarks, and three were at risk (41010, 50408, and 50505) using the Rural Road density benchmarks.

6 Restoration

6.1 Large Woody Debris placement areas

In this analysis, we used Rapid Bioassessment (RBA) data and aquatic habitat survey data (AQI data) to answer a specific question: What are some suitable locations for in-stream placement of large woody debris? This question is one of MCWC's top priorities for the next phase in watershed assessment and action planning using GIS.

Priority areas for placement of large woody debris (LWD) would be low-gradient, mid-sized streams (coho rearing habitat) which are currently being used by coho, but which currently have low quantities of LWD. It makes sense to look for reaches with high average juvenile coho densities (not just individual pools with high densities).

Using the ODFW habitat benchmarks (Watershed Professionals Network 1999) and ODFW and USFS aquatic habitat inventory data, we first selected stream reaches with undesirably low levels of LWD (less than 10 pieces of LWD per 100m). We then created 100m buffers around each selected stream reach. We then intersected the **RBA snorkel survey data** with the buffer polygons and averaged 1998-99 RBA juvenile coho/sq m for each buffer unit. We then joined the summary layer to the buffer layer to allow symbolization of the buffer layer by coho/sq m. The resulting shapefile is **lowlwd_rba_15oct.shp**.

Figure REC-1OT shows the results for the Ocean Tributaries basin. Red stream segments had the highest juvenile coho densities, plus low LWD levels. Blue segments had somewhat lower coho densities (but still above average for the basin), and low LWD levels. The only area in the Ocean Tributaries basin that had both high juvenile coho densities from RBA data, and low LWD from AQI data, was a portion of Rock Creek (tributary to Devil's lake). Average juvenile coho density for this reach was 1.7 coho/sq m when surveyed in 1999. Many other areas in the basin had low LWD, but lacked RBA data; a few areas had high juvenile coho densities, but lacked AQI data in GIS form (such as North Fork Beaver Creek and its tributary, Peterson Creek). Such areas could not be analyzed using the techniques of this section. AQI surveys (or placement of existing AQI data into the GIS) are recommended for these streams (see below).

When using the results of this analysis, it is important to remember that both the RBA data and the AQI data available in GIS format cover only limited portions of the stream network. It is likely that RBA and/or AQI data were missing for some areas that would benefit from LWD placement. Since many streams in the study area have low levels of LWD, the RBA data alone could be used to target LWD placement for areas lacking AQI data; or the RBA data could be used to select areas for further AQI data collection to improve data coverage (see **Data Recommendations** in **Main Report**). Collection of additional AQI and RBA data would improve the analysis.

6.2 Potential floodplain restoration sites

This analysis was designed to answer the question, "Where in the watershed are some potential floodplain restoration sites?" Potential floodplain restoration sites would be former floodplains (diked, drained, or otherwise altered) that do not have land uses incompatible with floodplain restoration. To locate potential floodplains, we used the DEM-derived slope GIS layer as described below. To locate areas that do not have incompatible land uses, we used the DLCD generalized zoning layer as described below.

In this multi-factor analysis, we used ARCView to perform a series of GIS layer "intersections" (a command available in the Geoprocessing Wizard of ARCView) to combine information from zoning and slope GIS layers onto the derived streams layer (**ST-1400**). This produced a single streams layer containing all of the information from the single factor analyses.

Before summarizing information in this newly created GIS layer, we manually removed stream segments where there was a lot of "flagging" on the derived streams layer (see **Appendix A: Supplemental Methods**).

To address the issue of incompatible land uses, we removed from consideration all stream segments that passed through property zoned as "urban", "rural residential", rural industrial", "rural commercial", and "rural service center" since these are unlikely areas for restoration projects.

To locate potential floodplains, we selected stream segments that flow through 'flat' areas (areas that had less than 5% slope). The 5% slope threshold was determined during the stream confinement analysis (**Main Report**, **Aquatic habitats: Stream confinement from DEMs**). Since it probably would not be practical to attempt to restore floodplains along very short segments of streams, we then selected those stream segments longer than 500m that flowed through these 'flat areas.' (In case the Council wishes to conduct further analyses using these data, we retained the shorter segments in the layer, but simply selected those longer than 500m for summarization and display on the maps.)

Information from this analysis is presented in two forms, as a summary showing the total stream length per 6th field meeting our selection criteria and as a sub-6th field map showing actual locations for stream restoration projects. Please note that stream lengths should be used as a relative measure of the amount of suitable (potential) floodplain restoration sites because stream lengths may be exaggerated, especially in low relief areas (e.g., along the coast) where the stream derivation algorithms had trouble placing the stream channel and stream “flagging” occurred.

Figure REC-2OT shows the stream segments identified as having potential floodplain restoration sites. There were two 6th field watersheds (50501 and 50714) in the Ocean Tributaries watersheds that had more than 20 km of stream identified as potential floodplain restoration sites. This includes one 6th field (50501) that had more than 47 km of streams matching our criteria.

7 References

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Salmon River Basin Insert

Important: This Basin Insert is a part of the MidCoast Sixth Field Watershed Assessment and is intended for use only with the full report. Please contact the MidCoast Watersheds Council at (541) 265-9195 for information on how to obtain the full report.

Table of Contents

1 Introduction

This basin insert is a supplement to the MidCoast Sixth Field Watershed Assessment and is intended for use only with the full report. This insert focuses on basin-specific results for a subset of the analyses conducted in the assessment, but provides little background, setting, methods or interpretation. Therefore, it is important to read the **Main Report** before using this Insert. If this basin insert has been separated from the **Main Report**, contact the MidCoast Watersheds Council (MCWC) at (541) 265-9195 for information on how to obtain the full report.

2 Setting

Setting for the MidCoast Sixth Field Watershed Assessment is described in the **Main Report**, as are summaries that compare the different basins. To provide details useful to local watershed groups, this basin insert contains several maps depicting features at a scale below that of the sixth field watershed.

2.1 Location

General features of the Salmon Basin are shown in **Figure SET-2SA**. Not all stream names are shown; names shown are those contained in the 100K streams layer (**mc_rivs**$^{\mathbf{M}}$). The location of the basin relative to the rest of the study area is shown in the general locator map (**Figure SET-1** in the **Main Report**).

2.2 Sixth field watershed boundaries

Boundaries of sixth field watersheds, and the watershed codes used in this analysis, are shown in **Figure SET-3SA**. The source of these boundaries, and the way we used them, are described in the **Main Report** (**Setting: 6th field watersheds**).

2.3 Zoning

DLCD generalized land use zoning categories are shown in **Figure SET-4SA**. Categories are described in the **Main Report** (**Setting: Land use zoning**).

The vast majority of the watershed is zoned for Forestry use. The estuary areas are zoned Estuary and Agriculture. Rural Residential zoning areas are found along the mainstem Salmon River, Bear Creek and Slickrock Creek. The Otis to Rose Lodge area is zoned Rural Service Center. The H.B. Van Duzer State Wayside is the major area zoned for Park use in the basin.

2.4 Land ownership

Major land ownership categories, and a breakdown of major private industrial landowners, are shown in **Figure SET-5SA**. The major industrial landowners shown separately are the top 5 ranked by acreage owned within the entire study area.

Timber land in the basin is owned by the USFS in the west half, with the east half mostly owned by private timber companies (Simpson, Stimson, Miami, Boise) and BLM. Private non-industrial in the lower Salmon River valley; the State of Oregon owns the VanDuzer corridor along Highway 18.

2.5 Hydric soils

Hydric soils mapped by NRCS and provided in GIS digital soils coverages are shown in **Figure SET-7SA**. Further information on the nature of hydric soils and why they are important to the watershed assessment is found in the **Main Report** (**Setting: Hydric soils** and **Aquatic habitats: Wetlands**).

The main area of hydric soils in the basin is in the Salmon River Estuary. This area is the site of many research projects and restoration activities (see **Main Report** for details). Some hydric soils are also found along the mainstem Salmon River upstream of Otis.

2.6 Lithology

General lithology is shown in **Figure SET-8SA**, with underlying formations color-coded by major types (sedimentary, igneous, and quaternary). These formations (and the importance of lithology in watershed assessment) are described in the **Main Report** (**Setting: Lithology**).

Underlying formations in the basin are about half igneous and half sedimentary. Igneous areas predominate in the center of the watershed (Panther Creek, Widow Creek, lower Treat River, lower Slick Rock Creek, lower Trout Creek, Bear Creek) and in the eastern portion (headwaters of Little Salmon River, Boulder Creek and Deer Creek)

3 Salmon and salmonid habitat

3.1 Rapid Bioassessment juvenile coho density

The Rapid Bioassessment (RBA) project (begun in 1998) provides data on distribution and abundance of juvenile coho, based on snorkel surveys of pools in the study area (see **Main Report**, **Species of concern: Rapid bioassessment**). We analyzed the RBA data to determine average coho per square meter for each 6th field watershed, based on pools within the observed distribution of coho in each stream in 1998 and 1999 (see methods described in **Main Report**). We weighted the average values by the number of pools snorkeled in each year to normalize results. We also summed the number of pools surveyed in 1998 and 1999 for each 6th field. Sixth fields with less than 10 pools snorkeled during 1998 and 1999 are indicated with a red outline on the map showing coho per square meter (**Figure SOC-8** in the **Main Report**). Caution should be exercised when interpreting results from basins with a limited number of observations.

The Rapid Bioassessment reports describe the year-to-year variability in fish counts and density when the same stream is snorkeled two years in a row (Bio-Surveys 1998, 1999). Understanding this variability is important to interpreting the data.

Average juvenile coho densities by 6th field watershed across the entire study area are discussed in the **Main Report** (**Species of concern: Salmonids: Distribution**); these average densities are shown on **Figure SOC-8**. **Table 3.1** shows the Salmon River Basin 6th field watersheds that had the highest average juvenile coho densities in 1998-99 (excluding those watersheds that had less than 10 pools snorkeled). The 6th field watershed names and codes shown are those found in the MCWC 6th field watershed coverage, **6th_field.shp**.

Table 3.1. 6th field watersheds within the Salmon River Basin that had highest average juvenile coho densities during 1998-99 Rapid Bioassessment surveys

6th field watershed name	6th field ID code	# of pools surveyed, 1998-99	Average coho/sq m, 1998-99
TROUT1	40909	22	0.3986
U. SALMON RIVER	40901	92	0.3040
SLICKROCK2	40907	20	0.2500
SALMON	40910	29	0.2183
L. SALMON RIVER	40911	13	0.2123

Figure SOC-9SA shows the locations of surveyed pools for 1998 and 1999, color-coded by average juvenile coho density in each pool. This map can be used to locate individual stream segments that had juvenile coho "hot spots," for use in action planning below the 6th field watershed level.

Rapid Bioassessment data provide the most comprehensive field-based data available on coho distribution and population in the study area. However, not all streams have been surveyed and, therefore, 6th field watersheds cannot be evaluated on Rapid Bioassessment data alone. The RBA data should be used to focus restoration efforts on those streams which are currently used by coho. The RBA data can also be used to focus further monitoring efforts. For example, where watershed conditions appear to be suitable for juvenile coho production and rearing, but RBA data show that coho are absent, further investigation is recommended to determine possible reasons for their absence such as migration barriers. Repeated RBA surveys on the same stream segments will be very useful for determining year-to-year variability in coho distribution and populations, which will help interpret the results of individual years' data.

3.2 Multi-factor analyses of salmonid habitat

As described in the **Main Report**, we conducted several multi-factor analyses of coho and winter steelhead habitat. Please read the **Main Report** for important details on the methods used for these analyses. The analyses were conducted using combinations of stream channel characteristics (derived from DEMs), AHI data, soils data, and coho juvenile survey data.

As described in the **Main Report**, no GIS data on anadromous migration barriers appropriate for ranking 6th field watersheds were available for this assessment, so we were not able to incorporate effects of barriers into these multi-factor analyses. Therefore, a limitation of this analysis is the fact that some top-ranked watersheds (or portions thereof) may be inaccessible to anadromous fish. Barriers can be either natural (such as falls) or artificial (such as culverts). **We recommend that when MCWC uses the results of these analyses for prioritizing management actions, they should refine the prioritization by adding local knowledge to the discussion.** Such local knowledge should include locations of fish barriers and other factors influencing choice and siting of management actions. MCWC should also seek to acquire new data on such factors to fill data gaps, as described in **Data collection and monitoring recommendations** in the **Main Report**.

3.3 Coho winter habitat

3.3.1 Potential coho winter habitat

The Potential Coho Winter Habitat analysis is an example of a multi-factor analysis that answers a specific question at the stream reach level. This analysis is designed to answer the question, "Where are stream segments with physical characteristics that make them potentially suitable for coho winter habitat?" As requested by MCWC, we included the following components in our analysis of potential coho winter habitat:

1. Gradient (criterion: low-gradient, 0 - 2 degrees = 0 - 3.5% slope)
2. Confinement (criterion: unconfined)
3. Soils (criterion: hydric)

Working with the DEM-derived streams layer (**derived_streams.zip**, shapefile name **st1400-c.shp**), we used ARCView to query the attributes of stream segments that met the criteria of low gradient and unconfined. We then selected those low-gradient, unconfined segments that flow over hydric soils as shown in the NRCS digital soil survey data.

Only five 6th field watersheds in the Salmon Basin had over 50m of potential coho winter habitat. **Table 3.2** shows these watersheds.

The specific stream reaches identified as potential habitat in this analysis are shown in **Figure AQ-18SA**. The figure also shows coho habitat as mapped by ODFW. Due to lack of appropriate GIS data (as described above), it was not possible to incorporate information on natural barriers into this analysis. Therefore, the potential habitat map may show areas that are inaccessible to fish. The ODFW habitat mapping may be useful in locating such areas; local knowledge should also be used to supplement the mapping.

Table 3.2. 6th field watersheds in the Salmon River Basin with greatest length of potential coho winter habitat

6th field watershed name	Major basin	6th field ID code	Length of potential coho winter habitat (m)
L. SALMON RIVER	Salmon	40911	7597
SALMON	Salmon	40910	1492
U. SALMON RIVER	Salmon	40901	1215

3.3.2 Functioning coho winter habitat

The Functioning Coho Winter Habitat Analysis is a 6th field ranking described in detail in the **Main Report** (**Aquatic habitats: Functioning coho winter habitat**). This analysis is designed to answer the question, "Which 6th field watersheds have average conditions most suitable for overwintering coho juveniles?" Briefly, we ranked 6th fields using factors that influence coho winter habitat. As requested by MCWC, we included the following factors: percent pools, channel widths per pool, large woody debris frequency, length of side channels, and length of potential habitat (low-gradient, unconfined streams flowing through hydric soils). All of the data except potential habitat were taken from aquatic habitat surveys conducted within the past 10 years.

Sixth field watersheds ranked highest for functioning coho winter habitat *across the entire study area* are described in the **Main Report** and shown in **Figure AQ-21**. In this basin report section, we present the highest-ranked 6th fields *within the basin.* Data that led to the rankings are found in the 6th field aquatic habitats summary shapefile (**aqhab_sum_final.shp**).

The Salmon River Basin contains 11 sixth field watersheds. **Table 3.3** shows the 5 sixth field watersheds that were ranked highest in the basin for functioning coho winter habitat. Possible ranks range from 1 (best) to 100 (worst) across the entire study area (all basins). Sixth field watershed names and codes shown are those found in the MCWC 6th field layer (**6th_field.shp**).

Table 3.3. 6th field watersheds ranked highest for functioning coho winter habitat within the Salmon River Basin.

6th field watershed name	6th field ID code	Rank (scale of 100, 1 is best)
U. SALMON RIVER	40901	40.48
BEAR2	40908	50.92
WIDOW	40902	60.93
TROUT1	40909	65.96
DEER	40904	72.04

Salmon River Basin sixth field watersheds generally ranked fairly low for coho winter habitat compared to the rest of the study area (all six basins). For those ranked highest in this basin, contributing factors included length of side channels (Upper Salmon River) and LWD frequency (Widow).

3.4 Coho summer habitat

3.4.1 Potential coho summer habitat

The potential coho summer habitat analysis is an example of a multi-factor analysis that answers a specific question at the stream reach level. This analysis is designed to answer the question, "Where are stream segments with physical characteristics that make them potentially suitable for coho summer habitat?" As requested by MCWC, we included the following components in our analysis of potential coho summer habitat:

1. Gradient (criterion: low-gradient, 0 - 2 degrees = 0 - 3.5% slope)
2. Confinement (criterion: unconfined)

Working with the ***DEM-derived streams layer***, we used ArcView to query the attributes of stream segments to find those that met the criteria of low gradient and unconfined.

Nine out of the ten 6th field watersheds in the Salmon Basin had over 50m of potential coho summer habitat. **Table 3.4** shows these watersheds.

The specific stream reaches identified as potential habitat in this analysis are shown in **Figure AQ-19SA**. The figure also shows coho habitat as mapped by ODFW. Due to lack of appropriate GIS data (as described above), it was not possible to incorporate information on natural barriers into this analysis. Therefore, the potential habitat map may show areas that are inaccessible to fish. The ODFW habitat mapping may be useful in locating such areas; local knowledge should also be used to supplement the mapping.

Table 3.4. 6th field watersheds with greatest length of potential coho summer habitat.

6th field watershed name	Major basin	6th field code	Length of potential coho summer habitat (m)
L. SALMON RIVER	Salmon	40911	17878
U. SALMON RIVER	Salmon	40901	14185
M. SALMON RIVER	Salmon	40906	7570
SALMON	Salmon	40910	5121
BEAR2	Salmon	40908	3793
TREAT/ALDER BROOK	Salmon	40903	2633
SLICKROCK2	Salmon	40907	2215
WIDOW	Salmon	40902	1197
PANTHER1	Salmon	40905	865
DEER	Salmon	40904	755

3.4.2 Functioning coho summer habitat

The Functioning Coho Summer Habitat Analysis is a 6th field ranking described in detail in the **Main Report** (**Aquatic habitats: Functioning coho summer habitat**). This analysis is designed to answer the question, "Which 6th field watersheds have average conditions most suitable for coho summer habitat?" Briefly, we ranked 6th fields using a several factors that are important to coho juveniles during the summer. As requested by MCWC, we included the following factors: percent pools, channel widths per pool, large woody debris frequency, percent shading of stream channels, length of riffle habitats with gravel substrate dominant, length of riffle habitats with bedrock substrate dominant (this factor reduced the ranking), length of potential habitat (low-gradient, unconfined streams flowing through hydric soils), and juvenile coho densities from Rapid Bioassessment surveys. Data on pools, LWD, shade, and substrates were taken from aquatic habitat surveys conducted within the past 10 years.

Sixth field watersheds ranked highest for functioning coho summer habitat *across the entire study area* are described in the **Main Report** and shown in **Figure AQ-22**. In this basin report section, we present the highest-ranked 6th fields *within the basin.* Data that led to the rankings are found in the 6th field aquatic habitats summary shapefile (**aqhab_sum_final.shp**).

Table 3.5 shows the 5 sixth field watersheds that were ranked highest (out of the 11 in the basin) for functioning coho summer habitat. Possible ranks range from 1 (best) to 100 (worst) across the entire study area (all basins). Sixth field watershed names and codes shown are those found in the MCWC 6th field layer (**6th_field.shp**).

Table 3.5. 6th field watersheds ranked highest for functioning coho summer habitat within the Salmon River Basin.

6th field watershed name	6th field ID code	Rank (scale of 100, 1 is best)
U. SALMON RIVER	40901	41.13
BEAR2	40908	46.35
WIDOW	40902	58.23
DEER	40904	58.73
L. SALMON RIVER	40911	61.94

Salmon River Basin sixth field watersheds did not generally have very high rankings for coho summer habitat. For those ranked highest in this basin, contributing factors included low amounts of bedrock substrate and substantial lengths of unconfined low-gradient streams.

3.5 Winter steelhead Habitat

3.5.1 Potential winter steelhead habitat

The potential winter steelhead habitat analysis is an example of a multi-factor analysis that answers a specific question at the stream reach level. This analysis is designed to answer the question, "Where are stream segments with physical characteristics that make them potentially suitable for winter steelhead habitat?" As requested by MCWC, we included the following components in our analysis of potential winter steelhead habitat:

1. Gradient (criterion: moderate gradient, 1-5 degrees = 1.75 - 8.75% slope)
2. Confinement (criterion: confined)

We used the 1.75 - 8.75% slope gradient because it was the closest we could come to the 2 - 8% slope range requested by MCWC, using the ***DEM-derived stream gradient coverage***. Working with the ***DEM-derived streams layer***, we used ARCView to query the attributes of stream segments to locate those that met the criteria of moderate gradient and confined.

Table 3.6 shows the length of potential winter steelhead habitat (moderate-gradient, confined streams) in the Salmon Basin 6th field watersheds.

The specific stream reaches identified as potential habitat in this analysis are shown in **Figure AQ-20SA**. The figure also shows winter steelhead habitat as mapped by ODFW. Due to lack of appropriate GIS data (as described above), it was not possible to incorporate information on natural barriers into this analysis. Therefore, the potential habitat map may show areas that are inaccessible to fish. The ODFW habitat mapping may be useful in locating such areas; local knowledge should also be used to supplement the mapping.

Table 3.6. 6th field watersheds with greatest length of potential winter steelhead habitat.

6th field watershed name	**Major basin**	**6th field ID code**	**Length of potential winter steelhead habitat (m)**
U. SALMON RIVER	Salmon	40901	10905
SLICKROCK2	Salmon	40907	5223
TREAT/ALDER BROOK	Salmon	40903	4296
BEAR2	Salmon	40908	3282
SALMON	Salmon	40910	2813
M. SALMON RIVER	Salmon	40906	2713
L. SALMON RIVER	Salmon	40911	2123
WIDOW	Salmon	40902	1964
TROUT1	Salmon	40909	1917
DEER	Salmon	40904	1838

3.5.2 Functioning winter steelhead habitat

The Functioning Winter Steelhead Habitat Analysis is a 6th field ranking described in detail in the **Main Report** (**Aquatic habitats: Functioning winter steelhead habitat**). This analysis is designed to answer the question, "Which 6th field watersheds have average conditions most suitable for winter steelhead?" Briefly, we ranked 6th fields using a several factors that are important to winter steelhead during the summer and winter. As requested by MCWC, we included the following factors: length of riffle habitat; length of riffle habitat with gravel-to-boulder-sized substrate dominant; and length of potential habitat (moderate-gradient, confined streams). Data on riffle length and substrates were taken from aquatic habitat surveys conducted within the past 10 years.

Sixth field watersheds ranked highest for functioning winter steelhead habitat *across the entire study area* are described in the **Main Report** and shown in **Figure AQ-23**. In this basin report section, we present the highest-ranked 6th fields *within the basin.* Data that led to the rankings are found in the 6th field aquatic habitats summary shapefile (**aqhab_sum_final.shp**).

Table 3.7 shows the 5 sixth field watersheds that were ranked highest (out of the 11 in the basin) for functioning winter steelhead habitat. Possible ranks range from 1 (best) to 100 (worst) across the entire study area (all basins). Sixth field watershed names and codes shown are those found in the MCWC 6th field layer (**6th_field.shp**).

Table 3.7. 6th field watersheds ranked highest for functioning winter steelhead habitat within the Salmon River Basin.

6th field watershed name	6th field ID code	Rank (scale of 100, 1 is best)
BEAR2	40908	29.40
U. SALMON RIVER	40901	37.46
L. SALMON RIVER	40911	59.27
WIDOW	40902	70.49
DEER	40904	73.36

Salmon River Basin sixth field watersheds did not generally have very high rankings for winter steelhead habitat. For those ranked highest in this basin, contributing factors included riffle length and gravel-to-boulder-sized substrate (Bear Creek watershed), and length of potential habitat (moderate-gradient, confined streams) (Upper Salmon River).

4 Erosion and shallow landslide risk

Although debris and sediments have been entering the streams of Oregon Coast Range since before the time of European settlement, the frequency, duration and intensity of mass wasting events is of concern (see **Appendix B: Ecosystem Processes**). Mass wasting events (such as landslides and debris flows) add both coarse and fine sediments to streams along with organic debris (i.e., LWD). The quality of in-stream conditions, especially salmonid habitat, can be dramatically affected by patterns in material transport to streams (see **Appendix B: Ecosystem Processes**). We performed a series of risk assessments that identify 6th field watersheds that are 'at risk' for three types of mass wasting events: (1) soil erosion risk, (2) shallow landslide risk, and (3) debris flows that could potentially transport LWD from riparian zones to streams.

4.1 Soil erosion risk

Erosion risk was determined for most soil types occurring in the study area (see Soil Erosion Risk). We then used ARCView to sum the area of each 6th field watershed covered by soils determined to have a "severe" risk of erosion. None of the 6th field watersheds in the Salmon River basin had more than 75% of their area occupied by the most severe risk category of soils. One way to use this information in planning is to avoid disturbing soils at times when precipitation would wash soils into streams or plan on leaving wide vegetated buffer strips to trap eroding sediments. Another way to use this information is to combine risk of soil erosion with other factors such as risk of shallow landslides (see below), in a multi-factor analysis.

4.2 Shallow landslide risk

Aside from the ODF debris flow hazard maps and a few mapped landslides, there was not much information with which to rank 6th field watersheds for shallow landslide risk (see **Main Report**, **Sediment Sources: Landslides**). We relied on work done by team in the State of Washington that compared several models that predicted landslide risk. Discussions with the authors of that report (Vaugeois, personal communication, 1999, see **Appendix A: Supplemental Methods**) suggested that the default settings of the SMORPH model should provide a good approximation of landslide risk in the northern section of the Oregon Coast Range, especially at the 6th field watershed level. Indeed, the first step in model calibration is to run the model without calibration and then compare model output with spatially explicit landslide inventories. SMORPH ranks each 10 X 10 m grid cell as having a "low", "medium" or "high" risk of shallow landslides. The model is influenced primarily by slope and topographic concavity, both derived from the DEM grid. Therefore, we used an uncalibrated model to assess landslide risk in the study area. We strongly suggest that the model output be used only in a general sense (i.e., on a 6th field watershed basis) and that model calibration be performed before using SMORPH to assess particular sites.

As with the soil erosion risk analysis, we ranked each 6th field watershed by the proportion of its area occupied by the 'high' risk category. Surprisingly, areas occupied by 'high' risk grid cells did not account for more than 50% of any of the 6th field watersheds. In the Salmon River basin only four 6th field watersheds (in decreasing order of importance 40909, 40908, 40903, and 40907) had more than 25% of their area identified by SMORPH as being "high" risk for a shallow landslide.

This information is useful in helping to identify 6th field watersheds that may have large areas prone to shallow landslides. We recommend that detailed landslide information be collected and used to calibrate this model. A calibrated model would be useful in identifying specific locations within the watershed that may be prone to shallow landslide. Land use actions could then be planned so that they avoid these areas whenever possible.

4.3 Combined soil erosion / shallow landslide risk

Finally, we performed a multi-factor analysis by combining information from the erodible soils and shallow landslide risk assessments. We used ARCView to create a shapefile depicting the “high risk” category from the SMORPH model. Due to the size and complexity of this layer, we used ARCView to intersect the SMORPH shapefile with highly erodible soils for each major river basin separately. This resulted in a single shapefile that contained both risk of soil erosion and of shallow landslide. The final step in this analysis was to rank each 6th field by the proportion of its area that met these two criteria.

The results of this analysis indicate that none of the 6th field watersheds in the Salmon Basin had more than 25% of their area in the high risk category for both soil erosion and shallow landslides. However, specific areas within the watershed may be at high risk for both factors. Both the SMORPH model output and the soils maps contain a great deal of detail and may be very important data sets for site specific planning. We have provided these data to MCWC, and we recommend that these data be field checked.

5 Peak flow impact

Water movement is an important factor in structuring ecosystems in the Oregon Coast Range. Water arrives in the watershed as precipitation (rain or snow), then moves across the land surface and into the stream network. Many factors affect the water’s capacity to erode and transport soils, sediments and pollutants. For example, vegetation can reduce the impact of rain on soils, or increase water storage capacity by slowing the movement of water as it moves downslope. Vegetation can also affect snow accumulation at higher elevations. In areas of higher elevation snow can accumulate in treeless areas. The snow can prevent infiltration of rainfall, so that if rain then falls on the snow, water can move quickly across the watershed into the stream network. This can result in high peak stream flows. Just as snow prevents rain from infiltrating soils in the upper watershed, impervious surfaces (roads and parking lots) can quickly route water into stream networks during precipitation events. Thus, both rain-on-snow and roaded areas can affect peak stream flows.

5.1 Rain-on-snow

Rain-on-Snow analysis identifies those areas within the watershed that could potentially experience increases in peak-flows under certain weather conditions. Proportionate to its area, the Salmon River Basin had the greatest potential for Rain-on-Snow events of the six MidCoast sub-regions. Three of the 11 6th field watersheds in the Salmon River Basin have potential for Rain-on-Snow events (40903, 40907, and 40909) and one of these 6th field watersheds (40907) has areas where the elevation exceeds 3000 ft. The CLAMS95 data show that there are several open areas within these zones of high elevation, but these areas comprise less than 10% of the watershed area, so the risk of peak flow impact from rain-on-snow events is low (Watershed Professionals Network 1999).

5.2 Roads

The impact of roads on peak flows can be assessed in several ways. Most important is to have a good map representation of where the roads actually are. Our assessment is based on the 100K roads layer because it was the best roads layer that was available for the entire study area. We estimate that the 100K roads layer may under-represent the actual frequency of roads in the watershed by about 38%, so the impact of roads on peak flows may also be underestimated using this dataset.

We used two methods for determining possible peak flow impacts from roads: a method that uses urban/residential road density as a surrogate for total impervious area, and a method that analyzes rural roads as a percent of watershed area (Watershed Professionals Network 1999). We found that for the eleven 6th fields of the Salmon River Basin, the average potential for peak-flow impact from roads was intermediate among those calculated in this study (the basin was ranked No. 3 out of the 6 basins). However, there were no 6th field watersheds identified as being at risk for peak flow impact using either the Total Impervious Surface or Rural Road density benchmarks.

6 Restoration

6.1 Large Woody Debris placement areas

In this analysis, we used Rapid Bioassessment (RBA) data and aquatic habitat survey data (AQI data) to answer a specific question: What are some suitable locations for in-stream placement of large woody debris? This question is one of MCWC's top priorities for the next phase in watershed assessment and action planning using GIS.

Priority areas for placement of large woody debris (LWD) would be low-gradient, mid-sized streams (coho rearing habitat) which are currently being used by coho, but which currently have low quantities of LWD. It makes sense to look for reaches with high average juvenile coho densities (not just individual pools with high densities).

Using the ODFW habitat benchmarks (Watershed Professionals Network 1999) and ODFW and USFS aquatic habitat inventory data, we first selected stream reaches with undesirably low levels of LWD (less than 10 pieces of LWD per 100m). We then created 100m buffers around each selected stream reach. We then intersected the **RBA snorkel survey data** with the buffer polygons and averaged 1998-99 RBA juvenile coho/sq m for each buffer unit. We then joined the summary layer to the buffer layer to allow symbolization of the buffer layer by coho/sq m. The resulting shapefile is **lowlwd_rba_15oct.shp**.

Figure REC-1SA shows the results for the Salmon River Basin. The Salmon River Basin was snorkeled for juvenile coho under the RBA project in 1998 and coho levels were generally low. The only prospect for LWD placement using the techniques of this analysis were portions of Trout Creek (shown in slightly darker green on the map), which had an average juvenile coho density of about 0.4 coho/sq m and also had low LWD frequency. Some pools on the Little Salmon River had juvenile coho densities between 1 and 2 coho/sq m in 1998, but these segments averaged under 0.4 coho/sq m, and also lacked AQI data that are in GIS form.

When using the results of this analysis, it is important to remember that both the RBA data and the AQI data available in GIS format cover only limited portions of the stream network. It is likely that RBA and/or AQI data were missing for some areas that would benefit from LWD placement. Since many streams in the study area have low levels of LWD, the RBA data alone could be used to target LWD placement for areas lacking AQI data; or the RBA data could be used to select areas for further AQI data collection to improve data coverage (see **Data Recommendations** in **Main Report**). Collection of additional AQI and RBA data would improve the analysis.

6.2 Potential floodplain restoration sites

This analysis was designed to answer the question, "Where in the watershed are some potential floodplain restoration sites?" Potential floodplain restoration sites would be former floodplains (diked, drained, or otherwise altered) that do not have land uses incompatible with floodplain restoration. To locate potential floodplains, we used the DEM-derived slope GIS layer as described below. To locate areas that do not have incompatible land uses, we used the DLCD generalized zoning layer as described below

In this multi-factor analysis, we used ARCView to perform a series of GIS layer "intersections" (a command available in the Geoprocessing Wizard of ARCView) to combine information from zoning and slope GIS layers onto the derived streams layer (**ST-1400**). This produced a single streams layer containing all of the information from the single factor analyses.

Before summarizing information in this newly created GIS layer, we manually removed stream segments where there was a lot of "flagging" on the derived streams layer (see **Appendix A: Supplemental Methods**).

To address the issue of incompatible land uses, we removed from consideration all stream segments that passed through property zoned as "urban", "rural residential", rural industrial", "rural commercial", and "rural service center" since these are unlikely areas for restoration projects.

To locate potential floodplains, we selected stream segments that flow through 'flat' areas (areas that had less than 5% slope). The 5% slope threshold was determined during the stream confinement analysis (**Main Report**, **Aquatic habitats: Stream confinement**

from DEMs). Since it probably would not be practical to attempt to restore floodplains along very short segments of streams, we then selected those stream segments longer than 500m that flowed through these 'flat areas.' (In case the Council wishes to conduct further analyses using these data, we retained the shorter segments in the layer, but simply selected those longer than 500m for summarization and display on the maps.)

Information from this analysis is presented in two forms, as a summary showing the total stream length per 6th field meeting our selection criteria and as a sub-6th field map showing actual locations for stream restoration projects. Please note that stream lengths should be used as a relative measure of the amount of suitable (potential) floodplain restoration sites because stream lengths may be exaggerated, especially in low relief areas (e.g., along the coast) where the stream derivation algorithms had trouble placing the stream channel and stream “flagging” occurred.

Figure REC-2SA shows the stream segments identified as having potential floodplain restoration sites. There was one 6th field watershed (40901) in the Salmon River basin that had more than 20 km of stream identified as potential floodplain restoration sites.

7 References

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Siletz Basin Insert

Important: This Basin Insert is a part of the MidCoast Sixth Field Watershed Assessment and is intended for use only with the full report. Please contact the MidCoast Watersheds Council at (541) 265-9195 for information on how to obtain the full report.

Table of Contents

1 Introduction

This basin insert is a supplement to the MidCoast Sixth Field Watershed Assessment and is intended for use only with the full report. This insert focuses on basin-specific results for a subset of the analyses conducted in the assessment, but provides little background, setting, methods or interpretation. Therefore, it is important to read the **Main Report** before using this Insert. If this basin insert has been separated from the **Main Report**, contact the MidCoast Watersheds Council (MCWC) at (541) 265-9195 for information on how to obtain the full report.

2 Setting

Setting for the MidCoast Sixth Field Watershed Assessment is described in the **Main Report**, as are summaries that compare the different basins. To provide details useful to local watershed groups, this basin insert contains several maps depicting features at a scale below that of the sixth field watershed.

2.1 Location

General features of the Siletz Basin are shown in **Figure SET-2SI**. Not all stream names are shown; names shown are those contained in the 100K streams layer (**mc_rivs^{M}**). The location of the basin relative to the rest of the study area is shown in the general locator map (**Figure SET-1** in the **Main Report**).

2.2 Sixth field watershed boundaries

Boundaries of sixth field watersheds, and the watershed codes used in this analysis, are shown in **Figure SET-3SI**. The source of these boundaries, and the way we used them, are described in the **Main Report** (**Setting: 6th field watersheds**).

2.3 Zoning

DLCD generalized land use zoning categories are shown in **Figure SET-4SI**. Categories are described in the **Main Report** (**Setting: Land use zoning**).

The vast majority of the basin is zoned for Forestry use. The Millport Slough area is zoned Estuary. Agriculture use areas are located along the mainstem Siletz River from Moonshine Park downstream to the estuary, and along lower Drift Creek and Schooner Creek. Rural Residential areas are scattered along the Siletz River near the town of Siletz, and along lower Drift and Schooner Creeks. Urban zoning is limited to the Taft, Cutler City and south Lincoln City area, and the town of Siletz.

2.4 Land ownership

Major land ownership categories, and a breakdown of major private industrial landowners, are shown in **Figure SET-5SI**. The major industrial landowners shown separately are the top 5 ranked by acreage owned within the entire study area.

Most of the timber land in the basin is privately owned. Georgia-Pacific and Boise Cascade own large portions of the basin; other Private Industrial landowners in the basin include Willamette, Simpson, Starker, Miami, and various others. BLM and the State of Oregon own substantial portions of the North Fork Siletz and Rock Creek watersheds respectively. The USFS (Siuslaw National Forest) owns a large block of land in the Drift and Schooner Creek watersheds.

2.5 Hydric soils

Hydric soils mapped by NRCS and provided in GIS digital soils coverages are shown in **Figure SET-7SI**. Further information on the nature of hydric soils and why they are important to the watershed assessment is found in the **Main Report** (**Setting: Hydric soils** and **Aquatic habitats: Wetlands**).

Major areas of hydric soils are found in the Siletz River Estuary (Brophy 2001), along the mainstem Siletz River, and along tributaries, particularly Long Tom Creek, Long Prairie Creek, Big Rock Creek, Mill Creek, Sunshine Creek, Fourth of July Creek, and the South Fork Siletz River. These areas of hydric soils along tributaries may provide good locations for restoration of off-channel habitat, backwater wetlands, active floodplains and similar habitats for anadromous fish.

2.6 Lithology

General lithology is shown in **Figure SET-8SI**, with underlying formations color-coded by major types (sedimentary, igneous, and quaternary). These formations (and the importance of lithology in watershed assessment) are described in the **Main Report** (**Setting: Lithology**).

Lithology in the south half of the basin is primarily sedimentary, with quaternary alluvial deposits in the valleys of the mainstem Siletz River, Rock Creek and lower Mill Creek. The north half of the basin contrasts sharply with the primary underlying formations being igneous.

3 Salmon and salmonid habitat

3.1 Rapid Bioassessment juvenile coho density

The Rapid Bioassessment (RBA) project (begun in 1998) provides data on distribution and abundance of juvenile coho, based on snorkel surveys of pools in the study area (see

Main Report, **Species of concern: Rapid bioassessment**). We analyzed the RBA data to determine average coho per square meter for each 6th field watershed, based on pools within the observed distribution of coho in each stream in 1998 and 1999 (see methods described in **Main Report**). We weighted the average values by the number of pools snorkeled in each year to normalize results. We also summed the number of pools surveyed in 1998 and 1999 for each 6th field. Sixth fields with less than 10 pools snorkeled during 1998 and 1999 are indicated with a red outline on the map showing coho per square meter (**Figure SOC-8** in the **Main Report**). Caution should be exercised when interpreting results from basins with a limited number of observations.

The Rapid Bioassessment reports describe the year-to-year variability in fish counts and density when the same stream is snorkeled two years in a row (Bio-Surveys 1998, 1999). Understanding this variability is important to interpreting the data.

Average juvenile coho densities by 6th field watershed across the entire study area are discussed in the **Main Report** (**Species of concern: Salmonids: Distribution**); these average densities are shown on **Figure SOC-8**. **Table 3.1** shows the Siletz Basin 6th field watersheds that had the highest average juvenile coho densities in 1998-99 (excluding those watersheds that had less than 10 pools snorkeled). The 6th field watershed names and codes shown are those found in the MCWC 6th field watershed coverage, **6th_field.shp**.

Table 3.1. 6th field watersheds within the Siletz Basin that had highest average juvenile coho densities during 1998-99 Rapid Bioassessment surveys

6th field watershed name	6th field ID code	# of pools surveyed, 1998-99	Average coho/sq m, 1998-99
SUNSHINE	40504	173	0.5982
SAM	40717	103	0.5689
ROCK_CR	40604	59	0.3215
UPPER FARM	40506	22	0.2782
CERINE	40507	37	0.2614
STEERE	40605	107	0.1945
WILDCAT	40808	32	0.1681
ELK	40502	14	0.1607
SAMPSON	40809	24	0.0838
LITTLE_ROCK	40606	156	0.0663

Figure SOC-9SI shows the locations of surveyed pools for 1998 and 1999, color-coded by average juvenile coho density in each pool. This map can be used to locate individual stream segments that had juvenile coho "hot spots," for use in action planning below the 6th field watershed level.

Rapid Bioassessment data provide the most comprehensive field-based data available on coho distribution and population in the study area. However, not all streams have been surveyed and, therefore, 6th field watersheds cannot be evaluated on Rapid Bioassessment data alone. The RBA data should be used to focus restoration efforts on those streams which are currently used by coho. The RBA data can also be used to focus further monitoring efforts. For example, where watershed conditions appear to be suitable for juvenile coho production and rearing, but RBA data show that coho are absent, further investigation is recommended to determine possible reasons for their absence such as migration barriers. Repeated RBA surveys on the same stream segments will be very useful for determining year-to-year variability in coho distribution and populations, which will help interpret the results of individual years' data.

3.2 Multi-factor analyses of salmonid habitat

As described in the **Main Report**, we conducted several multi-factor analyses of coho and winter steelhead habitat. Please read the **Main Report** for important details on the methods used for these analyses. The analyses were conducted using combinations of stream channel characteristics (derived from DEMs), AHI data, soils data, and coho juvenile survey data.

As described in the **Main Report**, no GIS data on anadromous migration barriers appropriate for ranking 6th field watersheds were available for this assessment, so we were not able to incorporate effects of barriers into these multi-factor analyses. Therefore, a limitation of this analysis is the fact that some top-ranked watersheds (or portions thereof) may be inaccessible to anadromous fish. In the sections below, we note the 6th field watersheds that ranked high, but are inaccessible to salmonids according to information provided to us by MCWC. However, other 6th field watersheds or portions thereof are no doubt inaccessible, due to either natural and artificial barriers. **We recommend that when MCWC uses the results of these analyses for prioritizing management actions, they should refine the prioritization by adding local knowledge to the discussion.** Such local knowledge should include locations of fish barriers and other factors influencing choice and siting of management actions. MCWC should also seek to acquire new data on such factors to fill data gaps, as described in **Data collection and monitoring recommendations** in the **Main Report**.

3.3 Coho winter habitat

3.3.1 Potential coho winter habitat

The Potential Coho Winter Habitat analysis is an example of a multi-factor analysis that answers a specific question at the stream reach level. This analysis is designed to answer the question, "Where are stream segments with physical characteristics that make them potentially suitable for coho winter habitat?" As requested by MCWC, we included the following components in our analysis of potential coho winter habitat:

1. Gradient (criterion: low-gradient, 0 - 2 degrees = 0 - 3.5% slope)
2. Confinement (criterion: unconfined)
3. Soils (criterion: hydric)

Working with the DEM-derived streams layer (**derived_streams.zip**, shapefile name **st1400-c.shp**), we used ARCView to query the attributes of stream segments that met the criteria of low gradient and unconfined. We then selected those low-gradient, unconfined segments that flow over hydric soils as shown in the NRCS digital soil survey data.

Table 3.2 shows the ten 6th field watersheds in the Siletz Basin that ranked highest for length of potential coho winter habitat. Although the South Fork Siletz watershed ranks high for this type of habitat, it is inaccessible to coho due to the anadromous migration barrier formed by Siletz Falls. Siletz Falls has a fish ladder and trap, but only summer steelhead are being passed through the trap to the ladder.

Table 3.2. 6th field watersheds in the Siletz Basin with greatest length of potential coho winter habitat

6th field watershed name	Major basin	6th field ID code	Length of potential coho winter habitat (m)
SF_SILETZ[1]	Siletz	40410	16387
SILETZ	Siletz	40701	9056
SUNSHINE	Siletz	40504	7339
L. SILETZ RIVER	Siletz	40812	5880
GORDY/L. DRIFT	Siletz	40811	5444
CERINE	Siletz	40507	3955
LITTLE_ROCK	Siletz	40606	3902
L. SCHOONER	Siletz	40810	3058
BIG_ROCK	Siletz	40601	2805
ROCK_CR	Siletz	40604	2610

[1] Anadromous migration barriers affect this watershed and may affect other watersheds. See text for details.

The specific stream reaches identified as potential habitat in this analysis are shown in **Figure AQ-18SI**. The figure also shows coho habitat as mapped by ODFW. Due to lack of appropriate GIS data (as described above), it was not possible to incorporate information on natural barriers into this analysis. Therefore, the potential habitat map may show areas that are inaccessible to fish. The ODFW habitat mapping may be useful in locating such areas; local knowledge should also be used to supplement the mapping.

3.3.2 Functioning coho winter habitat

The Functioning Coho Winter Habitat Analysis is a 6th field ranking described in detail in the **Main Report** (**Aquatic habitats: Functioning coho winter habitat**). This analysis is designed to answer the question, "Which 6th field watersheds have average conditions most suitable for overwintering coho juveniles?" Briefly, we ranked 6th fields using factors that influence coho winter habitat. As requested by MCWC, we included the following factors: percent pools, channel widths per pool, large woody debris frequency, length of side channels, and length of potential habitat (low-gradient, unconfined streams flowing through hydric soils). All of the data except potential habitat were taken from aquatic habitat surveys conducted within the past 10 years.

6th field watersheds ranked highest for functioning coho winter habitat *across the entire study area* are described in the **Main Report** and shown in **Figure AQ-21**. In this basin report section, we present the highest-ranked 6th fields *within the basin.* Data that led to the rankings are found in the 6th field aquatic habitats summary shapefile (**aqhab_sum_final.shp**).

The Siletz Basin contains 52 sixth field watersheds. **Table 3.3** shows the 10 sixth field watersheds that were ranked highest in the basin for functioning coho winter habitat. Possible ranks range from 1 (best) to 100 (worst) across the entire study area (all basins). Sixth field watershed names and codes shown are those found in the MCWC 6th field layer (**6th_field.shp**).

Table 3.3. 6th field watersheds ranked highest for functioning coho winter habitat within the Siletz basin.

6th field watershed name	**6th field ID code**	**Rank (scale of 100, 1 is best)**
SF_SILETZ[1]	40410	29.19
SUNSHINE	40504	30.18
ROOTS	40705	38.96
GORDY/L. DRIFT	40811	40.82
LONG TOM	40716	41.30
BIG_ROCK	40601	43.06
GRAVEL	40501	43.07
LONG PRAIRIE	40718	45.95
LITTLE_ROCK	40606	47.85
L. SCHOONER	40810	50.23

[1] Anadromous migration barriers affect this watershed and may affect other watersheds. See text for details.

For the Siletz Basin, sixth field watersheds ranked high for coho winter habitat usually achieved that ranking mainly through stream morphology -- namely, length of side channels and length of potential habitat (i.e., low-gradient unconfined streams passing over hydric soils). For the Long Tom 6th field, percent pools also played a strong role, and for the Roots Creek 6th field, high LWD frequency was an important factor.

The South Fork Siletz 6th field watershed ranked high in this analysis. However, this watershed is not accessible to coho because it is above Siletz Falls. The Falls have a fish ladder and trap, but currently, only summer steelhead are being passed through the trap to the ladder. The South Fork Siletz 6th field watershed had the highest rankings in the entire study area for both length of side channels (4.9 km) and potential habitat (17.13 km). Interestingly, the South Fork Siletz watershed also ranked highest in the study area for potential winter steelhead habitat (length of moderate-gradient, confined streams). Both results derive at least partly from the fact that this 6th field watershed had the among the highest total length of streams in the study area (length of 100K streams was the highest of all 6th field watersheds, at 55.7 km).

3.4 Coho summer habitat

3.4.1 Potential coho summer habitat

The potential coho summer habitat analysis is an example of a multi-factor analysis that answers a specific question at the stream reach level. This analysis is designed to answer the question, "Where are stream segments with physical characteristics that make them potentially suitable for coho summer habitat?" As requested by MCWC, we included the following components in our analysis of potential coho summer habitat:

1. Gradient (criterion: low-gradient, 0 - 2 degrees = 0 - 3.5% slope)
2. Confinement (criterion: unconfined)

Working with the DEM-derived streams layer, we used ArcView to query the attributes of stream segments to find those that met the criteria of low gradient and unconfined.

Table 3.4 shows the ten 6th field watersheds in the Siletz Basin that ranked highest for length of potential coho summer habitat.

Although the South Fork Siletz watershed ranks high for this type of habitat, it is inaccessible to coho due to the anadromous migration barrier formed by Siletz Falls. Siletz Falls has a fish ladder and trap, but only summer steelhead are being passed through the trap to the ladder.

Table 3.4. 6th field watersheds in the Siletz Basin with greatest length of potential coho summer habitat.

6th field watershed name	Major basin	6th field ID code	Length of potential coho summer habitat (m)
SF_SILETZ[1]	Siletz	40410	37124
SILETZ	Siletz	40701	28350
ROOT	Siletz	40705	26334
BENTILLA	Siletz	40712	24556
OJALLA	Siletz	40710	15249
LITTLE_ROCK	Siletz	40606	14488
GORDY/L. DRIFT	Siletz	40811	14089
TANGERMAN	Siletz	40713	13428
L. SCHOONER	Siletz	40810	11418
L. SILETZ RIVER	Siletz	40812	11384

[1] Anadromous migration barriers affect this watershed and may affect other watersheds. See text for details.

The specific stream reaches identified as potential habitat in this analysis are shown in **Figure AQ-19SI**. The figure also shows coho habitat as mapped by ODFW. Due to lack of appropriate GIS data (as described above), it was not possible to incorporate information on natural barriers into this analysis. Therefore, the potential habitat map may show areas that are inaccessible to fish. The ODFW habitat mapping may be useful in locating such areas; local knowledge should also be used to supplement the mapping.

3.4.2 Functioning coho summer habitat

The Functioning Coho Summer Habitat Analysis is a 6th field ranking described in detail in the **Main Report** (**Aquatic habitats: Functioning coho summer habitat**). This analysis is designed to answer the question, "Which 6th field watersheds have average conditions most suitable for coho summer habitat?" Briefly, we ranked 6th fields using a several factors that are important to coho juveniles during the summer. As requested by MCWC, we included the following factors: percent pools, channel widths per pool, large woody debris frequency, percent shading of stream channels, length of riffle habitats with gravel substrate dominant, length of riffle habitats with bedrock substrate dominant (this factor reduced the ranking), length of potential habitat (low-gradient, unconfined streams flowing through hydric soils), and juvenile coho densities from Rapid Bioassessment surveys. Data on pools, LWD, shade, and substrates were taken from aquatic habitat surveys conducted within the past 10 years.

Sixth field watersheds ranked highest for functioning coho summer habitat *across the entire study area* are described in the **Main Report** and shown in **Figure AQ-22**. In this basin report section, we present the highest-ranked 6th fields *within the basin.* Data that led to the rankings are found in the 6th field aquatic habitats summary shapefile (**aqhab_sum_final.shp**).

Table 3.5 shows the 10 sixth field watersheds (out of the 52 in the Siletz Basin) that were ranked highest for functioning coho summer habitat. Possible ranks range from 1 (best) to 100 (worst) across the entire study area (all basins). Sixth field watershed names and codes shown are those found in the MCWC 6th field layer (**6th_field.shp**).

The South Fork Siletz 6th field watershed ranked high in this analysis. However, this watershed is not accessible to coho because it is above Siletz Falls. The Falls have a fish ladder and trap, but currently, only summer steelhead are being passed through the trap to the ladder.

Table 3.5. 6th field watersheds ranked highest for functioning coho summer habitat within the Siletz basin.

6th field watershed name	6th field ID code	Rank (scale of 100, 1 is best)
SF_SILETZ[1]	40410	29.21
ROOT	40705	31.89
SUNSHINE	40504	33.22
WILDCAT	40808	35.27
L. SCHOONER	40810	39.31
LONG PRAIRIE	40718	41.35
JAYBIRD	40709	42.68
ERICKSON	40801	46.16

BIG_ROCK	40601	47.10
CERINE	40507	48.72
[1] Anadromous migration barriers affect this watershed and may affect other watersheds. See text for details.		

For the Siletz Basin, sixth field watersheds ranked high for coho summer habitat usually achieved that ranking mainly through low amounts of bedrock substrate. Percent shade was also ranked high for the Cerine Creek watershed.

3.5 Winter steelhead habitat

3.5.1 Potential winter steelhead habitat

The potential winter steelhead habitat analysis is an example of a multi-factor analysis that answers a specific question at the stream reach level. This analysis is designed to answer the question, "Where are stream segments with physical characteristics that make them potentially suitable for winter steelhead habitat?" As requested by MCWC, we included the following components in our analysis of potential winter steelhead habitat:

1. Gradient (criterion: moderate gradient, 1-5 degrees = 1.75 - 8.75% slope)
2. Confinement (criterion: confined)

We used the 1.75 - 8.75% slope gradient because it was the closest we could come to the 2 - 8% slope range requested by MCWC, using the ***DEM-derived stream gradient coverage***. Working with the ***DEM-derived streams layer***, we used ARCView to query the attributes of stream segments to locate those that met the criteria of moderate gradient and confined.

Table 3.6 shows the ten 6th field watersheds in the Siletz Basin that ranked highest for length of potential winter steelhead habitat (moderate-gradient, confined streams). Although the South Fork Siletz watershed ranks high for this type of habitat, it is affected by the migration barrier formed by Siletz Falls. Siletz Falls has a fish ladder and trap, but only summer steelhead are being passed through the trap to the ladder.

The specific stream reaches identified as potential habitat in this analysis are shown in **Figure AQ-20SI**. The figure also shows winter steelhead habitat as mapped by ODFW. Due to lack of appropriate GIS data (as described above), it was not possible to incorporate information on natural barriers into this analysis. Therefore, the potential habitat map may show areas that are inaccessible to fish. The ODFW habitat mapping may be useful in locating such areas; local knowledge should also be used to supplement the mapping.

Table 3.6. 6th field watersheds in the Siletz Basin with greatest length of potential winter steelhead habitat.

6th field watershed name	Major basin	6th field ID code	Length of potential winter steelhead habitat (m)
SF_SILETZ[1]	Siletz	40410	7329
BENTILLA	Siletz	40712	7280
EUCHRE	Siletz	40704	6618
CERINE	Siletz	40507	6529
GRAVEL	Siletz	40501	6081
U. CEDAR	Siletz	40703	5792
SUNSHINE	Siletz	40504	5660
ROOT	Siletz	40705	5643
BOULDER	Siletz	40403	5575
SAMPSON	Siletz	40809	5521

[1] Anadromous migration barriers affect this watershed and may affect other watersheds. See text for details.

3.5.2 Functioning winter steelhead habitat

The Functioning Winter Steelhead Habitat Analysis is a 6th field ranking described in detail in the **Main Report** (**Aquatic habitats: Functioning winter steelhead habitat**). This analysis is designed to answer the question, "Which 6th field watersheds have average conditions most suitable for winter steelhead?" Briefly, we ranked 6th fields using a several factors that are important to winter steelhead during the summer and winter. As requested by MCWC, we included the following factors: length of riffle habitat; length of riffle habitat with gravel-to-boulder-sized substrate dominant; and length of potential habitat (moderate-gradient, confined streams). Data on riffle length and substrates were taken from aquatic habitat surveys conducted within the past 10 years.

Sixth field watersheds ranked highest for functioning winter steelhead habitat *across the entire study area* are described in the **Main Report** and shown in **Figure AQ-23**. In this basin report section, we present the highest-ranked 6th fields *within the basin.* Data that led to the rankings are found in the 6th field aquatic habitats summary shapefile (**aqhab_sum_final.shp**).

Table 3.7 shows the 10 sixth field watersheds that were ranked highest (out of the 52 in the basin) for functioning winter steelhead habitat. Possible ranks range from 1 (best) to 100 (worst) across the entire study area (all basins). Sixth field watershed names and codes shown are those found in the MCWC 6th field layer (**6th_field.shp**).

Although the South Fork Siletz watershed ranks high in this analysis, it is affected by the migration barrier formed by Siletz Falls. Siletz Falls has a fish ladder and trap, but only summer steelhead are being passed through the trap to the ladder.

Table 3.7. 6th field watersheds ranked highest for functioning winter steelhead habitat within the Siletz basin.

6th field watershed name	6th field ID code	Rank (scale of 100, 1 is best)
EUCHRE	40704	8.20
SF_SILETZ[1]	40410	10.37
CERINE	40507	12.11
LITTLE_ROCK	40606	14.42
BIG_ROCK	40601	17.79
GRAVEL	40501	18.67
GORDY/L. DRIFT	40811	19.63
U. CEDAR	40703	24.99
BENTILLA	40712	31.23
ROOT	40705	32.81

[1] Anadromous migration barriers affect this watershed and may affect other watersheds. See text for details.

In general, all three factors (riffles, gravel-to-boulder substrate, and potential habitat) were important in creating the high rankings for the sixth fields listed above. There were some exceptions: The Upper Cedar, Bentilla and Roots Creek 6th field watersheds did not have particularly high rankings for riffle length or gravel-to-boulder-sized substrate, so length of potential habitat (moderate-gradient, confined streams) was important for these watersheds. By contrast, length of potential habitat was not important for the Gordy/Lower Drift Creek sixth field watershed; this watershed had relatively high rankings for riffle length and gravel-to-boulder-sized substrates. The South Fork Siletz ranked highest in the entire study area for length of potential habitat (49.4 km).

4 Erosion and shallow landslide risk

Although debris and sediments have been entering the streams of Oregon Coast Range since before the time of European settlement, the frequency, duration and intensity of mass wasting events is of concern (see **Appendix B: Ecosystem Processes**). Mass wasting events (such as landslides and debris flows) add both coarse and fine sediments to streams along with organic debris (i.e., LWD). The quality of in-stream conditions, especially salmonid habitat, can be dramatically affected by patterns in material transport to streams (see **Appendix B: Ecosystem Processes**). We performed a series of risk assessments that identify 6th field watersheds that are 'at risk' for three types of mass wasting events: (1) soil erosion risk, (2) shallow landslide risk, and (3) debris flows that could potentially transport LWD from riparian zones to streams.

4.1 Soil erosion risk

Erosion risk was determined for most soil types occurring in the study area (see Soil Erosion Risk). We then used ARCView to sum the area of each 6th field watershed covered by soils determined to have a "severe" risk of erosion. The following ten 6th field watersheds in the Siletz River basin had more than 75% of their area occupied by the most severe risk category of soils: 40401, 40404, 40406, 40408, 40409, 40502, 40503, 40702, 40808, and 40809. One way to use this information in planning is to avoid disturbing soils at times when precipitation would wash soils into streams or plan on leaving wide vegetated buffer strips to trap eroding sediments. Another way to use this information is to combine risk of soil erosion with other factors such as risk of shallow landslides (see below), in a multi-factor analysis.

4.2 Shallow landslide risk

Aside from the ODF debris flow hazard maps and a few mapped landslides, there was not much information with which to rank 6th field watersheds for shallow landslide risk (see **Main Report**, **Sediment Sources: Landslides**). We relied on work done by team in the State of Washington that compared several models that predicted landslide risk. Discussions with the authors of that report (Vaugeois, personal communication, 1999, see **Appendix A: Supplemental Methods**) suggested that the default settings of the SMORPH model should provide a good approximation of landslide risk in the northern section of the Oregon Coast Range, especially at the 6th field watershed level. Indeed, the first step in model calibration is to run the model without calibration and then compare model output with spatially explicit landslide inventories. SMORPH ranks each 10 X 10 m grid cell as having a “low”, “medium” or “high” risk of shallow landslides. The model is influenced primarily by slope and topographic concavity, both derived from the DEM grid. Therefore, we used an uncalibrated model to assess landslide risk in the study area. We strongly suggest that the model output be used only in a general sense (i.e., on a 6th field watershed basis) and that model calibration be performed before using SMORPH to assess particular sites.

As with the soil erosion risk analysis, we ranked each 6th field watershed by the proportion of its area occupied by the ‘high’ risk category. Surprisingly, areas occupied by ‘high’ risk grid cells did not account for more than 50% of any of the 6th field watersheds. In the Siletz River basin thirty-seven 6th field watersheds had more than 25% of their area identified by SMORPH as being “high” risk for a shallow landslide. The top three 6th field watersheds in terms of proportion of their area at “high” risk were 40503 (39.9%), 40808 (39.8%), and 40409 (37.8%).

This information is useful in helping to identify 6th field watersheds that may have large areas prone to shallow landslides. We recommend that detailed landslide information be collected and used to calibrate this model. A calibrated model would be useful in identifying specific locations within the watershed that may be prone to shallow landslide. Land use actions could then be planned so that they avoid these areas whenever possible.

4.3 Combined soil erosion / shallow landslide risk

Finally, we performed a multi-factor analysis by combining information from the erodible soils and shallow landslide risk assessments. We used ARCView to create a shapefile depicting the “high risk” category from the SMORPH model. Due to the size and complexity of this layer, we used ARCView to intersect the SMORPH shapefile with highly erodible soils for each major river basin separately. This resulted in a single shapefile that contained both risk of soil erosion and of shallow landslide. The final step in this analysis was to rank each 6th field by the proportion of its area that met these two criteria.

Table 4.1 shows the 6th field watersheds in the basin that have more than 25% of their area at high risk for both soil erosion and shallow landslides.

TABLE 4.1. 6th Field Watersheds in the Siletz Basin that had more than 25% of their area occupied by areas with both erodible soils and high risk of shallow landslide.

6th field watershed name	6th field ID code	Proportion of 6th Field area
WILDCAT	40808	0.36
BUCK	40503	0.33
SAMPSON	40809	0.32
ELK	40502	0.32
BEAR/SKUNK	40702	0.31
LOWER BOULDER	40404	0.29
DRIFT	40409	0.29
UPPER_NF_SILETZ	40407	0.27
EUCHRE	40704	0.25

Both the SMORPH model output and the soils maps contain a great deal of detail and may be very important data sets for site specific planning. We have provided these data to MCWC, and we recommend that these data be field checked.

5 Peak flow impact

Water movement is an important factor in structuring ecosystems in the Oregon Coast Range. Water arrives in the watershed as precipitation (rain or snow), then moves across the land surface and into the stream network. Many factors affect the water’s capacity to erode and transport soils, sediments and pollutants. For example, vegetation can reduce the impact of rain on soils or increase water storage capacity by slowing the movement of water as it moves down slope. Vegetation can also affect snow accumulation at higher elevations. In areas of higher elevation snow can accumulate in treeless areas. The snow can prevent infiltration of rainfall, so that if rain then falls on the snow, water can move quickly across the watershed into the stream network. This can result in high peak stream flows. Just as snow prevents rain from infiltrating soils in the upper watershed, impervious surfaces (roads and parking lots) can quickly route water into stream networks during precipitation events. Thus, both rain-on-snow and roaded areas can affect peak stream flows.

5.1 Rain-on-snow

Rain-on-Snow analysis identifies those areas within the watershed that ***could potentially*** experience increases in peak-flows under certain weather conditions. The Siletz River Basin had the second greatest potential for Rain-on-Snow events of the six MidCoast sub-regions. Generally, 10 of the 52 6th field watersheds in the Siletz River sub-region have potential for Rain-on-Snow events (40401, 40402, 40403, 40406, 40407, 40408, 40409, 40410, 40502 and 40410) and three of these 6th field watersheds have areas where the elevation exceeds 3000 ft. Fortunately, the CLAMS95 data show that there are no open areas within these zones of high elevation; therefore, the risk for Rain-on-Snow is minimal.

5.2 Roads

The impact of roads on peak flows can be assessed in several ways. Most important is to have a good map representation of where the roads actually are. Our assessment is based on the 100K roads layer because it was the best roads layer that was available for the entire study area. We estimate that the 100K roads layer may under-represent the actual frequency of roads in the watershed by about 38%, so the impact of roads on peak flows may also be underestimated using this dataset.

We used two methods for determining possible peak flow impacts from roads: a method that uses urban/residential road density as a surrogate for total impervious area, and a method that analyzes rural roads as a percent of watershed area (Watershed Professionals Network 1999). We found that for the fifty-two 6th fields in the Siletz River Basin, the average potential for peak-flow impact from roads was among the highest calculated in this study (the basin was ranked No. 2 out of the 6 basins). However, only two 6th field watersheds were at risk (i.e., 40404 and 40402) using the Total Impervious Surface benchmarks. These two 6th fields were not at risk using the Rural Road density benchmarks. Since these 6th fields were in rural areas, the Rural Road density method is the more appropriate method.

6 Restoration

6.1 Large Woody Debris placement areas

In this analysis, we used Rapid Bioassessment (RBA) data and aquatic habitat survey data (AQI data) to answer a specific question: What are some suitable locations for in-stream placement of large woody debris? This question is one of MCWC's top priorities for the next phase in watershed assessment and action planning using GIS.

Priority areas for placement of large woody debris (LWD) would be low-gradient, mid-sized streams (coho rearing habitat) which are currently being used by coho, but which currently have low quantities of LWD. It makes sense to look for reaches with high average juvenile coho densities (not just individual pools with high densities).

Using the ODFW habitat benchmarks (Watershed Professionals Network 1999) and ODFW and USFS aquatic habitat inventory data, we first selected stream reaches with undesirably low levels of LWD (less than 10 pieces of LWD per 100m). We then created 100m buffers around each selected stream reach. We then intersected the **RBA snorkel survey data** with the buffer polygons and averaged 1998-99 RBA juvenile coho/sq m for each buffer unit. We then joined the summary layer to the buffer layer to allow symbolization of the buffer layer by coho/sq m. The resulting shapefile is **lowlwd_rba_15oct.shp**.

Figure REC-1SI shows the results for the Siletz Basin. In general, AQI data in GIS form were lacking for areas where the RBA survey showed high juvenile coho densities. Portions of Sunshine Creek had an average juvenile coho density of 0.56 coho/sq m and also had low LWD. Portions of Fourth of July Creek had high coho densities but lacked AQI data in GIS form. The same was true Long Prairie Creek and one of its tributaries, and upper Sams Creek, William Creek, and several other areas. AQI surveys (or placement of existing AQI data into the GIS) are recommended for these streams (see below).

When using the results of this analysis, it is important to remember that both the RBA data and the AQI data available in GIS format cover only limited portions of the stream network. It is likely that RBA and/or AQI data were missing for some areas that would benefit from LWD placement. Since many streams in the study area have low levels of LWD, the RBA data alone could be used to target LWD placement for areas lacking AQI data; or the RBA data could be used to select areas for further AQI data collection to improve data coverage (see **Data Recommendations** in **Main Report**). Collection of additional AQI and RBA data would improve the analysis.

6.2 Potential floodplain restoration sites

This analysis was designed to answer the question, "Where in the watershed are some potential floodplain restoration sites?" Potential floodplain restoration sites would be former floodplains (diked, drained, or otherwise altered) that do not have land uses incompatible with floodplain restoration. To locate potential floodplains, we used the DEM-derived slope GIS layer as described below. To locate areas that do not have incompatible land uses, we used the DLCD generalized zoning layer as described below

In this multi-factor analysis, we used ARCView to perform a series of GIS layer "intersections" (a command available in the Geoprocessing Wizard of ARCView) to combine information from zoning and slope GIS layers onto the derived streams layer (**ST-1400**). This produced a single streams layer containing all of the information from the single factor analyses.

Before summarizing information in this newly created GIS layer, we manually removed stream segments where there was a lot of "flagging" on the derived streams layer (see **Appendix A: Supplemental Methods**).

To address the issue of incompatible land uses, we removed from consideration all stream segments that passed through property zoned as "urban", "rural residential", rural industrial", "rural commercial", and "rural service center" since these are unlikely areas for restoration projects.

To locate potential floodplains, we selected stream segments that flow through 'flat' areas (areas that had less than 5% slope). The 5% slope threshold was determined during the stream confinement analysis (**Main Report**, **Aquatic habitats: Stream confinement from DEMs**). Since it probably would not be practical to attempt to restore floodplains along very short segments of streams, we then selected those stream segments longer than 500m that flowed through these 'flat areas.' (In case the Council wishes to conduct further analyses using these data, we retained the shorter segments in the layer, but simply selected those longer than 500m for summarization and display on the maps.)

Information from this analysis is presented in two forms, as a summary showing the total stream length per 6th field meeting our selection criteria and as a sub-6th field map showing actual locations for stream restoration projects. Please note that stream lengths should be used as a relative measure of the amount of suitable (potential) floodplain restoration sites because stream lengths may be exaggerated, especially in low relief areas (e.g., along the coast) where the stream derivation algorithms had trouble placing the stream channel and stream “flagging” occurred.

Figure REC-2SI shows the stream segments identified as having potential floodplain restoration sites. There were six 6th field watersheds (40410, 40712, 40606, 40507,40710, and 40506) in the Siletz River basin that had more than 20 km of stream identified as potential floodplain restoration sites. This includes one 6th field (40410) that had more than 53 km of streams matching our criteria, the highest in the Midcoast study area.

7 References

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Yachats Basin Insert

Important: This Basin Insert is a part of the MidCoast Sixth Field Watershed Assessment and is intended for use only with the full report. Please contact the MidCoast Watersheds Council at (541) 265-9195 for information on how to obtain the full report.

Table of Contents

1 Introduction

This basin insert is a supplement to the MidCoast Sixth Field Watershed Assessment and is intended for use only with the full report. This insert focuses on basin-specific results for a subset of the analyses conducted in the assessment, but provides little background, setting, methods or interpretation. Therefore, it is important to read the **Main Report** before using this Insert. If this basin insert has been separated from the **Main Report**, contact the MidCoast Watersheds Council (MCWC) at (541) 265-9195 for information on how to obtain the full report.

2 Setting

Setting for the MidCoast Sixth Field Watershed Assessment is described in the **Main Report**, as are summaries that compare the different basins. To provide details useful to local watershed groups, this basin insert contains several maps depicting features at a scale below that of the sixth field watershed.

2.1 Location

General features of the Yachats Basin are shown in **Figure SET-2YA**. Not all stream names are shown; names shown are those contained in the 100K streams layer (**mc_rivs**$^{\mathbf{M}}$). The location of the basin relative to the rest of the study area is shown in the general locator map (**Figure SET-1** in the **Main Report**).

2.2 Sixth field watershed boundaries

Boundaries of sixth field watersheds, and the watershed codes used in this analysis, are shown in **Figure SET-3YA**. The source of these boundaries, and the way we used them, are described in the **Main Report** (**Setting: 6th field watersheds**).

2.3 Zoning

DLCD generalized land use zoning categories are shown in **Figure SET-4YA**. Categories are described in the **Main Report** (**Setting: Land use zoning**).

The vast majority of the basin is zoned for Forestry use. Agricultural use areas are located alnog the mainstem Yachats River, and in the lower North Fork Yachats River. The City of Yachats is the only Urban zoning in the basin. Two areas zoned Rural Residential are located along the Yachats river.

2.4 Land ownership

Major land ownership categories, and a breakdown of major private industrial landowners, are shown in **Figure SET-5YA**. The major industrial landowners shown separately are the top 5 ranked by acreage owned within the entire study area.

The predominant landowner in the basin is the USFS. There are several fairly large private timber company holdings, including Simpson, Willamette, Georgia-Pacific, and Boise Cascade. BLM and the State of Oregon own small areas.

2.5 Hydric soils

Hydric soils mapped by NRCS and provided in GIS digital soils coverages are shown in **Figure SET-7YA**. Further information on the nature of hydric soils and why they are important to the watershed assessment is found in the **Main Report** (**Setting: Hydric soils** and **Aquatic habitats: Wetlands**).

Major areas of hydric soils are located along the mainstem Yachats River, and in the lower valleys of several tributaries including Carson Creek, Helms Creek, Grass Creek, Fish Creek, Williamson Creek and the North Fork Yachats River. These areas of hydric soils associated with streams may provide good locations for restoration of off-channel habitat, backwater wetlands, active floodplains and similar habitats for anadromous fish.

2.6 Lithology

General lithology is shown in **Figure SET-8YA**, with underlying formations color-coded by major types (sedimentary, igneous, and quaternary). These formations (and the importance of lithology in watershed assessment) are described in the **Main Report** (**Setting: Lithology**).

Underlying geologic formations are primarily sedimentary in the upper watershed, and igneous in the lower watershed near the coast. Quaternary alluvial formations are found in the valley of the Yachats River.

3 Salmon and salmonid habitat

3.1 Rapid Bioassessment juvenile coho density

The Rapid Bioassessment (RBA) project (begun in 1998) provides data on distribution and abundance of juvenile coho, based on snorkel surveys of pools in the study area (see **Main Report**, **Species of concern: Rapid bioassessment**). We analyzed the RBA data to determine average coho per square meter for each 6th field watershed, based on pools within the observed distribution of coho in each stream in 1998 and 1999 (see methods described in **Main Report**). We weighted the average values by the number of pools snorkeled in each year to normalize results. We also summed the number of pools surveyed in 1998 and 1999 for each 6th field. Sixth fields with less than 10 pools snorkeled during 1998 and 1999 are indicated with a red outline on the map showing coho per square meter (**Figure SOC-8** in the **Main Report**). Caution should be exercised when interpreting results from basins with a limited number of observations.

The Rapid Bioassessment reports describe the year-to-year variability in fish counts and density when the same stream is snorkeled two years in a row (Bio-Surveys 1998, 1999). Understanding this variability is important to interpreting the data.

Average juvenile coho densities by 6th field watershed across the entire study area are discussed in the **Main Report** (**Species of concern: Salmonids: Distribution**); these average densities are shown on **Figure SOC-8**. **Table 3.1** shows the Yachats Basin 6th field watersheds that had the highest average juvenile coho densities in 1998-99 (excluding those watersheds that had less than 10 pools snorkeled). The 6th field watershed names and codes shown are those found in the MCWC 6th field watershed coverage, **6th_field.shp**.

Table 3.1. 6th field watersheds within the Yachats Basin that had highest average juvenile coho densities during 1998-99 Rapid Bioassessment surveys

6th field watershed name	6th field ID code	# of pools surveyed, 1998-99	Average coho/sq m, 1998-99
U. YACHATS	50513	101	0.5418
SCHOOL	50511	61	0.3935
NORTH YACHATS	50508	199	0.3605

Figure SOC-9YA shows the locations of surveyed pools for 1998 and 1999, color-coded by average juvenile coho density in each pool. This map can be used to locate individual stream segments that had juvenile coho "hot spots," for use in action planning below the 6th field watershed level.

Rapid Bioassessment data provide the most comprehensive field-based data available on coho distribution and population in the study area. However, not all streams have been surveyed and, therefore, 6th field watersheds cannot be evaluated on Rapid Bioassessment data alone. The RBA data should be used to focus restoration efforts on those streams which are currently used by coho. The RBA data can also be used to focus further monitoring efforts. For example, where watershed conditions appear to be suitable for juvenile coho production and rearing, but RBA data show that coho are absent, further investigation is recommended to determine possible reasons for their absence such as migration barriers. Repeated RBA surveys on the same stream segments will be very useful for determining year-to-year variability in coho distribution and populations, which will help interpret the results of individual years' data.

3.2 Multi-factor analyses of salmonid habitat

As described in the **Main Report**, we conducted several multi-factor analyses of coho and winter steelhead habitat. Please read the **Main Report** for important details on the methods used for these analyses. The analyses were conducted using combinations of stream channel characteristics (derived from DEMs), AHI data, soils data, and coho juvenile survey data.

As described in the **Main Report**, no GIS data on anadromous migration barriers appropriate for ranking 6th field watersheds were available for this assessment, so we were not able to incorporate effects of barriers into these multi-factor analyses. Therefore, a limitation of this analysis is the fact that some top-ranked watersheds (or portions thereof) may be inaccessible to anadromous fish. Barriers can be either natural (such as falls) or artificial (such as culverts). **We recommend that when MCWC uses the results of these analyses for prioritizing management actions, they should refine the prioritization by adding local knowledge to the discussion.** Such local knowledge should include locations of fish barriers and other factors influencing choice and siting of management actions. MCWC should also seek to acquire new data on such factors to fill data gaps, as described in **Data collection and monitoring recommendations** in the **Main Report**.

3.3 Coho winter habitat

3.3.1 Potential coho winter habitat

The Potential Coho Winter Habitat analysis is an example of a multi-factor analysis that answers a specific question at the stream reach level. This analysis is designed to answer the question, "Where are stream segments with physical characteristics that make them potentially suitable for coho winter habitat?" As requested by MCWC, we included the following components in our analysis of potential coho winter habitat:

1. Gradient (criterion: low-gradient, 0 - 2 degrees = 0 - 3.5% slope)
2. Confinement (criterion: unconfined)
3. Soils (criterion: hydric)

Working with the DEM-derived streams layer (**derived_streams.zip**, shapefile name **st1400-c.shp**), we used ARCView to query the attributes of stream segments that met the criteria of low gradient and unconfined. We then selected those low-gradient, unconfined segments that flow over hydric soils as shown in the NRCS digital soil survey data.

Only two 6th field watersheds in the Yachats Basin had over 500m of potential coho winter habitat. **Table 3.2** shows these watersheds.

Table 3.2. 6th field watersheds in the Yachats Basin with greatest length of potential coho winter habitat			
6th field watershed name	**Major basin**	**6th field ID code**	**Length of potential coho winter habitat (m)**
YACHATS	Yachats	50512	5617
NORTH YACHATS	Yachats	50508	2567

The specific stream reaches identified as potential habitat in this analysis are shown in **Figure AQ-18YA**. The figure also shows coho habitat as mapped by ODFW. Due to lack of appropriate GIS data (as described above), it was not possible to incorporate information on natural barriers into this analysis. Therefore, the potential habitat map may show areas that are inaccessible to fish. The ODFW habitat mapping may be useful in locating such areas; local knowledge should also be used to supplement the mapping.

3.3.2 Functioning coho winter habitat

The Functioning Coho Winter Habitat Analysis is a 6th field ranking described in detail in the **Main Report** (**Aquatic habitats: Functioning coho winter habitat**). This analysis is designed to answer the question, "Which 6th field watersheds have average conditions most suitable for overwintering coho juveniles?" Briefly, we ranked 6th fields using factors that influence coho winter habitat. As requested by MCWC, we included the following factors: percent pools, channel widths per pool, large woody debris frequency, length of side channels, and length of potential habitat (low-gradient, unconfined streams flowing through hydric soils). All of the data except potential habitat were taken from aquatic habitat surveys conducted within the past 10 years.

Sixth field watersheds ranked highest for functioning coho winter habitat *across the entire study area* are described in the **Main Report** and shown in **Figure AQ-21**. In this basin report section, we present the highest-ranked 6th fields *within the basin.* Data that led to the rankings are found in the 6th field aquatic habitats summary shapefile (**aqhab_sum_final.shp**).

The Yachats Basin contains 6 sixth field watersheds. **Table 3.3** shows the 3 sixth field watersheds that were ranked highest in the basin for functioning coho winter habitat. Possible ranks range from 1 (best) to 100 (worst) across the entire study area (all basins). Sixth field watershed names and codes shown are those found in the MCWC 6th field layer (**6th_field.shp**).

Table 3.3. 6th field watersheds ranked highest for functioning coho winter habitat within the Yachats basin.		
6th field watershed name	**6th field ID code**	**Rank (scale of 100, 1 is best)**
NORTH YACHATS	50508	31.00
U. YACHATS	50513	35.43
YACHATS	50512	47.79

For the Yachats Basin, the three subwatersheds ranked highest for coho winter habitat achieved that ranking because of relatively high length of side channels (North Yachats, Upper Yachats) and length of potential habitat (North Yachats, Yachats).

3.4 Coho summer habitat

3.4.1 Potential coho summer habitat

The potential coho summer habitat analysis is an example of a multi-factor analysis that answers a specific question at the stream reach level. This analysis is designed to answer the question, "Where are stream segments with physical characteristics that make them potentially suitable for coho summer habitat?" As requested by MCWC, we included the following components in our analysis of potential coho summer habitat:

1. Gradient (criterion: low-gradient, 0 - 2 degrees = 0 - 3.5% slope)
2. Confinement (criterion: unconfined)

Working with the ***DEM-derived streams layer***, we used ArcView to query the attributes of stream segments to find those that met the criteria of low gradient and unconfined.

Table 3.4 shows the length of potential coho summer habitat in the Yachats Basin 6th field watersheds.

The specific stream reaches identified as potential habitat in this analysis are shown in **Figure AQ-19YA**. The figure also shows coho habitat as mapped by ODFW. Due to lack of appropriate GIS data (as described above), it was not possible to incorporate information on natural barriers into this analysis. Therefore, the potential habitat map may show areas that are inaccessible to fish. The ODFW habitat mapping may be useful in locating such areas; local knowledge should also be used to supplement the mapping.

Table 3.4. 6th field watersheds in the Yachats Basin, with length of potential coho summer habitat in each watershed.

6th field watershed name	Major basin	6th field ID code	Length of potential coho summer habitat (m)
YACHATS	Yachats	50512	10875
L. YACHATS	Yachats	50510	8641
NORTH YACHATS	Yachats	50508	3101
U. YACHATS	Yachats	50513	1134
SCHOOL	Yachats	50511	796
STUMP	Yachats	50514	126

3.4.2 Functioning coho summer habitat

The Functioning Coho Summer Habitat Analysis is a 6th field ranking described in detail in the **Main Report** (**Aquatic habitats: Functioning coho summer habitat**). This analysis is designed to answer the question, "Which 6th field watersheds have average conditions most suitable for coho summer habitat?" Briefly, we ranked 6th fields using a several factors that are important to coho juveniles during the summer. As requested by MCWC, we included the following factors: percent pools, channel widths per pool, large woody debris frequency, percent shading of stream channels, length of riffle habitats with gravel substrate dominant, length of riffle habitats with bedrock substrate dominant (this factor reduced the ranking), length of potential habitat (low-gradient, unconfined streams flowing through hydric soils), and juvenile coho densities from Rapid Bioassessment surveys. Data on pools, LWD, shade, and substrates were taken from aquatic habitat surveys conducted within the past 10 years.

Sixth field watersheds ranked highest for functioning coho summer habitat *across the entire study area* are described in the **Main Report** and shown in **Figure AQ-22**. In this basin report section, we present the highest-ranked 6th fields *within the basin.* Data that led to the rankings are found in the 6th field aquatic habitats summary shapefile (**aqhab_sum_final.shp**).

Table 3.5 shows the 3 sixth field watersheds that were ranked highest (out of the 6 sixth fields in the basin) for functioning coho summer habitat. Possible ranks range from 1 (best) to 100 (worst) across the entire study area (all basins). Sixth field watershed names and codes shown are those found in the MCWC 6th field layer (**6th_field.shp**).

Table 3.5. 6th field watersheds ranked highest for functioning coho summer habitat within the Yachats basin.

6th field watershed name	6th field ID code	Rank (scale of 100, 1 is best)
U. YACHATS	50513	35.43
NORTH YACHATS	50508	42.96
YACHATS	50512	48.51

For the Yachats Basin, the three subwatersheds ranked highest for coho summer habitat achieved that ranking because of length of riffles with gravel substrate dominant, and length of potential habitat (low-gradient, unconfined streams).

3.5 Winter steelhead habitat

3.5.1 Potential winter steelhead habitat

The potential winter steelhead habitat analysis is an example of a multi-factor analysis that answers a specific question at the stream reach level. This analysis is designed to answer the question, "Where are stream segments with physical characteristics that make them potentially suitable for winter steelhead habitat?" As requested by MCWC, we included the following components in our analysis of potential winter steelhead habitat:

1. Gradient (criterion: moderate gradient, 1-5 degrees = 1.75 - 8.75% slope)
2. Confinement (criterion: confined)

We used the 1.75 - 8.75% slope gradient because it was the closest we could come to the 2 - 8% slope range requested by MCWC, using the DEM-derived stream gradient coverage. Working with the DEM-derived streams layer, we used ARCView to query the attributes of stream segments to locate those that met the criteria of moderate gradient and confined.

Table 3.6 shows the length of potential winter steelhead habitat (moderate-gradient, confined streams) in the Yachats Basin 6th field watersheds.

Table 3.6. 6th field watersheds in the Yachats Basin, with length of potential winter steelhead habitat in each watershed.

6th field watershed name	Major basin	6th field ID code	Length of potential winter steelhead habitat (m)
NORTH YACHATS	Yachats	50508	5881
YACHATS	Yachats	50512	4572
L. YACHATS	Yachats	50510	4238
U. YACHATS	Yachats	50513	3006
STUMP	Yachats	50514	2086
SCHOOL	Yachats	50511	1336

The specific stream reaches identified as potential habitat in this analysis are shown in **Figure AQ-20YA**. The figure also shows winter steelhead habitat as mapped by ODFW. Due to lack of appropriate GIS data (as described above), it was not possible to incorporate information on natural barriers into this analysis. Therefore, the potential habitat map may show areas that are inaccessible to fish. The ODFW habitat mapping may be useful in locating such areas; local knowledge should also be used to supplement the mapping.

3.5.2 Functioning winter steelhead habitat

The Functioning Winter Steelhead Habitat Analysis is a 6th field ranking described in detail in the **Main Report** (**Aquatic habitats: Functioning winter steelhead habitat**). This analysis is designed to answer the question, "Which 6th field watersheds have average conditions most suitable for winter steelhead?" Briefly, we ranked 6th fields using a several factors that are important to winter steelhead during the summer and winter. As requested by MCWC, we included the following factors: length of riffle habitat; length of riffle habitat with gravel-to-boulder-sized substrate dominant; and length of potential habitat (moderate-gradient, confined streams). Data on riffle length and substrates were taken from aquatic habitat surveys conducted within the past 10 years.

Sixth field watersheds ranked highest for functioning winter steelhead habitat *across the entire study area* are described in the **Main Report** and shown in **Figure AQ-23**. In this basin report section, we present the highest-ranked 6th fields *within the basin.* Data that led to the rankings are found in the 6th field aquatic habitats summary shapefile (**aqhab_sum_final.shp**).

Table 3.7 shows the 3 sixth field watersheds that were ranked highest (out of the 6 sixth fields in the basin) for functioning winter steelhead habitat. Possible ranks range from 1 (best) to 100 (worst) across the entire study area (all basins). Sixth field watershed names and codes shown are those found in the MCWC 6th field layer (**6th_field.shp**).

Table 3.7. 6th field watersheds ranked highest for functioning winter steelhead habitat within the Yachats basin.

6th field watershed name	6th field ID code	Rank (scale of 100, 1 is best)
NORTH YACHATS	50508	7.51
L. YACHATS	50510	11.53
YACHATS	50512	15.80

In general, all three factors (riffles, gravel-to-boulder substrate, and potential habitat) were important in creating the high rankings for the sixth field watersheds of the Yachats Basin. The NorthYachats watershed was among the highest in the entire study area for length of riffle habitat with gravel-to-boulder-sized substrate dominant (10.8 km).

4 Erosion and shallow landslide risk

Although debris and sediments have been entering the streams of Oregon Coast Range since before the time of European settlement, the frequency, duration and intensity of mass wasting events is of concern (see **Appendix B: Ecosystem Processes**). Mass wasting (such as landslides and debris flows) adds both coarse and fine sediments to streams along with organic debris (i.e., LWD). The quality of in-stream conditions, especially salmonid habitat, can be dramatically affected by patterns in material transport to streams (see **Appendix B: Ecosystem Processes**). We performed a series of risk assessments that identify 6th field watersheds that are ‘at risk’ for three types of mass wasting events: (1) soil erosion risk, (2) shallow landslide risk, and (3) debris flows that could potentially transport LWD from riparian zones to streams.

4.1 Soil erosion risk

Erosion risk was determined for most soil types occurring in the study area (see **Main Report**, **Sediment Sources: Surface erosion: Soils**). We then used ARCView to sum the area of each 6th field watershed covered by soils determined to have a “severe” risk of erosion. None of the 6th field watersheds in the Yachats River basin had more than 75% of their area occupied by the most severe risk category of soils. One way to use this information in planning is to avoid disturbing soils at times when precipitation would wash soils into streams or plan on leaving wide vegetated buffer strips to trap eroding sediments. Another way to use this information is to combine risk of soil erosion with other factors such as risk of shallow landslides (see below), in a multi-factor analysis.

4.2 Shallow landslide risk

Aside from the ODF debris flow hazard maps and a few mapped landslides, there was not much information with which to rank 6th field watersheds for shallow landslide risk (see **Main Report**, **Sediment Sources: Landslides**). We relied on work done by a team in the State of Washington that compared several models that predicted landslide risk. Discussions with the authors of that report (Vaugeois, personal communication, 1999, see **Appendix A: Supplemental Methods**) suggested that the default settings of the SMORPH model should provide a good approximation of landslide risk in the northern section of the Oregon Coast Range, especially at the 6th field watershed level. Indeed, the first step in model calibration is to run the model without calibration and then compare model output with spatially explicit landslide inventories. SMORPH ranks each 10 X 10 m grid cell as having a "low", "medium" or "high" risk of shallow landslides. The model is influenced primarily by slope and topographic concavity, both derived from the DEM grid. Therefore, we used an uncalibrated model to assess landslide risk in the study area. We strongly suggest that the model output be used only in a general sense (i.e., on a 6th field watershed basis) and that model calibration be performed before using SMORPH to assess particular sites.

As with the soil erosion risk analysis, we ranked each 6th field watershed by the proportion of its area occupied by the 'high' risk category. Surprisingly, areas occupied by 'high' risk grid cells did not account for more than 50% of any of the 6th field watersheds. In the Yachats River basin six 6th field watersheds had more than 25% of their area identified by SMORPH as being "high" risk for a shallow landslide. The top three 6th field watersheds in terms of proportion of their area that were at "high" risk were 50514 (36.8%), 50511 (34.9%), and 50513 (32.7%).

This information is useful in helping to identify 6th field watersheds that may have large areas prone to shallow landslides. We recommend that detailed landslide information be collected and used to calibrate this model. A calibrated model would be useful in identifying specific locations within the watershed that may be prone to shallow landslide. Land use actions could then be planned so that they avoid these areas whenever possible.

4.3 Combined soil erosion / shallow landslide risk

Finally, we performed a multi-factor analysis by combining information from the erodible soils and shallow landslide risk assessments. We used ARCView to create a shapefile depicting the "high risk" category from the SMORPH model. Due to the size and complexity of this layer, we used ARCView to intersect the SMORPH shapefile with highly erodible soils for each major river basin separately. This resulted in a single shapefile that contained both risk of soil erosion and of shallow landslide. The final step in this analysis was to rank each 6th field by the proportion of its area that met these two criteria.

The results of this analysis indicate that none of the 6th field watersheds in the Yachats Basin had more than 25% of their area in the high risk category for both soil erosion and shallow landslides. However, specific areas within the watershed may be at high risk for both factors. Both the SMORPH model output and the soils maps contain a great deal of detail and may be very important data sets for site specific planning. We have provided these data to MCWC, and we recommend that these data be field checked.

5 Peak flow impact

Water movement is an important factor in structuring ecosystems in the Oregon Coast Range. Water arrives in the watershed as precipitation (rain or snow), then moves across the land surface and into the stream network. Many factors affect the water's capacity to erode and transport soils, sediments and pollutants. For example, vegetation can reduce the impact of rain on soils or increase water storage capacity by slowing the movement of water as it moves down slope. Vegetation can also affect snow accumulation at higher elevations. In areas of higher elevation snow can accumulate in treeless areas. The snow can prevent infiltration of rainfall, so that if rain then falls on the snow, water can move quickly across the watershed into the stream network. This can result in high peak stream flows. Just as snow prevents rain from infiltrating soils in the upper watershed, impervious surfaces (roads and parking lots) can quickly route water into stream networks during precipitation events. Thus, both rain-on-snow and roaded areas can affect peak stream flows.

5.1 Rain-on-snow

Rain-on-Snow analysis identifies those areas within the watershed that ***could potentially*** experience increases in peak-flows under certain weather conditions. The Yachats River Basin had the lowest potential for Rain-on-Snow events of the six MidCoast sub-regions. None of the six 6th field watersheds in the Yachats Basin had potential for Rain-on-Snow events because the elevation, for the most part, did not exceed 2000 feet in the sub-region.

5.2 Roads

The impact of roads on peak flows can be assessed in several ways. Most important is to have a good map representation of where the roads actually are. Our assessment is based on the 100K roads layer because it was the best roads layer that was available for the entire study area. We estimate that the 100K roads layer may under-represent the actual frequency of roads in the watershed by about 38%, so the impact of roads on peak flows may also be underestimated using this dataset.

We used two methods for determining possible peak flow impacts from roads: a method that uses urban/residential road density as a surrogate for total impervious area, and a method that analyzes rural roads as a percent of watershed area (Watershed Professionals Network 1999). We found that for the six 6th fields in the Yachats River Basin, the average potential for peak-flow impact from roads was among the lowest calculated in this study (the basin was ranked No. 4 out of the 6 basins). Using the Total Impervious Surface or Rural Road Density methods, there were no 6th field watersheds identified as being at risk for peak-flow impacts from roads.

6 Restoration

6.1 Large Woody Debris placement areas

We used Rapid Bioassessment (RBA) data and aquatic habitat survey data (AQI data) to answer a specific question: What are some suitable locations for in-stream placement of large woody debris? This question is one of MCWC's top priorities for the next phase in watershed assessment and action planning using GIS.

Priority areas for placement of large woody debris (LWD) would be low-gradient, mid-sized streams (coho rearing habitat) which are currently being used by coho, but which currently have low quantities of LWD. It makes sense to look for reaches with high average juvenile coho densities (not just individual pools with high densities).

Using the ODFW habitat benchmarks (Watershed Professionals Network 1999) and ODFW and USFS aquatic habitat inventory data, we first selected stream reaches with undesirably low levels of LWD (less than 10 pieces of LWD per 100m). We then created 100m buffers around each selected stream reach. We then intersected the RBA snorkel survey data with the buffer polygons and averaged 1998-99 RBA juvenile coho/sq m for each buffer unit. We then joined the summary layer to the buffer layer to allow symbolization of the buffer layer by coho/sq m. The resulting shapefile is **lowlwd_rba_15oct.shp**.

Figure REC-1YA shows the results for the Yachats Basin. Much of Fish Creek had an average juvenile coho density of around 0.75 coho/sq m, and also had low LWD when surveyed in 1992-94. Some portions of Grass Creek and the upper Yachats River had pools with coho densities above 1 coho/sq m, but lacked AQI survey data in GIS form. AQI surveys (or placement of existing AQI data into the GIS) are recommended for these streams (see below).

When using the results of this analysis, it is important to remember that both the RBA data and the AQI data available in GIS format cover only limited portions of the stream network. It is likely that RBA and/or AQI data were missing for some areas that would benefit from LWD placement. Since many streams in the study area have low levels of LWD, the RBA data alone could be used to target LWD placement for areas lacking AQI data; or the RBA data could be used to select areas for further AQI data collection to improve data coverage (see **Data Recommendations** in **Main Report**). Collection of additional AQI and RBA data would improve the analysis.

6.2 Potential floodplain restoration sites

This analysis was designed to answer the question, "Where in the watershed are some potential floodplain restoration sites?" Potential floodplain restoration sites would be former floodplains (diked, drained, or otherwise altered) that do not have land uses incompatible with floodplain restoration. To locate potential floodplains, we used the DEM-derived slope GIS layer as described below. To locate areas that do not have incompatible land uses, we used the DLCD generalized zoning layer as described below

In this multi-factor analysis, we used ARCView to perform a series of GIS layer "intersections" (a command available in the Geoprocessing Wizard of ARCView) to combine information from zoning and slope GIS layers onto the derived streams layer (**ST-1400**). This produced a single streams layer containing all of the information from the single factor analyses.

Before summarizing information in this newly created GIS layer, we manually removed stream segments where there was a lot of "flagging" on the derived streams layer (see **Appendix A: Supplemental Methods**).

To address the issue of incompatible land uses, we removed from consideration all stream segments that passed through property zoned as "urban", "rural residential", rural industrial", "rural commercial", and "rural service center" since these are unlikely areas for restoration projects.

To locate potential floodplains, we selected stream segments that flow through 'flat' areas (areas that had less than 5% slope). The 5% slope threshold was determined during the stream confinement analysis (**Main Report**, **Aquatic habitats: Stream confinement from DEMs**). Since it probably would not be practical to attempt to restore floodplains along very short segments of streams, we then selected those stream segments longer than 500m that flowed through these 'flat areas.' (In case the Council wishes to conduct further analyses using these data, we retained the shorter segments in the layer, but simply selected those longer than 500m for summarization and display on the maps.)

Information from this analysis is presented in two forms, as a summary showing the total stream length per 6th field meeting our selection criteria and as a sub-6th field map showing actual locations for stream restoration projects. Please note that stream lengths should be used as a relative measure of the amount of suitable (potential) floodplain restoration sites because stream lengths may be exaggerated, especially in low relief areas (e.g., along the coast) where the stream derivation algorithms had trouble placing the stream channel and stream “flagging” occurred.

Figure REC-2YA shows the stream segments identified as having potential floodplain restoration sites. There were no 6th field watersheds in the Yachats River basin that had more than 20 km and only one 6th field watershed that had more than 15 km of stream identified as potential floodplain restoration sites.

7 References

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Yaquina Basin Insert

Important: This Basin Insert is a part of the MidCoast Sixth Field Watershed Assessment and is intended for use only with the full report. Please contact the MidCoast Watersheds Council at (541) 265-9195 for information on how to obtain the full report.

Table of Contents

1 Introduction

This basin insert is a supplement to the MidCoast Sixth Field Watershed Assessment and is intended for use only with the full report. This insert focuses on basin-specific results for a subset of the analyses conducted in the assessment, but provides little background, setting, methods or interpretation. Therefore, it is important to read the **Main Report** before using this Insert. If this basin insert has been separated from the **Main Report**, contact the MidCoast Watersheds Council (MCWC) at (541) 265-9195 for information on how to obtain the full report.

2 Setting

Setting for the MidCoast Sixth Field Watershed Assessment is described in the **Main Report**, as are summaries that compare the different basins. To provide details useful to local watershed groups, this basin insert contains several maps depicting features at a scale below that of the sixth field watershed.

2.1 Location

General features of the Yaquina Basin are shown in **Figure SET-2YQ**. Not all stream names are shown; names shown are those contained in the 100K streams layer (**mc_rivs**$^{\mathbf{M}}$). The location of the basin relative to the rest of the study area is shown in the general locator map (**Figure SET-1** in the **Main Report**).

2.2 Sixth field watershed boundaries

Boundaries of sixth field watersheds, and the watershed codes used in this analysis, are shown in **Figure SET-3YQ**. The source of these boundaries, and the way we used them, are described in the **Main Report** (**Setting: 6th field watersheds**).

2.3 Zoning

DLCD generalized land use zoning categories are shown in **Figure SET-4YQ**. Categories are described in the **Main Report** (**Setting: Land use zoning**).

The vast majority of the basin is zoned for Forestry use. Agricultural use areas are located in Boone Slough and Nute Slough, and in the valleys of the Yaquina, Big Elk and major tributaries, especially Depot Creek, Thornton Creek, Little Elk Creek, Oglesby Creek, and Spout Creek. Urban zoning is limited to the cities of Toledo and Newport (including South Beach). Rural residential areas are located along West Olalla Creek, Olalla Creek, the mainstem Yaquina downstream of Toledo, and the east side of Yaquina Bay.

2.4 Land ownership

Major land ownership categories, and a breakdown of major private industrial landowners, are shown in **Figure SET-5YQ**. The major industrial landowners shown separately are the top 5 ranked by acreage owned within the entire study area.

Timberland in the basin is mostly in Private Industrial ownership, but USFS, BLM and the State of Oregon own substantial portions of the southern and eastern areas. Major private timber landholders include Georgia-Pacific, Simpson, and Starker. Private non-industrial land ownership is unusually high in the Yaquina basin and is scattered throughout the basin, with concentrations near Toledo, along the Big Elk and Little Elk, and in the upper Yaquina drainage.

2.5 Hydric soils

Hydric soils mapped by NRCS and provided in GIS digital soils coverages are shown in **Figure SET-7YQ**. Further information on the nature of hydric soils and why they are important to the watershed assessment is found in the **Main Report** (**Setting: Hydric soils** and **Aquatic habitats: Wetlands**).

The Yaquina Estuary is one of the largest estuaries in the study areas and comprises the majority of hydric soils in the basin. Prominent parts of the Yaquina Estuary include Poole Slough, McCaffery Slough, Boone Slough, Nute Slough, Depot Slough, Olalla Slough, and fringing marshes along the mainstem Yaquina River. Many of these areas are currently tidegated or diked, and may provide excellent opportunities for restoration of tidal marsh habitats (Brophy 1999). Narrow bands of hydric soils are also located in the valleys of the Yaquina, Big Elk, Little Elk, and many tributaries.

2.6 Lithology

General lithology is shown in **Figure SET-8YQ**, with underlying formations color-coded by major types (sedimentary, igneous, and quaternary). These formations (and the importance of lithology in watershed assessment) are described in the **Main Report** (**Setting: Lithology**).

The Yaquina Basin is underlain almost entirely by sedimentary formations, particularly the Tyee formation. Quaternary alluvial deposits underlie most of the Yaquina Estuary and portions of the valleys of the Big Elk, Little Elk, and Yaquina River.

3 Salmon and salmonid habitat

3.1 Rapid Bioassessment juvenile coho density

The Rapid Bioassessment (RBA) project (begun in 1998) provides data on distribution and abundance of juvenile coho, based on snorkel surveys of pools in the study area (see

Main Report, **Species of concern: Rapid bioassessment**). We analyzed the RBA data to determine average coho per square meter for each 6th field watershed, based on pools within the observed distribution of coho in each stream in 1998 and 1999 (see methods described in **Main Report**). We weighted the average values by the number of pools snorkeled in each year to normalize results. We also summed the number of pools surveyed in 1998 and 1999 for each 6th field. Sixth fields with less than 10 pools snorkeled during 1998 and 1999 are indicated with a red outline on the map showing coho per square meter (**Figure SOC-8** in the **Main Report**). Caution should be exercised when interpreting results from basins with a limited number of observations.

The Rapid Bioassessment reports describe the year-to-year variability in fish counts and density when the same stream is snorkeled two years in a row (Bio-Surveys 1998, 1999). Understanding this variability is important to interpreting the data.

Average juvenile coho densities by 6th field watershed across the entire study area are discussed in the **Main Report** (**Species of concern: Salmonids: Distribution**); these average densities are shown on **Figure SOC-8**. **Table 3.1** shows the Yaquina Basin 6th field watersheds that had the highest average juvenile coho densities in 1998-99 (excluding those watersheds that had less than 10 pools snorkeled). The 6th field watershed names and codes shown are those found in the MCWC 6th field watershed coverage, **6th_field.shp**.

Table 3.1. 6th field watersheds within the Yaquina Basin that had highest average juvenile coho densities during 1998-99 Rapid Bioassessment surveys

6th field watershed name	6th field ID code	# of pools surveyed, 1998-99	Average coho/sq m, 1998-99
MILL	40308	45	1.3713
LITTLE ELK	40111	159	1.2939
BEAR	40108	40	1.1938
CRYSTAL	40106	36	0.8340
OLALLA	40302	98	0.7305
YAQUINA HEADWATERS	40101	46	0.6608
SIMPSON	40103	52	0.6155
THORNTON	40104	70	0.5970
BEAVER	40312	61	0.5343
FEAGLES	40211	72	0.5192

Figure SOC-9YQ shows the locations of surveyed pools for 1998 and 1999, color-coded by average juvenile coho density in each pool. This map can be used to locate individual stream segments that had juvenile coho "hot spots," for use in action planning below the 6th field watershed level.

Rapid Bioassessment data provide the most comprehensive field-based data available on coho distribution and population in the study area. However, not all streams have been surveyed and, therefore, 6th field watersheds cannot be evaluated on Rapid Bioassessment data alone. The RBA data should be used to focus restoration efforts on those streams which are currently used by coho. The RBA data can also be used to focus further monitoring efforts. For example, where watershed conditions appear to be suitable for juvenile coho production and rearing, but RBA data show that coho are absent, further investigation is recommended to determine possible reasons for their absence such as migration barriers. Repeated RBA surveys on the same stream segments will be very useful for determining year-to-year variability in coho distribution and populations, which will help interpret the results of individual years' data.

3.2 Multi-factor analyses of salmonid habitat

As described in the **Main Report**, we conducted several multi-factor analyses of coho and winter steelhead habitat. Please read the **Main Report** for important details on the methods used for these analyses. The analyses were conducted using combinations of stream channel characteristics (derived from DEMs), AHI data, soils data, and coho juvenile survey data.

As described in the **Main Report**, no GIS data on anadromous migration barriers appropriate for ranking 6th field watersheds were available for this assessment, so we were not able to incorporate effects of barriers into these multi-factor analyses. Therefore, a limitation of this analysis is the fact that some top-ranked watersheds (or portions thereof) may be inaccessible to anadromous fish. Barriers can be either natural (such as falls) or artificial (such as culverts). **We recommend that when MCWC uses the results of these analyses for prioritizing management actions, they should refine the prioritization by adding local knowledge to the discussion.** Such local knowledge should include locations of fish barriers and other factors influencing choice and siting of management actions. MCWC should also seek to acquire new data on such factors to fill data gaps, as described in **Data collection and monitoring recommendations** in the **Main Report**.

3.3 Coho winter habitat

3.3.1 Potential coho winter habitat

The Potential Coho Winter Habitat analysis is an example of a multi-factor analysis that answers a specific question at the stream reach level. This analysis is designed to answer the question, "Where are stream segments with physical characteristics that make them potentially suitable for coho winter habitat?" As requested by MCWC, we included the following components in our analysis of potential coho winter habitat:

1. Gradient (criterion: low-gradient, 0 - 2 degrees = 0 - 3.5% slope)
2. Confinement (criterion: unconfined)
3. Soils (criterion: hydric)

Working with the DEM-derived streams layer (**derived_streams.zip**, shapefile name **st1400-c.shp**), we used ARCView to query the attributes of stream segments that met the criteria of low gradient and unconfined. We then selected those low-gradient, unconfined segments that flow over hydric soils as shown in the NRCS digital soil survey data.

Table 3.2 shows the ten 6th field watersheds in the Yaquina Basin that ranked highest for length of potential coho winter habitat.

Table 3.2. 6th field watersheds in the Yaquina Basin with greatest length of potential coho winter habitat

6th field watershed name	Major basin	6th field ID code	Length of potential coho winter habitat (m)
BUTTERMILK	Yaquina	40105	12653
BOONE SLOUGH	Yaquina	40315	11964
L. BIG ELK	Yaquina	40208	4396
LITTLE ELK	Yaquina	40111	3981
U. BIG ELK	Yaquina	40209	3648
FEAGLES	Yaquina	40211	3638
LOWER POOLE SLOUGH	Yaquina	40309	3559
OLALLA	Yaquina	40302	3091
BEAR	Yaquina	40201	2699
DEER	Yaquina	40202	2560

The specific stream reaches identified as potential habitat in this analysis are shown in **Figure AQ-18YQ**. The figure also shows coho habitat as mapped by ODFW. Due to lack of appropriate GIS data (as described above), it was not possible to incorporate information on natural barriers into this analysis. Therefore, the potential habitat map may show areas that are inaccessible to fish. The ODFW habitat mapping may be useful in locating such areas; local knowledge should also be used to supplement the mapping.

3.3.2 Functioning coho winter habitat

The Functioning Coho Winter Habitat Analysis is a 6th field ranking described in detail in the **Main Report** (**Aquatic habitats: Functioning coho winter habitat**). This analysis is designed to answer the question, "Which 6th field watersheds have average conditions most suitable for overwintering coho juveniles?" Briefly, we ranked 6th fields using factors that influence coho winter habitat. As requested by MCWC, we included the following factors: percent pools, channel widths per pool, large woody debris frequency, length of side channels, and length of potential habitat (low-gradient, unconfined streams flowing through hydric soils). All of the data except potential habitat were taken from aquatic habitat surveys conducted within the past 10 years.

Sixth field watersheds ranked highest for functioning coho winter habitat *across the entire study area* are described in the **Main Report** and shown in **Figure AQ-21**. In this basin report section, we present the highest-ranked 6th fields *within the basin.* Data that

led to the rankings are found in the 6th field aquatic habitats summary shapefile (**aqhab_sum_final.shp**).

The Yaquina basin contains 38 sixth field watersheds. **Table 3.3** shows the 10 sixth field watersheds that were ranked highest in the basin for functioning coho winter habitat. Possible ranks range from 1 (best) to 100 (worst) across the entire study area (all basins). Sixth field watershed names and codes shown are those found in the MCWC 6th field layer (**6th_field.shp**).

Table 3.3. 6th field watersheds ranked highest for functioning coho winter habitat within the Yaquina basin.

6th field watershed name	6th field ID code	Rank (scale of 100, 1 is best)
LOWER_SPOUT	40203	26.19
BUTTERMILK	40105	32.08
GRANT	40212	35.81
L. BIG ELK	40208	39.05
SPOUT	40207	40.30
HOMESTEAD	40206	42.86
LITTLE ELK	40111	43.00
MILL	40308	46.42
YAQUINA HEADWATERS	40101	48.67
M. BIG ELK	40210	50.06

For the Yaquina Basin, sixth field watersheds ranked high for coho winter habitat achieved that ranking through length of side channels (Buttermilk, Grant, Lower Big Elk, Homestead), length of potential habitat (Buttermilk, Lower Big Elk, Little Elk), and percent pools and channel widths/pool (Lower Spout and Spout). Average LWD frequency was generally not high within the basin. Length of potential habitat was particularly important for the Buttermilk 6th field, which highest in the entire study area for length of unconfined low-gradient streams running across hydric soils (12.78 km).

3.4 Coho summer habitat

3.4.1 Potential coho summer habitat

The potential coho summer habitat analysis is an example of a multi-factor analysis that answers a specific question at the stream reach level. This analysis is designed to answer the question, "Where are stream segments with physical characteristics that make them potentially suitable for coho summer habitat?" As requested by MCWC, we included the following components in our analysis of potential coho summer habitat:

1. Gradient (criterion: low-gradient, 0 - 2 degrees = 0 - 3.5% slope)
2. Confinement (criterion: unconfined)

Working with the DEM-derived streams layer, we used ArcView to query the attributes of stream segments to find those that met the criteria of low gradient and unconfined.

Table 3.4 shows the ten 6th field watersheds in the Yaquina Basin that ranked highest for length of potential coho summer habitat.

Table 3.4. 6th field watersheds in the Yaquina Basin with greatest length of potential coho summer habitat.

6th field watershed name	Major basin	6th field ID code	Length of potential coho summer habitat (m)
BOONE SLOUGH	Yaquina	40315	36565
BUTTERMILK	Yaquina	40105	21827
DEPOT	Yaquina	40311	16206
LITTLE ELK	Yaquina	40111	15810
L. BIG ELK	Yaquina	40208	12191
BEAVER	Yaquina	40312	11660
BEAR	Yaquina	40201	11623
ABBEY	Yaquina	40303	10199
OLALLA - WEST	Yaquina	40301	8601
LOWER POOLE SLOUGH	Yaquina	40309	8218

The specific stream reaches identified as potential habitat in this analysis are shown in **Figure AQ-19YQ**. The figure also shows coho habitat as mapped by ODFW. Due to lack of appropriate GIS data (as described above), it was not possible to incorporate information on natural barriers into this analysis. Therefore, the potential habitat map may show areas that are inaccessible to fish. The ODFW habitat mapping may be useful in locating such areas; local knowledge should also be used to supplement the mapping.

3.4.2 Functioning coho summer habitat

The Functioning Coho Summer Habitat Analysis is a 6th field ranking described in detail in the **Main Report** (**Aquatic habitats: Functioning coho summer habitat**). This analysis is designed to answer the question, "Which 6th field watersheds have average conditions most suitable for coho summer habitat?" Briefly, we ranked 6th fields using a several factors that are important to coho juveniles during the summer. As requested by MCWC, we included the following factors: percent pools, channel widths per pool, large woody debris frequency, percent shading of stream channels, length of riffle habitats with gravel substrate dominant, length of riffle habitats with bedrock substrate dominant (this factor reduced the ranking), length of potential habitat (low-gradient, unconfined streams flowing through hydric soils), and juvenile coho densities from Rapid Bioassessment surveys. Data on pools, LWD, shade, and substrates were taken from aquatic habitat surveys conducted within the past 10 years.

Sixth field watersheds ranked highest for functioning coho summer habitat *across the entire study area* are described in the **Main Report** and shown in **Figure AQ-22**. In this basin report section, we present the highest-ranked 6th fields *within the basin.* Data that

led to the rankings are found in the 6th field aquatic habitats summary shapefile (**aqhab_sum_final.shp**).

Table 3.5 shows the 10 sixth field watersheds that were ranked highest (out of the 38 in the basin) for functioning coho summer habitat. Possible ranks range from 1 (best) to 100 (worst) across the entire study area (all basins). Sixth field watershed names and codes shown are those found in the MCWC 6th field layer (**6th_field.shp**).

Table 3.5. 6th field watersheds ranked highest for functioning coho summer habitat within the Yaquina Basin.

6th field watershed name	6th field ID code	Rank (scale of 100, 1 is best)
LOWER_SPOUT	40203	28.77
SIMPSON	40103	30.99
MILL	40308	35.80
LITTLE ELK	40111	39.90
BEAR	40108	40.25
SPOUT	40207	41.01
CRYSTAL	40106	42.16
BUTTERMILK	40105	43.45
YAQUINA HEADWATERS	40101	45.21
GRANT	40212	45.62

A variety of factors were important to these rankings. High percent shade was important for the Spout, Lower Spout, and Simpson watersheds; high percent pools and low channel widths/pool also contributed to the high rankings for Spout and Lower Spout. Length of riffles with gravel substrate dominant, and length of potential habitat (low-gradient, unconfined streams) were important for the Buttermilk Creek watershed. Length of potential habitat also was important to the Little Elk Creek watershed's ranking. Low total length of riffles with bedrock substrate dominant contributed to the high rankings for the Lower Spout and Simpson watersheds.

3.5 Winter steelhead habitat

3.5.1 Potential winter steelhead habitat

The potential winter steelhead habitat analysis is an example of a multi-factor analysis that answers a specific question at the stream reach level. This analysis is designed to answer the question, "Where are stream segments with physical characteristics that make them potentially suitable for winter steelhead habitat?" As requested by MCWC, we included the following components in our analysis of potential winter steelhead habitat:

1. Gradient (criterion: moderate gradient, 1-5 degrees = 1.75 - 8.75% slope)
2. Confinement (criterion: confined)

We used the 1.75 - 8.75% slope gradient because it was the closest we could come to the 2 - 8% slope range requested by MCWC, using the ***DEM-derived stream gradient***

coverage. Working with the ***DEM-derived streams layer***, we used ARCView to query the attributes of stream segments to locate those that met the criteria of moderate gradient and confined.

Table 3.6 shows the ten 6th field watersheds in the Yaquina Basin that ranked highest for length of potential winter steelhead habitat (moderate-gradient, confined streams).

Table 3.6. 6th field watersheds in the Yaquina Basin with greatest length of potential winter steelhead habitat.

6th field watershed name	**Major basin**	**6th field ID code**	**Length of potential winter steelhead habitat (m)**
LITTLE ELK	Yaquina	40111	9879
BUTTERMILK	Yaquina	40105	8994
BEAR	Yaquina	40201	7515
L. BIG ELK	Yaquina	40208	5645
YAQUINA HEADWATERS	Yaquina	40101	5527
DEPOT	Yaquina	40311	5316
BEAVER	Yaquina	40312	4455
U. BIG ELK	Yaquina	40209	4222
CRYSTAL	Yaquina	40106	4114
HOMESTEAD	Yaquina	40206	4017

The specific stream reaches identified as potential habitat in this analysis are shown in **Figure AQ-20YQ**. The figure also shows winter steelhead habitat as mapped by ODFW. Due to lack of appropriate GIS data (as described above), it was not possible to incorporate information on natural barriers into this analysis. Therefore, the potential habitat map may show areas that are inaccessible to fish. The ODFW habitat mapping may be useful in locating such areas; local knowledge should also be used to supplement the mapping.

3.5.2 Functioning winter steelhead habitat

The Functioning Winter Steelhead Habitat Analysis is a 6th field ranking described in detail in the **Main Report** (**Aquatic habitats: Functioning winter steelhead habitat**). This analysis is designed to answer the question, "Which 6th field watersheds have average conditions most suitable for winter steelhead?" Briefly, we ranked 6th fields using a several factors that are important to winter steelhead during the summer and winter. As requested by MCWC, we included the following factors: length of riffle habitat; length of riffle habitat with gravel-to-boulder-sized substrate dominant; and length of potential habitat (moderate-gradient, confined streams). Data on riffle length and substrates were taken from aquatic habitat surveys conducted within the past 10 years.

Sixth field watersheds ranked highest for functioning winter steelhead habitat *across the entire study area* are described in the **Main Report** and shown in **Figure AQ-23**. In this basin report section, we present the highest-ranked 6th fields *within the basin.* Data that

led to the rankings are found in the 6th field aquatic habitats summary shapefile (**aqhab_sum_final.shp**).

Table 3.7 shows the 10 sixth field watersheds that were ranked highest (out of the 38 in the basin) for functioning winter steelhead habitat. Possible ranks range from 1 (best) to 100 (worst) across the entire study area (all basins). Sixth field watershed names and codes shown are those found in the MCWC 6th field layer (**6th_field.shp**).

Table 3.7. 6th field watersheds ranked highest for functioning winter steelhead habitat within the Yaquina basin.

6th field watershed name	**6th field ID code**	**Rank (scale of 100, 1 is best)**
BUTTERMILK	40105	14.00
GRANT	40212	22.27
LITTLE ELK	40111	24.49
L. BIG ELK	40208	32.07
HOMESTEAD	40206	37.67
YAQUINA HEADWATERS	40101	40.90
BEAR	40108	45.14
WOLF	40205	47.50
M. BIG ELK	40210	50.70
BEAVER	40312	50.74

For the sixth field watersheds ranked highest in the Yaquina Basin, length of potential habitat (moderate-gradient, confined streams) was the major contributing factor for half (Buttermilk, Little Elk, Little Big Elk, Yaquina Headwaters, and Beaver). Total length of riffles, and length of riffles dominated by gravel-to-boulder-sized substrate contributed strongly to the Grant Creek watersheds' high ranking.

4 Erosion and shallow landslide risk

Although debris and sediments have been entering the streams of Oregon Coast Range since before the time of European settlement, the frequency, duration and intensity of mass wasting events is of concern (see **Appendix B: Ecosystem Processes**). Mass wasting adds both coarse and fine sediments to streams along with organic debris (i.e., LWD). The quality of in-stream conditions, especially salmonid habitat, can be dramatically affected by patterns in material transport to streams (see **Appendix B: Ecosystem Processes**). We performed a series of risk assessments that identify 6th field watersheds that are 'at risk' for three types of mass wasting events: (1) soil erosion risk, (2) shallow landslide risk, and (3) debris flows that could potentially transport LWD from riparian zones to streams.

4.1 Soil erosion risk

Erosion risk was determined for most soil types occurring in the study area (see Soil Erosion Risk). We then used ARCView to sum the area of each 6th field watershed covered by soils determined to have a "severe" risk of erosion. None of the 6th field watersheds in the Yaquina River basin had more than 75% of their area occupied by the most severe risk category of soils. One way to use this information in planning is to avoid disturbing soils at times when precipitation would wash soils into streams or plan on leaving wide vegetated buffer strips to trap eroding sediments. Another way to use this information is to combine risk of soil erosion with other factors such as risk of shallow landslides (see below), in a multi-factor analysis.

4.2 Shallow landslide risk

Aside from the ODF debris flow hazard maps and a few mapped landslides, there was not much information with which to rank 6th field watersheds for shallow landslide risk (see **Main Report**, **Sediment Sources: Landslides**). We relied on work done by team in the State of Washington that compared several models that predicted landslide risk. Discussions with the authors of that report (Vaugeois, personal communication, 1999, see **Appendix A: Supplemental Methods**) suggested that the default settings of the SMORPH model should provide a good approximation of landslide risk in the northern section of the Oregon Coast Range, especially at the 6th field watershed level. Indeed, the first step in model calibration is to run the model without calibration and then compare model output with spatially explicit landslide inventories. SMORPH ranks each 10 X 10 m grid cell as having a "low", "medium" or "high" risk of shallow landslides. The model is influenced primarily by slope and topographic concavity, both derived from the DEM grid. Therefore, we used an uncalibrated model to assess landslide risk in the study area. We strongly suggest that the model output be used only in a general sense (i.e., on a 6th field watershed basis) and that model calibration be performed before using SMORPH to assess particular sites.

As with the soil erosion risk analysis, we ranked each 6th field watershed by the proportion of its area occupied by the 'high' risk category. Surprisingly, areas occupied by 'high' risk grid cells did not account for more than 50% of any of the 6th field watersheds. In the Yaquina River basin twenty-seven 6th field watersheds had more than 25% of their area identified by SMORPH as being "high" risk for a shallow landslide. The top three 6th field watersheds in terms of proportion of their area at "high" risk were 40212 (36.0%), 40204 (35.2%), and 40307 (34.4%).

This information is useful in helping to identify 6th field watersheds that may have large areas prone to shallow landslides. We recommend that detailed landslide information be collected and used to calibrate this model. A calibrated model would be useful in identifying specific locations within the watershed that may be prone to shallow landslide. Land use actions could then be planned so that they avoid these areas whenever possible.

4.3 Combined soil erosion / shallow landslide risk analysis

Finally, we performed a multi-factor analysis by combining information from the erodible soils and shallow landslide risk assessments. We used ARCView to create a shapefile depicting the "high risk" category from the SMORPH model. Due to the size and complexity of this layer, we used ARCView to intersect the SMORPH shapefile with highly erodible soils for each major river basin separately. This resulted in a single shapefile that contained both risk of soil erosion and of shallow landslide. The final step in this analysis was to rank each 6th field by the proportion of its area that met these two criteria.

The results of this analysis indicate that none of the 6th field watersheds in the Yaquina Basin had more than 25% of their area in the high risk category for both soil erosion and shallow landslides. However, specific areas within the watershed may be at high risk for both factors. Both the SMORPH model output and the soils maps contain a great deal of detail and may be very important data sets for site specific planning. We have provided these data to MCWC, and we recommend that these data be field checked.

5 Peak flow impact

Water movement is an important factor in structuring ecosystems in the Oregon Coast Range. Water arrives in the watershed as precipitation (rain or snow), then moves across the land surface and into the stream network. Many factors affect the water's capacity to erode and transport soils, sediments and pollutants. For example, vegetation can reduce the impact of rain on soils or increase water storage capacity by slowing the movement of water as it moves down slope. Vegetation can also affect snow accumulation at higher elevations. In areas of higher elevation snow can accumulate in treeless areas. The snow can prevent infiltration of rainfall, so that if rain then falls on the snow, water can move quickly across the watershed into the stream network. This can result in high peak stream flows. Just as snow prevents rain from infiltrating soils in the upper watershed, impervious surfaces (roads and parking lots) can quickly route water into stream networks during precipitation events. Thus, both rain-on-snow and roaded areas can affect peak stream flows.

5.1 Rain-on-snow

Rain-on-Snow analysis identifies those areas within the watershed that ***could potentially*** experience increases in peak-flows under certain weather conditions. Generally, the 38 6th field watersheds in the Yaquina River sub-region have low potential for Rain-on-Snow events. There was only one 6th field watershed in the Yaquina River sub-region (40211) where Rain-on-Snow could potentially be a factor. Even in this 6th field, the open area over 2001' represents well under 10% of the watershed area, so risk of peak-flow enhancement from Rain-on-Snow is low.

5.2 Roads

The impact of roads on peak flows can be assessed in several ways. Most important is to have a good map representation of where the roads actually are. Our assessment is based on the 100K roads layer because it was the best roads layer that was available for the entire study area. We estimate that the 100K roads layer may under-represent the actual frequency of roads in the watershed by about 38%, so the impact of roads on peak flows may also be underestimated using this dataset.

We used two methods for determining possible peak flow impacts from roads: a method that uses urban/residential road density as a surrogate for total impervious area, and a method that analyzes rural roads as a percent of watershed area (Watershed Professionals Network 1999). We found that the 38 6th field watersheds in the Yaquina Basin had relatively low average total impervious area, and rural road densities were relatively low compared to other basins in this study (the basin was ranked No. 4 out of the 6 basins). However, several 6th field watersheds were at risk for peak-flow impact from roads (i.e., 40313, 40304, and 40305).

6 Restoration

6.1 Large Woody Debris placement areas

We used Rapid Bioassessment (RBA) data and aquatic habitat survey data (AQI data) to answer a specific question: What are some suitable locations for in-stream placement of large woody debris? This question is one of MCWC's top priorities for the next phase in watershed assessment and action planning using GIS.

Priority areas for placement of large woody debris (LWD) would be low-gradient, mid-sized streams (coho rearing habitat) which are currently being used by coho, but which currently have low quantities of LWD. It makes sense to look for reaches with high average juvenile coho densities (not just individual pools with high densities).

Using the ODFW habitat benchmarks (Watershed Professionals Network 1999) and ODFW and USFS aquatic habitat inventory data, we first selected stream reaches with undesirably low levels of LWD (less than 10 pieces of LWD per 100m). We then created 100m buffers around each selected stream reach. We then intersected the **RBA snorkel survey data** with the buffer polygons and averaged 1998-99 RBA juvenile coho/sq m for each buffer unit. We then joined the summary layer to the buffer layer to allow symbolization of the buffer layer by coho/sq m. The resulting shapefile is **lowlwd_rba_15oct.shp**.

Figure REC-1YQ shows the results for the Yaquina Basin. The stream segments shown in red had low LWD and also had average juvenile coho densities of greater than 1 coho/sq m. These included portions of East Fork Bales Creek, Hayes Creek, and Mill Creek. Portions of Buttermilk Creek had coho densities of around 0.7 - 0.8 coho/sq m along with low LWD. There were many stream reaches that had high average coho densities but lacked AQI data in GIS form, such as Randal Creek, tributaries to Little Elk and Oglesby Creeks, Sutter Creek, Sloop Creek, Bear Creek, Bear Creek and tributaries to Olalla Creek. AQI surveys (or placement of existing AQI data into the GIS) are recommended for these streams (see below).

When using the results of this analysis, it is important to remember that both the RBA data and the AQI data available in GIS format cover only limited portions of the stream network. It is likely that RBA and/or AQI data were missing for some areas that would benefit from LWD placement. Since many streams in the study area have low levels of LWD, the RBA data alone could be used to target LWD placement for areas lacking AQI data; or the RBA data could be used to select areas for further AQI data collection to improve data coverage (see **Data Recommendations** in **Main Report**). Collection of additional AQI and RBA data would improve the analysis.

6.2 Potential floodplain restoration sites

This analysis was designed to answer the question, "Where in the watershed are some potential floodplain restoration sites?" Potential floodplain restoration sites would be former floodplains (diked, drained, or otherwise altered) that do not have land uses incompatible with floodplain restoration. To locate potential floodplains, we used the DEM-derived slope GIS layer as described below. To locate areas that do not have incompatible land uses, we used the DLCD generalized zoning layer^{M} as described below

In this multi-factor analysis, we used ARCView to perform a series of GIS layer "intersections" (a command available in the Geoprocessing Wizard of ARCView) to combine information from zoning^{M} and slope GIS layers onto the derived streams layer (**ST-1400**). This produced a single streams layer containing all of the information from the single factor analyses.

Before summarizing information in this newly created GIS layer, we manually removed stream segments where there was a lot of "flagging" on the derived streams layer (see **Appendix A: Supplemental Methods**).

To address the issue of incompatible land uses, we removed from consideration all stream segments that passed through property zoned as "urban", "rural residential", rural industrial", "rural commercial", and "rural service center" since these are unlikely areas for restoration projects.

To locate potential floodplains, we selected stream segments that flow through 'flat' areas (areas that had less than 5% slope). The 5% slope threshold was determined during the stream confinement analysis (**Main Report**, **Aquatic habitats: Stream confinement from DEMs**). Since it probably would not be practical to attempt to restore floodplains along very short segments of streams, we then selected those stream segments longer than 500m that flowed through these 'flat areas.' (In case the Council wishes to conduct further analyses using these data, we retained the shorter segments in the layer, but simply selected those longer than 500m for summarization and display on the maps.)

Information from this analysis is presented in two forms, as a summary showing the total stream length per 6th field meeting our selection criteria and as a sub-6th field map showing actual locations for stream restoration projects. Please note that stream lengths should be used as a relative measure of the amount of suitable (potential) floodplain restoration sites because stream lengths may be exaggerated, especially in low relief areas (e.g., along the coast) where the stream derivation algorithms had trouble placing the stream channel and stream "flagging" occurred.

Figure REC-2YQ shows the stream segments identified as having potential floodplain restoration sites. There were seven 6th field watersheds (40105, 40315, 40111, 40311, 40201, 40312, and 40208) in the Yaquina River basin that had more than 20 km of stream identified as potential floodplain restoration sites. This includes one 6th field watershed (40179) having more than 40 km of stream meeting our selection criteria.

7 References

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