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BIOLOGICAL ASSESSMENT OF THE REVISED OREGON WATER QUALITY STANDARDS FOR DISSOLVED OXYGEN, TEMPERATURE, and PH

For the
U.S. FISH AND WILDLIFE SERVICE

and the
NATIONAL MARINE FISHERIES SERVICE

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EXECUTIVE SUMMARY

Section 303 of the Clean Water Act (CWA) requires States to adopt Water Quality Standards (WQS) to restore and maintain the chemical, physical and biological integrity of the Nation's waters. WQS consist of beneficial uses (i.e. salmonid fish spawning, resident fish and aquatic life) designated for specific waterbodies and water quality criteria to protect the uses. States have primary responsibility for developing appropriate beneficial uses for waterbodies in their State. States review, and if appropriate, revise their water quality standards on a triennial basis in accordance with CWA §303(c). Also under CWA §303(c), EPA must review and approve or disapprove any revised or new standards. If EPA disapproves any portion of the state standards the state has 90 days to adopt the changes specified by EPA, after which time EPA must propose and promulgate such standards.

Oregon completed the Triennial Review with the adoption of revised water quality standards for Temperature, Dissolved Oxygen, and pH on January, 1996. In July, 1996 Oregon submitted their adopted standards to EPA for review and approval. EPA is proposing to approve Oregon water quality standards for these three parameters with the exception of the numeric criteria for temperature for the Willamette River (mouth to river mile 50) following conclusion of this consultation.

The purpose of this Biological Assessment is to assess the potential effects of EPA's proposed approval of Oregon's revised dissolved oxygen (DO), temperature and pH criteria on species listed under the Endangered Species Act (ESA). This assessment will be provided to the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) under section 2© and 7(a)(2) of the ESA.

After assessing the impacts of Oregon's standards for dissolved oxygen, temperature, and pH, EPA has determined that Oregon's temperature criterion for rearing salmonids will likely adversely affect anadromous salmonids covered by this assessment. EPA also determined that Oregon's temperature criterion for bull trout will likely adversely affect bull trout. EPA has determined that the other standards will not be likely to adversely affect the species covered by this assessment.

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I. BACKGROUND INFORMATION

A. CONSULTATION HISTORY

The Oregon Department of Environmental Quality (ODEQ) completed a Triennial Review of their water quality standards (standards, WQS) in January 1996 and submitted their revised standards to the U.S. Environmental Protection Agency, Region 10 (EPA) in July 1996. Three of the key areas revised were the criteria for dissolved oxygen (DO), temperature (T) and pH. Because of the significance of Oregon's water quality standards and their potential for affecting threatened and endangered species, in particular salmonids, and because of the requirements of Section 7 of the Endangered Species Act (ESA), EPA and the National Marine Fisheries Services (NMFS) and U.S. Fish & Wildlife Service (FWS) (jointly referred to as the Services) determined that consultation was important to complete prior to EPA's approval of Oregon's water quality standards.

EPA commenced the consultation process and review of the standards in January 1997. EPA submitted a request to the Services for a species list on January 15,1997. On February 10, 1997, EPA received from NMFS a species list for Oregon. A species list for species under the jurisdiction of the FWS was received on March 19, 1997. These lists were updated in 1998 as this analysis was completed. The 1998 lists (NMFS, June 18, 1998; FWS, July 1, 1998) are included as Appendix A and are the lists governing the species to be considered in this consultation. On March 25, 1997, EPA staff conducted a conference call with NMFS and FWS staff to scope the species and issues of concern for this consultation. Decisions were made regarding listed species most likely to be affected by the changes in DO, temperature and pH levels in surface waters. EPA has since been in frequent communications with the Services on the content and structure of this Biological Assessment .

The following is a chronology of key steps relevant to this consultation:

- Oregon initiated triennial review -- request for comments — 5/22/92 - 6/24/92
- Letters from Oregon to Services requesting early involvement in process — 10/19/92
- Letter from ODEQ to Services requesting input on whether extension of pH criteria to 9.0 would be fully protective of uses for life stages of salmonids and anadromous fish — 11/1/93

- Public comment period on draft WQS -- Hearings held 9/5/95 - 9/12/95 Public comment period extended to 1/9/96 — 7/28/95 - 9/19/95

- Oregon adoption of water quality standards (effective date March 1,1996 for DO, pH July 1,1996 for T) — 1/11/96

- Oregon submittal of revised water quality standards to EPA — 7/11/96

- EPA request for list of ESA - listed species from Services- — 1/15/97

- Service list of species:
  - -- NMFS list provided 2/10/97; updated 6/22/98
  - -- FWS list provided 3/19/97; updated 7/1/98

- Meeting with Services to discuss integrating consultation procedures for states in Region 10 — 2/21/97

- Teleconference with Services to scope ESA issues for BA — 4/23/97

- Teleconference with Services to discuss CWA & ESA review — 4/8/98

- Meeting with Services' Directors, Director ODEQ, EPA RA to discuss consultation process and schedule — 5/10/98

- Letter to ODEQ Director confirming consultation schedule and inviting state participation — 6/16/98

- Meeting with Services to discuss progress/issues on consultation — 7/16/98

B. EPA'S ACTION

Pursuant to Section 303© of the Clean Water Act (CWA), states are required to adopt water quality standards to restore and maintain the chemical, physical and biological integrity of the Nation's waters. These standards must be submitted to EPA for review and subsequent approval or disapproval. States are further required to review and revise (if appropriate) their standards every three years. This process is known as the triennial review.

The Oregon Department of Environmental Quality submitted revised water quality standards for dissolved oxygen, temperature and pH to EPA for review and approval on July 11, 1996 (see Appendix B). Subsequently, ODEQ submitted a Policy Letter to EPA (Llewelyn, 1998) on June 22, 1998 clarifying how some of the provisions of their new standards would be implemented (see

Appendix C). EPA is proposing to approve the DO, temperature, and pH standards as submitted with the exception of the temperature criterion for the Willamette River, mouth to river mile 50. Therefore, for purposes of this consultation, EPA's action is the proposed approval of Oregon's water quality standards for DO, temperature, and pH. EPA is deferring consultation on the temperature criteria for the Willamette River, mouth to river mile 50, until a final action (approval of revised State criterion or EPA promulgation of new criterion) is proposed.

C. OVERVIEW OF WATER QUALITY STANDARDS

A water quality standard defines the water quality goals of a waterbody by designating the use or uses to be made of the water, by setting criteria necessary to protect the uses and by preventing or limiting degradation of water quality through antidegradation provisions. The CWA provides the statutory basis for the water quality standards program and defines broad water quality goals. For example, Section 101(a) states, in part, that wherever attainable, waters achieve a level of quality that provides for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water ("fishable/swimmable").

Section 303© of the CWA requires that all states adopt water quality standards and that EPA review and approve these standards. In addition to adopting water quality standards, states are required to review and revise standards every three years. This public process, commonly referred to as the triennial review, allows for new technical and scientific data to be incorporated into the standards. The regulatory requirements governing water quality standards are established at 40 CFR 131.

The minimum requirements that must be included in the state standards are designated uses, criteria to protect the uses, and an antidegradation policy to protect existing uses, high quality waters, waters designated as Outstanding National Resource Waters. In addition to these elements, the regulations allow for states to adopt discretionary policies such as allowances for mixing zones and water quality standards variances. These policies are also subject to EPA review and approval.

Section 303(c)(2)(B) of the CWA requires the State to adopt numeric criteria for all toxic pollutants for which criteria have been published under Section 304(a). EPA publishes criteria documents as guidance to states. States consider these criteria documents, along with the most recent scientific information, when adopting regulatory criteria.

All standards officially adopted by the State are submitted to EPA for review and approval or disapproval. EPA reviews the standards to determine whether the analyses performed are adequate and evaluates whether the designated uses are appropriate and the criteria are protective of those uses. EPA makes a determination whether the standards meet the requirements of the CWA and EPA's water quality standards regulations. EPA then formally notifies the state of these results. If EPA determines that any such revised or new water quality standard is not consistent with the applicable requirements of the CWA, EPA is required to specify the disapproved portions and the changes needed to meet the requirements. The State is then given an opportunity to make appropriate changes. If the State does not adopt the required changes, EPA must promulgate federal regulations to replace those disapproved portions.

Water quality standards are important for several environmental, programmatic and legal reasons. Control of pollutants in surface waters is necessary to achieve the CWA's goals and objectives, including the protection of all species dependent upon the aquatic environment. Water quality standards provide the framework necessary to identify, protect and restore the water quality in Oregon's surface waters.

Water quality standards are important to State and EPA efforts to address water quality problems. Clearly articulated water quality goals established by the water quality standards enhance the effectiveness of many of the state, local and federal water quality programs including point source permit programs, nonpoint source control programs, development of total maximum daily load limitations (TMDLs) and ecological protection efforts.

D. OVERVIEW OF THE REVISIONS TO OREGON'S WATER QUALITY STANDARDS

The new standards that Oregon adopted for dissolved oxygen , temperature, and pH replaced existing standards for all three parameters. In many respects the changes that were made to the standards were significant. In certain aspects there was little or no change in the standards. The new standards are applied in the context of basins, which have been the basis for how all or most of Oregon's standards have been described. The changes made to the standards range from changes in unit of measurement, addition of classes or life stages to be protected, to new limits for a criterion. The most important changes stem from Oregon's recognition of the importance of these conventional standards in the protection of aquatic species, particularly threatened and endangered species such as salmonids. As a result of this recognition, Oregon stepped out in front of other northwest states and took a lead in review the technical literature released since EPA's Criteria Document in order to develop a sound basis for establishing criteria that are supportive of not only specific critical species but also sensitive life stages. Below is a description of the differences between the old and new standards by parameter. In addition, Table of Oregon Standard, Appendix D, contains a comparison of the new and old standards.

DISSOLVED OXYGEN

Old Standard:

The previous standard for DO had been in effect since 1972. It identified eight criteria for DO for the eight basins in Oregon. The standard was expressed as absolute minimums and measured as percent saturation, although a few basins had criteria described in terms of milligrams per liter. The old standard recognized two classes: salmonid spawning waters and non-salmonid spawning waters. The criteria were 95% saturation for salmonid spawning waters and 90% saturation for non-spawning waters for all of the westside basins except for the Willamette, and for the Hood and Deschutes basins. For the Willamette, the basin was divided into three segments with a standard for each segment: 5mg/L for the lower reaches (mouth to Newburg); 7mg/L for the mid- reaches; and 95% 90% saturation for the upper reaches and other basin waters. For most eastside basins the criteria were 95% saturation for salmonid spawning waters and 75% saturation for non-salmonid spawning waters. However, a criterion of 7mg/L was established for Goose Lake and several criteria were applied to the Klamath Basin. The Klamath basin was divided into three segments: the Lake and upper reaches of the River were set at 5mg/L; 7mg/L for the mid- reaches of the River; and for the rest of the basin - 90% saturation for salmonid spawning waters and 6 mg/L for non-salmonid spawning waters. The criterion for the Columbia River was 90% saturation.

According to the Final Issue Paper for Dissolved Oxygen (ODEQ, 1995 (a)) "the 75% saturation criterion was assumed to be similar to the 6.0mg/L criterion" and 90% saturation is slightly greater than 8mg/L. There is not a linear relationship between percent saturation and milligram per liter measurement units, therefore there is not a direct way to compare the old standard unit of measurement with the new unit of measurement.

New Standard:

The new DO standard consists of four classes -- salmonid spawning, cold water, cool water, and warm water, with different criteria for each class. The unit of measurement is expressed in milligrams per liter, and measurement periods for these criteria are 30 day mean minimum, 7 day mean minimum, 7 day minimum mean, and absolute minimum. In addition, the new standard also includes intergravel DO criteria for salmonid spawning waters. In general, the westside basins, excluding the central Willamette basin, are designated as cold water and have a water column criterion of 11 mg/L and an intergravel DO criterion of 6mg/L for salmonid spawning waters during periods of spawning and a water column criterion of 8mg/L for all other waters/times of year (non-spawning times). The central Willamette basin is designated cool water and has a DO criterion of 6.5mg/L. The eastside basins are designated cool and warm water, except for where there are salmonid spawning waters -- mostly the upper portions of the basins, which are designated cold water for the times of the year when spawning is not occurring. For those waters designated cool water, the DO criterion is 6.5mg/L. For those waters designated warm waters, the DO criterion is 5.5mg/L. The criteria applicable to salmonid spawning waters are the same as above.

In summary, the differences between the old and new DO standard include different measurement units (from percent saturation to mg/L) and measurement periods (from absolute minimum to 30 day mean minimum, 7 day mean minimum, 7 day minimum mean and absolute minimum), different number of classes (from salmonid spawning and non-salmonid spawning classes to four classes -- salmonid spawning, cold, cool, and warm water classes); and the addition of an intergravel criterion for salmonid spawning waters.

TEMPERATURE

Old Standard

Oregon's previous temperature criteria had been in effect since 1967 although they were last modified in 1979. The criterion was written as an amount of increase in water temperature allowed due to anthropogenic activity. When temperatures were at or above a specified value, no measurable increase in temperature due to human activity was allowed. The temperature above which no increase was allowed varied by basin and ranged from 58° F to 72° F. The criterion for most westside basins and the Hood, and Deschutes basins was 58° F. The Mid Coast and South Coast criterion was 64°F. For the Willamette Basin the criteria were 70° F for the mouth, 64°F for the mid-reaches and 58° F for headwaters and all other waters. The criterion for eastside basins was 68° F. For Klamath Basin the criterion was 58° F for salmonid waters and 72° F for non-salmonid waters. The unit of measurement was expressed as an absolute--"no measurable increase above 58°F". (Final Issue Paper for Temperature, ODEQ, 1995 (b)).

New Standard

The new temperature standard is significantly different from the previous standard. The new standard created four categories -- salmonid spawning times and areas, salmonid rearing times and areas, bull trout areas, and designated warm water areas. A temperature criterion was established for all but warm water areas: 55° F for salmonid spawning , 64°F for salmonid rearing, and 50° F bull trout. Through an oversight the State did not establish a numeric criterion for warm waters. The State has clarified its intent to protect these waters with the following provisions: "no measurable temperature increase resulting from anthropogenic activities..In stream segments containing federally listed Threatened and Endangered populations" and/or "no measurable surface water temperature increase resulting from anthropogenic activities..In natural lakes." (Llewelyn, 1998). The temperature criteria for the lower Willamette was lowered to 68° F. Finally, the new standard adopted a new form of measurement -- seven day rolling average of the daily maximum. The new criteria apply by basin as did the criteria in the previous standard.

In summary the changes made to Oregon's temperature standard include creating four categories --salmonid spawning and rearing waters (55°F and 64°F respectively), bull trout waters (50°F), and warm waters (narrative criteria that may lead to no measurable temperature increase resulting from anthropogenic activities) and changing the temperature for the lower Willamette to 68°F. These changes result in lower temperatures in the lower Willamette, lower temperatures for eastside basins where salmonids are present (from 68°F to 55°F/ 64°F), and higher temperatures for the west side basins outside of spawning periods (from 58°F to 64°F). In addition, the new standard adopted a new way of measuring temperature values by expressing the criteria as the 7 day rolling average of the daily maximum, rather than the previous standard's use of absolute values.

pH

Old Standard

The previous pH standard had been in effect since 1976. The standard varied by basin, but the basic criterion for most waters of the state, including estuarine waters, was the range of 6.5 - 8.5 pH units. All marine waters and waters of the Columbia River were to be within the range of 7.0 - 9.0 pH units. The Snake River criterion was for the range of 7.0 - 9.0 pH units and Goose Lake waters were to be maintained within the range of 7.5 - 9.5 pH units. (Final Issue Paper for Hydrogen Ion Concentration, ODEQ, 1995 (c)).

New Standard

The new standard is similar to the old in that the new standard varies by basin as did the old standard. The criteria for most basins, marine waters, and the Columbia and Snake Rivers remained unchanged. There are four significant changes in the new standard. The first is the addition of a new subcategory of waterbody, Cascade Lakes, to the following basins: Umpqua, Rogue, Willamette, Sandy, Hood River, Deschutes, and Klamath. The criteria, which apply to Cascade Lakes above 3,000 ft and 5,000 ft for Klamath basin lakes, is a range of 6.0 - 8.5 pH units. The second change, is raising the pH range for eastside basins -- John Day, Umatilla/Walla Walla, Grande Ronde, and Powder to 6.5 - 9.0 pH units (from 6.5 - 8.5). The third change is lowering the Klamath Basin criteria to the range of 6.5 - 9.0, (from 7.0 -9.0). Finally the fourth change is the addition of an exceptions provision for dams. The provision, which applies to all basins, is: "waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria"

In summary the changes made by the new pH standard are to add a new sub- category with its own criterion the standard (Cascade Lakes above 3,000 ft with 6.0 - 8.5 pH), allow for more alkalinity in certain eastside basins, to allow for more acidity in the Klamath basin, and provided an exception for dams. Other than those four changes, the new standard is the same as the old standard (marine waters, Columbia and Snake Rivers, and westside basins).

E. OVERVIEW OF OREGON'S WATER QUALITY PROGRAM

In Oregon, ODEQ has responsibility for protecting the quality of the state's waters. The mission of ODEQ is to protect and enhance the quality of Oregon's rivers, streams, lakes, estuaries, and groundwaters and to maintain the beneficial uses for each drainage basin. ODEQ's primary method for achieving this mission is through development, adoption, and application of the State's water quality standards and criteria.

Both federal and state regulations are utilized to protect Oregon's water quality. State programs are based on the Oregon Revised Statutes and Oregon Administrative Rules (OAR). ODEQ carries out these rules and regulations under the guidance of the Environmental Quality Commission (EQC). Under the federal Clean Water Act the state develops and/or implements:

- Standards to protect beneficial uses of the state's waters.
- A listing of impaired waterbodies (303(d) list) and total maximum daily loads (TMDLs) to restore those impaired waterbodies.
- A Clean Lakes Program.
- Permits, monitoring, and loans for wastewater discharge facilities.
- Programs to control nonpoint sources of pollution.
- Water quality certification of federal activities that could threaten beneficial uses of the State's waters.

Since 1984, the emphasis of Oregon's program has gradually shifted from technology-based controls, i.e., predetermined wastewater quality achievable through application of treatment technology, to water quality-based controls, wherein individual point and nonpoint source discharges are managed based on how they affect the receiving waters. This shift in emphasis is supported by making specific evaluations and assessments of water quality and designating those waters not meeting standards or protecting beneficial uses.

ODEQ has established a statewide ambient river monitoring network of 142 sites which are sampled to provide conventional pollutant data for trend analysis, standard compliance, and problem identification. Sites were selected to represent all major rivers in the state and provide statewide geographical representation. (ODEQ, July 1998, Draft Oregon 1998 Water Quality Status Assessment Report) The locations of these sites reflect the integrated water quality impacts from point and nonpoint source activities as well as the natural geological, hydrological and biological impacts on water quality for the watershed that they represent. In addition, biological and habitat monitoring are conducted to determine the degree to which habitat and biological impairments occur. Water quality conditions are also assessed in association with the issuance of wastewater discharge permits, watershed assessments conducted for TMDLs or site/watershed specific actions, special monitoring initiatives and complaint investigations.

Data acquired during chemical, physical and biological monitoring studies is utilized in evaluating the quality of the State's waters and designing appropriate water quality controls. Waters identified as "water quality limited" are included on the 303(d) list and reported in the 305(b) report, both submitted to EPA biennially.

For each "water quality limited" water on the 303(d) list, ODEQ develops a TMDL. That is, ODEQ determines the total amount of a pollutant (load) that the receiving waters can assimilate while maintaining water quality standards and allocates these loads to the various sources. The CWA requires that all contributing sources, both point and nonpoint, be identified and addressed in this assessment, that seasonal variations be taken into account, that a margin of safety be established to account for uncertainties and that the attainment of the TMDL lead to the attainment of applicable water quality standards.

Water quality controls for point sources are contained within permits issued based on both federal regulations and state rules. In accordance with the CWA, EPA has delegated authority to ODEQ to issue National Pollutant Discharge Elimination System (NPDES) Permits. NPDES permits are issued to sources discharging to surface waters. State Water Pollution Control Facilities (WPCF) permits are issued to those not discharging to surface waters, e.g., treatment lagoons with land irrigation, or subsurface disposal. If a TMDL has been established for a waterbody, the wasteload allocations established in the TMDL are incorporated into discharge permits. Additionally, effluent limitations in permits for all waters are required to be written such that discharges do not result in a violation of water quality standards in the receiving water.

Control of nonpoint sources of pollution occurs through several mechanisms. ODEQ has recently developed memoranda of agreement (MOAs) with the Oregon Department of Agriculture (ODA) and the Oregon Department of Forestry (ODF) to address the implementation of TMDLs on state and private forest and agricultural lands in Oregon. ODA, in consultation with ODEQ and local advisory committees, will develop agricultural water quality management plans to address agricultural sources of pollution to "water quality limited waters". ODF and ODEQ will work together to ensure that current forest practice rules will either lead to the attainment of water quality standards or be revised to do so. ODEQ is also working with federal agencies to develop and implement water quality management plans on federal lands in the state. Additional efforts under the Oregon Plan, Coastal Zone Management Plan, National Estuary Program and numerous other federal and state programs are utilized to minimize inputs from nonpoint source pollution to waters of the State of Oregon.

EPA provides funding and assistance for implementing nonpoint source controls through the Nonpoint Source (Section 319), National Estuary and Coastal Zone Management programs. Assistance in water quality management plan development, funding and implementation is also available through programs of numerous state and federal natural resource agencies including the Natural Resource Conservation Service (NRCS), the Soil and Water Conservation Districts, Oregon Department of Fish and Wildlife (ODF&W) and ODEQ. Significant funding is expected to become available for nonpoint source controls in the near future through the Clean Water Action Plan (CWAP) and several NRCS Programs including the Riparian Enhancement Initiative under the Conservation Reserve Enhancement Program.

F. OVERVIEW OF WATER QUALITY CONDITIONS IN OREGON

Oregon has a diversity of surface waterbodies that are regulated by the State's water quality standards. The State has over 100,000 miles of rivers, over 6,000 lakes greater than one acre in size, nine major estuaries, and over 360 coastal miles. The State's monitoring program routinely monitors approximately 3,500 miles of streams. (ODEQ, Oregon's 1994 Water Quality Status Assessment Report, April 1994).

To assess the current condition of Oregon waterbodies, EPA relies on the biennial water quality monitoring reports provided by ODEQ. As noted above, the 303(d) list provides a listing of assessed waters which are not in attainment of water quality standards. ODEQ is currently finalizing the 1998 303(d) list. The following table, based on the draft 1998 list (March 1998), summarizes the number of waterbodies and streams miles found to be in non-attainment of the DO, temperature and pH standards. For the 1998 list 2,365 streams were reviewed.

	draft 1998 list total	DO	Temperature	pH
stream miles	13,796	1,130	12,146	1,117
# streams	1,066	61	862	49
# lakes/ reservoirs	32	4	0	15

Maps illustrating the stream segments identified on the draft 1998 303(d) list and their relationship to the locations of Evolutionarily Significant Units (ESU) identified for listed species are attached in Appendix E.

The summary below is taken from Forest Ecosystem Management: An Ecological, Economic, and Social Assessment, Report of the Forest Ecosystem Management Assessment Team, July 1993 (USDA, et al, 1993) and the Integrated Scientific Assessment for Ecosystem Management In the Interior Columbia Basin and Portions of the Klamath and Great Basins (Quigley, et al, 1996).

Key physical components of a fully functioning aquatic ecosystem include complex habitats consisting of floodplains, banks, channel structure, water column and subsurface waters. These are created and maintained by rocks, sediment, large wood, and favorable conditions of water quantity and quality. Spatial and temporal connectivity within and between watersheds is necessary for maintaining aquatic and riparian ecosystem functions. Lateral, vertical, and drainage network linkages are critical to aquatic system function. Unobstructed physical and chemical paths to areas critical for fulfilling life history requirements of aquatic and riparian-dependent species must also be maintained. Connections among basins must allow for movement between refugia.

Human activities, such as timber harvesting, road building, stream channelization, farming, grazing, and urbanization have resulted in the simplication of habitat and a reduction in aquatic system quality in the majority of river basins within the Pacific Northwest . These activities have caused or contributed to the lose of large woody debris, sedimentation, loss of riparian vegetation, loss of frequency and depth of pools, increase in temperature, and other effects all of which have reduce the habitat quality. On federal lands in Oregon, 55 percent of the streams are moderately or severely impaired. The system of dams in the Columbia Basin has altered water flows in the larger water systems resulting in changes in water temperatures, timing and level of peak flows, barriers to fish migration, reductions in riparian areas, and changes in the physical attributes. Habitat simplification and decreased quality leads to a decrease in the health and diversity of the anadromous salmonid populations. The composition, distribution, and status of fish within the Basin are different than they were historically. Habitat loss, fragmentation and isolation may place remaining populations at risk.

G. SCOPE OF ANALYSIS

On February 10, 1997, EPA received from NMFS a species list for Oregon. A species list for species under the jurisdiction of FWS was received on March 19, 1997. These lists were updated in 1998 as this analysis was completed. The 1998 lists (NMFS list received June 22, 1998, FWS list received July 1, 1998.) are included as Appendix A and are the lists governing the species to be considered in this consultation. On March 25, 1997, EPA staff conducted a conference call with NMFS and FWS staff to scope the species and issues that should be the central focus of this ESA consultation. Decisions were made regarding species most likely to be affected by the changes in DO, temperature, and pH, levels in surface waters. There are many species at risk in Oregon, that are either proposed for listing or candidate species. Conferencing is required for proposed species; there is no requirement to consult on candidate species. Because candidate species may be listed before the next triennial review is completed, and because EPA shares a concern with FWS and NMFS that it is critical to conserve these species, and if at all possible avoid the need to list, the consultation is covering selected species from the candidate list. Further scoping discussions were conducted in June 1998.

Pursuant to advice provided by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service , the following threatened and endangered species will be considered in this assessment. This list contains all species currently listed and proposed for listing under the Endangered Species Act which are known or suspected to occur in the State of Oregon. In addition, two species of candidate frogs were added to the list for consultation as amphibians may represent a sensitivity different than that of fish.

Species of Concern for ESA Consultation

Sockeye Salmon	*Onocorhynchus nerka*
Snake River	
Chinook Salmon	*O. tshawytscha*
Snake River Fall	
Snake River Spring/Summer	
Upper Columbia River Spring Run	
Upper Willamette River	
Lower Columbia River	
S. Oregon/N.California Coastal	
Coho Salmon	*O. kisutch*
Lower Columbia River/SW Washington Coast	
Oregon Coast	
S.Oregon/N. California Coastal	
Chum Salmon	*O. keta*
Columbia River	
Steelhead	*O.mykiss*
Snake River Basin	
Upper Columbia River	
Middle Columbia River	
Lower Columbia River	
Upper Willamette River	
Oregon Coast	
Klamath Mountains Province	
Bull Trout	*Salvelinus confluentus*
Columbia River Basin	
Klamath River Basin	
Cutthroat Trout	*O. clarki clarki*
Lahontan River	
Umpqua River	
Sea-run (all populations except for Umpqua R)	
Hutton Spring tui Chub	*Gila bicolor ssp.*

Borax Lake Chub	*Gila boraxobius*
Oregon Chub	*Oregonichthys crameri*
Warner Sucker	*Catostomus warnerensis*
Shortnose Sucker	*Chasmistes brevirostris*
Lost River Sucker	*Deltistes luxatus*
Foskett speckled dace	*Rhinichthys osculus ssp.*
Columbia Spotted Frog	*Rana luteiventris*
Oregon Spotted Frog	*Rana pretiosa*
Vernal Pool fairy shrimp	*Branchinecta lynchi*

All of these species reside either all or part of their lives in the freshwaters of the State of Oregon and therefore have the potential to be directly affected by the surface water quality standards. Anadromous salmonids are also exposed to estuarine and marine waters of the state.

Discussion Species

The listed and/or proposed species that will not be the focus of this consultation, based on the scoping meetings with the Services, are mammals, birds and plants. It was determined that these species would not be directly impacted by changes to the DO, temperature, and pH criteria and thus the approval of the changes to these criteria would not be likely to have an adverse effect on these species. The following is a list of species.

<u>Marine Mammals</u>

Humpback Whale	*Megaptera novaeangliae*
Blue Whale	*Balaenoptera musculus*
Fin Whale	*Balaenoptera physalus*
Sei Whale	*Balaenoptera borealis*
Sperm Whale	*Physeter macrocephalus*
Stellar Sea Lion	*Eumetopias jubatus*

<u>Marine Turtles</u>

Leatherback sea turtle	*Dermochelys coriacea*

<u>Mammals and Birds</u>

Columbian white-tailed deer	*Odocoileus virginianus leucurus*
Marbled murrelet	*Brachyramphus marmoratus*
Aleutian Canada goose	*Branta canadensis leucopareia*
Western snowy plover	*Charadrius alexandrinus nivosus*
Bald Eagle	*Haliaeetus leucocephalus*
Brown Pelican	*Pelecanus occidentalis*

<u>Plants</u>

Macdonald's rockcress	*Arabis macdonaldiana*
Applegate's milk-vetch	*Astragalus applegatei*
Golden Indian paintbrush	*Castilleja levisecta*

Howellia	*Howellia aquatilis*
Bradshaw's lomatium	*Lomatium bradshawii*
MacFarlane's four o'clock	*Mirabilis macfarlanei*
Western lily	*Lilium occidentale*
Nelson's checker-mallow	*Sidalcea nelsoniana*
Willamette daisy	*Erigeron decumbens va.decumbens*
Rough popcorn flower	*Plagiobothrys hirtus*
Howell's spectacular thelypody	*Thelypodium howellii ssp. Spectabilis*

Bald eagle, brown pelican, marbled murrelet, western snowy plover are not likely to be directly affected by EPA's proposed approval of the changes to Oregon's DO, temperature, and pH criteria. However, because they prey on fish and invertebrates and some of these may live a portion of their lives in waters affected by these changes, there is some potential for indirect effects on these species. However, because these species rely on a varied prey base, there is only limited possible indirect effects, and it has been determined that EPA's proposed approval of the changes to Oregon's DO, temperature, and pH criteria would not be likely to adversely affect the bald eagle, brown pelican, marbled murrelet, and western snowy plover.

The Aleutian Canada Goose is not likely to be directly affected by EPA's approval of the changes to Oregon's DO, temperature, and pH criteria. The Canada goose relies on water for drinking and floating. These criteria will not affect the ability of the Canada goose to float or drink the water. Therefore, EPA's proposed approval of the changes to Oregon's DO, temperature, and pH criteria would not be likely to adversely affect the Aleutian Canada goose.

Listed Marine Mammals are not likely to be directly affected by Oregon's criteria for DO, temperature, and pH. With the exception of the stellar sea lion, these species may be present along Oregon's coast and may venture into estuarine waters, but they are not permanent residents of the Oregon coast. Stellar sea lions may spend more time on Oregon's coast and estuaries.
However, because they prey on fish and invertebrates and some of these species may live a portion of their lives in waters affected by these changes, there is some potential for indirect effects on the stellar sea lion. However, due to the limited nature and extent of these possible indirect effects, it has been determined that EPA's proposed approval of the changes to Oregon's DO, temperature, and pH criteria would not be likely to adversely affect the listed marine mammals.

Columbian white tailed deer and listed plants are not likely to be directly affected by Oregon's criteria for DO, temperature, pH criteria. The primary exposure of these species to water quality impacts is through either drinking water exposure or habitat degradation. Neither of these exposure routes is likely to be significantly affected by the changes to the DO, temperature, and pH criteria. Therefore, EPA's proposed approval of the changes to Oregon's DO, temperature, and pH criteria would not be likely to adversely affect Columbian white tailed deer and listed plants.

Leatherback sea turtles are rarely found offshore of Oregon's coast and does not nest on Oregon's beaches. They prey on jellyfish, which would not be directly affected by Oregon's DO, temperature, and pH criteria. Therefore, EPA's proposed approval of the changes to Oregon's DO, temperature, and pH criteria would not be likely to adversely affect the leatherback sea turtle.

No Effect Determination

At the time Oregon adopted revised standards for DO, temperature, pH it also adopted a revised water quality standard for bacteria. The adopted criterion for freshwater and estuarine waters other than shellfish growing waters are (I) A 30 day log mean of 126 E.coli organisms per 100 ml based on a minimum of 5 samples. (II) No single sample shall exceed 406 E. coli organisms per 100ml. For marine and estuarine shellfish growing waters the criterion is: A fecal coliform median concentration of 14 organisms per 100 milliliters, with not more than 10% of the samples exceeding 43 organisms per 100 ml. This criterion is set to protect human health, and as such, the levels used in the criteria are below that which we expect would affect aquatic species. Based on this reasoning it was determined that EPA would not consult on Oregon's revised bacteria standard.

Assumptions

The analysis of effects under Section III, Proposed Actions, assumes that the organisms are exposed to waters meeting the water quality standards. As described under Overview of Water Quality Conditions in Oregon, there are many waters that currently are not meeting these standards for dissolved oxygen, temperature, and pH. Implementation of the standards is key to changing the current condition. However, the only action under consideration at this time is whether the standards themselves and EPA's approval of them will have an adverse effect on species of concern. As the State of completes TMDLs designed to meet the revised standards, issues/reissues permits in conjunction with those TMDLs, and incorporates nonpoint source controls to meet water quality standards the condition of impaired waters, and thus the environmental baseline, will improve.

H. DESCRIPTION OF ACTION AREA

The action area of this consultation consists of all surface waters of the state of Oregon for which revised DO, temperature and pH criteria have been adopted. The application of these standards are further refined by temporal, spatial, and species specific provisions to the standards. The standards and provisions are discussed in detail in Section III. The waterbodies to which each criterion is applicable are identified later in this assessment. Water quality standards apply to all surface waters of the state, defined as all lakes, bays, ponds, impounding reservoirs, springs, rivers, streams, creeks, estuaries, marshes, inlets, canals, the Pacific Ocean within the territorial limits of the State of Oregon, and all other bodies of surface waters, natural or artificial, inland or coastal, fresh or salt, public or private (except those private waters which do not combine or effect a junction with natural surface or underground waters), which are wholly or partially within or bordering the state or within its jurisdiction [OAR 340-41-006 (14)]. EPA's approval action does not apply to, and thus the action area does not include, any waters within Indian Country (reservations).

II. HABITAT AND LIFE HISTORY OF SPECIES OF CONCERN

(Anadromous fish that are considered under ESA pertain to wild stocks only.)

Snake River sockeye salmon (*Oncorhynchus nerka*): (the following summary information is from NOAA, 1993). **Endangered** status Idaho 11/20/91, 56FR58519.

Adult Migration and Spawning. Snake River sockeye salmon enter the Columbia River primarily during June and July. Arrival at Redfish Lake, which now supports the only remaining run of Snake River sockeye salmon, peaks in August and spawning occurs primarily in October (Bjornn et al., 1968). Eggs hatch in the spring between 80 and 140 days after spawning. Fry remain in the gravel for three to five weeks, emerge in April through May, and move immediately into the lake where juveniles feed on plankton for one to three years before migrating to the ocean. Migrants leave Redfish Lake from late April through May (Bjornn et al., 1968), and smolts migrate almost 900 miles to the Pacific Ocean. For detailed information on the Snake River sockeye salmon, see Wapels et al. (1991a) and November 20, 1991, 56 FR 58619.

The critical habitat for the Snake River sockeye salmon was listed on December 28, 1993 (58FR68543). The designated habitat consists of river reaches of the Columbia, Snake, and Salmon Rivers, Alturas Lake Creek, Valley Creek, and Stanley, Redfish, Yellow Belly, Pettit, and Alturas Lakes (including their inlet and outlet creeks).

Juvenile Outmigration/Smolts. Passage at Lower Granite Dam (the first dam on the Snake River downstream from the Salmon River) ranges from late April to July, with peak passage from May to late June. Once in the ocean, the smolts remain inshore or within the Columbia River influence during the early summer months. Later, they migrate through the northeast Pacific Ocean (Hart, 1973, Hart and Dell, 1986). Snake River sockeye salmon usually spend two to three years in the Pacific Ocean and return in their fourth or fifth year of life. Historically, the largest numbers of Snake River sockeye salmon returned to headwaters of the Payette River, where 75,000 were taken one year by a single fishing operation in Big Payette Lake. During the early 1880s, returns of Snake River sockeye salmon to the headwaters of the Grande Ronde river in Oregon (Walleye Lake) were estimated between 24,000 and 30,000 at a minimum (Cramer, 1990). During the 1950s and 1960s, adult returns to Redfish Lake numbered more than 4,000 fish.

Snake River sockeye salmon returns to Redfish Lake since at least 1985, when the Idaho Department of Fish and Game began operating a temporary weir below the lake, have been extremely small (one to 29 adults counted per year). Snake River sockeye salmon have a very limited distribution relative to critical spawning and rearing habitat. Redfish Lake represents only one of the five Stanley Basin lakes historically occupied by Snake River sockeye salmon and is designated as critical habitat for the species.

Habitat Physical/Chemical Characteristics (note the differences compared to the table on page 21):
Normal spawning temperatures range from 3-7 degrees C (Ricker,1966, Foerster, 1968).
Adult migration 7.2-15.6 degrees C. (Reiser and Bjornn, 1979).
Recommended incubation guidelines (intergravel vs water column, not specified) are: dissolved

oxygen at or near saturation (minimum of 5.0 mg/l); water temperatures of 4-14 degrees C. (Reiser and Bjornn, 1979).

The upper lethal water temperature is 24.4 degrees C. (Brett, 1952), but growth ceases at temperatures above 20.3 degrees C. (Bell, 1984).

pH - low pH can affect the viability of embryos and alevins, and nitrogen supersaturation can adversely affect out migrating smolts (no values cited) (Ebel et al., 1971).

Threats:

Factors for the decline include: The present or threatened destruction, modification, or curtailment of the species habitat or range such as loss, damage or change to the species' natural environment through water diversions, forestry, agriculture, mining, and urbanization; over-utilization of the species for commercial, recreational, scientific or educational purposes - particularly over fishing; predation, introduction of non-native species, and habitat loss or impairment resulting in increase stress on surviving individuals and thus, increase susceptibility of the species to numerous bacterial, protozoan, viral, and parasitic diseases; the inadequacy of existing regulatory mechanisms to prevent the decline of the species; and other natural and manmade factors such as the 1977 drought and the extremely low flow water years through 1990 may have contributed to reduced Snake River sockeye salmon production. The NMFS concludes there is no direct evidence that artificially propagated fish have compromised the genetic integrity of Stanley Basin sockeye salmon. Refer to 53FR58622 for a detailed generic discussion of factors affecting this sockeye salmon ESU.

Chinook salmon (*Oncorhynchus tshawytscha*) - general life history and ecology:
(The following summary is taken from 63FR11481, 3/9/98).

Chinook salmon are easily distinguished from other *Oncorhynchus* species by their large size. Adults weighing over 120 pounds have been caught in North American waters. Chinook salmon are very similar to coho salmon in appearance while at sea (blue-green back with silver flanks), except for their large size, small black spots on both lobes of the tail, and black pigment along the base of the teeth. Chinook salmon are anadromous and semelparous. This means that as adults, they migrate from a marine environment into the freshwater streams and rivers of their birth (anadromous) where they spawn and die (semelparous). Adult female chinook will prepare a spawning bed, called a redd, in a stream area with suitable gravel composition, water depth and velocity. Redds will vary widely in size and in location within the stream or river. The adult female chinook may deposit eggs in four to five "nesting pockets" within a single redd. After laying eggs in a redd, adult chinook will guard the redd from four to 25 days before dying. Chinook salmon eggs will hatch, depending upon water temperatures, between 90 to 150 days after deposition. Stream flow, gravel quality, and silt load all significantly influence the survival of developing chinook salmon eggs. Juvenile chinook may spend from three months to two years in freshwater after emergence and before migrating to estuarine areas as smolts, and then into the ocean to feed and mature.

Among chinook salmon two distinct races have evolved. One race, described as a "stream-type" chinook, is found most commonly in headwater streams. Steam-type chinook salmon have a longer freshwater residency, and perform extensive offshore migrations before returning to their natal streams in the spring or summer months. The second race is called the "ocean-type" chinook, which is commonly found in coastal steams in North America. Ocean-type chinook typically migrate to sea within the first three months of emergence, but they may spend up to a year in freshwater prior to emigration. They also spend their ocean life in coastal waters. Ocean-type chinook salmon return to their natal streams or rivers as spring, winter, fall, summer, and late-fall runs, but summer and fall runs predominate. The difference between these life history types is also physical, with both genetic and morphological foundations.

Juvenile steam- and ocean-type chinook salmon have adapted to different ecological niches. Ocean-type chinook salmon tend to utilize estuaries and coastal areas more extensively for juvenile rearing. The brackish water areas in estuaries also moderate physiological stress during parr-smolt transition. The development of the ocean-type life history strategy may have been a response to the limited carrying capacity of smaller stream systems and glacially scoured, unproductive, watersheds, or a means of avoiding the impact of seasonal floods in the lower portion of may watersheds.

Stream-type juveniles are much more dependent on freshwater stream ecosystems because of their extended residence in these areas. A stream-type life history may be adapted to those watersheds, or parts of watersheds, that are more consistently productive and less susceptible to dramatic changes in water flow, or which have environmental conditions that would severely limit the success of subyearling smolts. At the time of saltwater entry, stream-type (yearling) smolts are much larger, averaging 73-134 mm depending on the river system, than their ocean-type (subyearling) counterparts and are, therefore, able to move offshore relatively quickly.

Coast wide, chinook salmon remain at sea for one to six years (more common, two to four years), with the exception of a small proportion of yearling males, called jack salmon, which mature in freshwater or return after two or three months in salt water. Ocean- and steam-type chinook salmon are recovered differentially in coastal and mid-ocean fisheries, indicating divergent migratory routes. Ocean-type chinook salmon tend to migrate along the coast, while stream-type chinook salmon are found far from the coast in the central North Pacific. Differences in the ocean distribution of specific stocks may be indicative of resource partitioning and may be important to the success of the species as a whole.

There is a significant genetic influence to the freshwater component of the returning adult migratory process. A number of studies show that chinook salmon return to their natal streams with a high degree of fidelity. Salmon may have evolved this trait as a method of ensuring an adequate incubation and rearing habitat. It also provides a mechanism for reproductive isolation and local adaptation. Conversely, returning to a stream other than that of one's origin is important in colonizing new areas and responding to unfavorable or perturbed conditions at the natal steam.

Chinook salmon stocks exhibit considerable variability in size and age of maturation, and at least some portion of this variation is genetically determined. The relationship between size and length of migration may also reflect the earlier timing of river entry and the cessation of feeding for chinook salmon stocks that migrate to the upper reaches of river systems. Body size, which is correlated with age, may be an important factor in migration and redd construction success. Under high density conditions on the spawning ground, natural selection may produce stocks with exceptionally large-sized returning adults.

Early researchers recorded the existence of different temporal "runs" or modes in the migration of chinook salmon from the ocean to freshwater. Freshwater entry and spawning timing are believed to be related to local temperature and water flow regimes. Seasonal "runs" (i.e., spring, summer, fall, or winter) have been identified on the basis of when adult chinook salmon enter freshwater to begin their spawning migration. However, distinct runs also differ in the degree of maturation at the time of river entry, the thermal regime and flow characteristics of their spawning site, and their actual time of spawning. Egg deposition must occur at a time to ensure that fry emerge during the following spring when the river or estuary productivity is sufficient for juvenile survival and growth.

Pathogen resistance is another locally adapted trait. Chinook salmon from the Columbia River drainage were less susceptible to *Ceratomyxa shasta*, an endemic pathogen, then stocks from coastal rivers where the disease is not know to occur. Alaskan and Columbia River stocks of chinook salmon exhibit different levels of susceptibility to the infectious hematopoietic necrosis virus (IHNV). Variability in temperature tolerance between populations is likely due to selection for local conditions; however, there is little information on the genetic basis of this trait.

Snake River fall chinook salmon (*Oncorhynchus tshawytscha*): (The following summary is taken from information from NOAA, 1993 and NOAA, 1991b). **Listed threatened** status OR, WA, ID 4/22/92, 59FR66786.

This ESU was listed as threatened on 4/22/92. The 11/2/94 Emergency Rule (59FR54840), reclassifying Snake River chinook from threatened to endangered, expired on 5/26/95. The critical habitat for the Snake River fall chinook salmon was listed on December 28, 1993 (58FR68543) and modified on 3/9/98 (63FR11515) to include the Deschutes River.

A 1995 status review found that the Deschutes River fall-run chinook salmon population should be considered part of the Snake River fall-run ESU. Populations from Deschutes River and the Marion Drain (tributary of the Yakima River) show a greater genetic affinity to Snake River ESU fall chinook than to the Upper Columbia River summer/fall-run chinook (3/9/98, 63FR11490). The designated critical habitat (63FR11515 , 3/9/98) includes all river reaches assessable to chinook salmon in the Columbia River from The Dalles Dam upstream to the confluence with the Snake River in Washington (inclusive). Critical habitat in the Snake River includes its tributaries in Idaho, Oregon, and Washington (exclusive of the upper Grande Ronde River and the Wallowa River in Oregon, the Clearwater River above its confluence with Lolo Creek in Idaho, and the Salmon River upstream of its confluence with French Creek in Idaho). Also included are river reaches and estuarine areas in the Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) and the west end of the Peacock jetty (north jetty, Washington side) upstream to The Dalles Dam. Excluded are areas above specific dams identified in Table 17 (see 3/9/98, 63FR11519) or above longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years).

ESU Status: Almost all historical Snake River fall-run chinook salmon spawning habitat in the

Snake River Basin was blocked by the Hells Canyon Dam complex; other habitat blockages have also occurred in Columbia River tributaries. The ESU's range has also been affected by agricultural water withdrawals, grazing, and vegetation management. The continued straying by non-native hatchery fish into natural production areas is an additional source of risk. Assessing extinction risk to the newly-configured ESU is difficult because of the geographic discontinuity and the disparity in the status of the two remaining populations. The relatively recent extirpation of fall-run chinook in the John Day, Umatilla, and Walla Walla Rivers is also a factor in assessing the risk to the overall ESU. Long term trends in abundance for specific tributary systems are mixed. NMFS concluded that the ESU as a whole is likely to become an endangered species within the foreseeable future, in spite of the relative health of the Deschutes River population.

See the second paragraph under Snake River spring/summer chinook salmon for life history comparisons between fall and spring/summer chinook salmon. Adult Snake River fall chinook salmon enter the Columbia River in July and migrate into the Snake River from August through October. Fall chinook salmon natural spawning is primarily limited to the Snake River below Hells Canyon Dam, and the lower reaches of the Clearwater, Grand Ronde, Imnaha, Salmon and Tucannon Rivers. Fall chinook salmon generally spawn from October through November and fry emerge from March through April.

Downstream migration generally begins within several weeks of emergence (Becker, 1970; Allen and Meekin, 1973) with juveniles rearing in backwaters and shallow water areas through mid-summer prior to smolting and migration. Bell (1959, 1961) found that peak migration in the Brownlee-Oxbow Dam reach of the Snake River occurred from April through the middle of May. Juveniles will spend one to four years in the Pacific Ocean before beginning their spawning migration. Van Hyning (1968) reported that chinook salmon fry tend to linger in the lower Columbia River and may spend a considerable portion of their first year in the estuary. For detailed information on the Snake River fall chinook salmon see Waples et al. (1991b), NMFS (1992b) and June 27, 1991, 56 FR 29542.

Elevated water temperatures are thought to preclude returning of fall chinook salmon in the Snake River after early to mid-July (Chapman et al., 1991). The preferred temperature range for chinook salmon has been variously described as 12.2-13.9 degrees C. (Brett, 1952), 10-15.6 degrees C. (Burrows, 1963), or 13-18 degrees C. (Theurer et al., 1985). Summer temperatures in the Snake River substantially exceed the upper limits of this range.

No reliable historic estimates of abundance are available for Snake River fall chinook salmon. Estimated returns of Snake River fall chinook salmon declined from 72,000 annually between 1938 and 1949, to 29,000 from 1950 through 1959 (Bjornn and Horner, 1980, cited in Bevan et al., 1994). Estimated returns of naturally produced adults form 1985 through 1993 range from 114 to 742 fish.

Threats:

Factors influencing the decline include: the present or threatened destruction, modification, or curtailment of the species habitat or range such as loss, damage or change to the species' natural environment through water diversions, forestry, agriculture, mining, and urbanization;

overutilization of the species for commercial, recreational, scientific or educational purposes - particularly over fishing; predation, introduction of non-native species, and habitat loss or impairment increasing stress on any surviving individuals and thus increasing susceptibility of the species to numerous bacterial, protozoan, viral, and parasitic diseases; the inadequacy of existing regulatory mechanism to prevent the decline of the species. Refer to 63FR11498 for a detailed generic discussion of factors affecting this chinook salmon ESU.

Snake River spring/summer chinook salmon (*Oncorhynchus tshawytscha*): (The following summary information is from NOAA, 1993 and NOAA, 1991a). **Listd threatened** status OR, WA, ID 12/28/94, 59FR66786.

This Evolutionarily Significant Unit (ESU) was listed as threatened on 4/22/92 and was "downgraded" to a proposed endangered status on 12/28/94. The 11/2/94 Emergency Rule (59FR54840), reclassifing Snake River chinook from threatened to endangered, expired on 5/26/95. The critical habitat for the Snake River spring/summer chinook salmon was listed on December 28, 1993 (58FR68543). The designated habitat consists of river reaches of the Columbia, Snake, and Salmon Rivers, and all tributaries of the Snake and Salmon Rivers (except the Clearwater River) presently or historically accessible to Snake River spring/summer chinook salmon (except reaches above impassable natural falls and Hells Canyon Dam).

ESU status. (From 56FR29544) Historically, it is estimated that 44 percent of the combined Columbia River spring/summer chinook salmon returning adults entered the Salmon River. Since the 1960s, counts at Snake River dams have declined considerably. Snake River redd counts in index areas provide the best indicator of trends and status of the wild spring/summer chinook population. The abundance of wild Snake River spring/summer chinook has declined more at the mouth of the Columbia River than the redd trends indicate. Although pre-1991 data suggest several thousand wild spring/summer chinook salmon return to the Snake River each year, these fish are thinly spread over a large and complex river system.

In general, the habitats utilized for spawning and early juvenile rearing are different among the three chinook salmon forms (spring, summer, and fall) (Chapman, et al., 1991). In both the Columbia and Snake Rivers, spring chinook salmon tend to use small, higher elevation streams (headwaters), and fall chinook salmon tend to use large, lower elevation streams or mainstem areas. Summer chinook are more variable in their spawning habitats; in the Snake river, they inhabit small, high elevation tributaries typical of spring chinook salmon habitat, whereas in the upper Columbia River they spawn in the larger lower elevation streams characteristic of fall chinook salmon habitat. Differences are also evident in juvenile out-migration behavior. In both rivers, spring chinook salmon migrate swiftly to sea as yearling smolts, and fall chinook salmon move seaward slowly as subyearlings. Summer chinook salmon in the Snake River resemble spring-run fish in migrating as yearlings, but migrate as subyearlings in the upper Columbia River. Early researchers categorized the two behavioral types as "ocean-type" chinook for seaward migrating subyearlings and as "stream-type" chinook for the yearling migrants (Gilbert, 1912).

Life history information clearly indicates a strong affinity between summer- and fall-run fish in the upper Columbia River, and between spring- and summer-run fish in the Snake River. Genetic data support the hypothesis that these affinities correspond to ancestral relationships. The relationship between Snake River spring and summer chinook salmon is more complex and is not discussed here.

The present range of spawning and rearing habitat for naturally-spawned Snake River spring/summer chinook salmon is primarily limited to the Salmon, Grande Ronde, Imnaha, and Tucannon sub-basins. Most Snake River spring/summer chinook salmon enter individual sub-basins from May through September. Juvenile Snake River spring/summer chinook salmon emerge from spawning gravels from February through June (Perry and Bjornn, 1991). Typically, after rearing in their nursery streams for about one year, smolts begin migrating seaward in April through May (Bugert et al., 1990; Cannamela, 1992). After reaching the mouth of the Columbia River, spring/summer chinook salmon probably inhabit near shore areas before beginning their northeast Pacific Ocean migration, which lasts two to three years. For detailed information on the life history and stock status of Snake River spring/summer chinook salmon, see Matthews and Waples (1991), NMFS (1991a), and 56 FR 29542 (June 27, 1991).

The number of wild adult Snake River spring/summer chinook salmon in the late 1800s was estimated to be more than 1.5 million fish annually. By the 1950s, the population had declined to an estimated 125,000 adults. Escapement estimates indicate that the population continued to decline through the 1970s. Redd count data also show that the populations continued to decline through about 1980.

The Snake River spring/summer chinook salmon ESU, the distinct population segment listed for ESA protection, consists of 39 local spawning populations (sub-populations) spread over a large geographic area. The number of fish returning to a given subpopulation would, therefore, be much less than the total run size.

Based on recent trends in redd counts in major tributaries of the Snake River, many sub-populations could be at critically low levels. Sub-populations in the Grande Ronde River, Middle Fork Salmon River, and Upper Salmon River basins are at particularly high risk. Both demographic and genetic risks would be of concern for such sub-populations, and in some cases, habitat may be so sparsely populated that adults have difficulty finding mates.

Threats:

Factors influencing the decline include: the present or threatened destruction, modification, or curtailment of its habitat or range such as loss, damage or change to the species' natural environment through water diversions, forestry, agriculture, mining, and urbanization; over-utilization for commercial, recreational, scientific or educational purposes - particularly over-fishing; predation, introduction of non-native species, and habitat loss or impairment increasing stress on any surviving individuals and thus increasing susceptibility to numerous bacterial, protozoan, viral, and parasitic diseases. Refer to 63FR11498 for a detailed generic discussion of factors affecting this chinook salmon ESUs.

Habitat Physical Chemical Characteristics for chinook salmon, in general:

Temperatures for optimal egg incubation are 5.0-14.4 degrees C. (Bell, 1984).
Upper lethal limit is 25.1 degrees C. (Brett, 1952), but may be lower depending on other water quality factors (Ebel et al., 1971).
Dissolved oxygen for successful egg development in redds is ≥ 5.0 mg/l, and water temperatures of 4-14 degrees C. (Reiser and Bjornn, 1979). (Again, for DO, intergravel vs water column is not specified, however, although the implication seems to be intergravel DO.)
Freshwater juveniles avoid water with ≤ 4.5 mg/l dissolved oxygen at 20 degrees C. (Whitmore et al., 1960).
Migrating adults will pass through water with dissolved oxygen levels as low as 3.5-4.0 mg/l (Fujioka, 1970; Alabaster 1988, 1989). Excessive silt loads (>4000 mg/l) may halt chinook salmon movements or migrations (Reiser and Bjornn, 1979). Silt can also hinder fry emergence, and limit benthic invertebrate production (Reiser and Bjornn, 1979). Low pH decreases egg and alevin survival (no values given).

Upper Columbia River spring-run chinook salmon (*Oncorhynchus tshawytscha*): Proposed endangered status WA, 3/9/98, 63FR11481. (The following life history information is taken from 63FR11489.)

The NMFS on 3/9/98, proposed several chinook salmon ESUs for listing under the ESA (63FR11481). The Upper Columbia River spring-run chinook ESU is proposed-endangered. This ESU includes stream-type chinook salmon spawning above Rock Island Dam - that is, those in the Wenatchee, Entiat, and Methow Rivers. All chinook salmon in the Okanogan River are apparently ocean-type and are considered part of the Upper Columbia River summer- and fall-run ESU. Critical habitat designation is found on page 11515 of 63FR (3/9/98). Designated habitat includes all river reaches accessible to chinook salmon in Columbia River tributaries upstream of the Rock Island Dam and downstream of Chief Joseph Dam in Washington, excluding the Okanogan River. Also included are river reaches and estuarine areas in the Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) and the west end of the Peacock jetty (north jetty, Washington side) upstream to Chief Joseph Dam in Washington. Excluded are areas above specific dams identified in Table 16 of 63FR11481 or above longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years).

This ESU was first identified as the Mid-Columbia River summer/fall chinook salmon ESU but a later determinations concluded this ESU's boundaries do not extend downstream from the Snake River. The ESU status of the Marion Drain population from the Yakima River is still unresolved.

ESU status. Access to a substantial portion of historical habitat was blocked by Chief Joseph and Grand Coulee Dams. There are local habitat problems related to irrigation diversions and hydroelectric development, as well as degraded riparian and instream habitat from urbanization and livestock grazing. Mainstem Columbia River hydroelectric development has resulted in a major disruption of migration corridors and affected flow regimes and estuarine habitat. Some populations in this ESU must migrate through nine mainstem dams.

Artificial propagation efforts have had a significant impact on spring-run populations in this

ESU, either through hatchery-based enhancement or the extensive trapping and transportation. Harvest rates are low for this ESU, with very low ocean and moderate instream harvest. Previous assessments of stocks within this ESU have identified several as being at risk or of concern. Due to lack of information on chinook salmon stocks that are presumed to be extinct, the relationship of these stocks to existing ESUs is uncertain. Recent total abundance of this ESU is quite low, and escapements in 21994-1996 were the lowest in at least 60 years. At least six populations of spring chinook salmon in this ESU have become extinct, and almost all remaining naturally-spawning populations have fewer than 100 spawners. In addition to extremely small population sizes, both recent and long-term trends in abundance are downward, some extremely so. NMFS concluded that chinook salmon in this ESU are in danger of extinction.

Chinook salmon from this ESU primarily emigrate to the ocean as subyearlings but mature at an older age than ocean-type chinook salmon in the Lower Columbia and Snake Rivers. Furthermore, a greater proportion of tag recoveries for this ESU occur in the Alaskan coastal fishery than is the case for Snake River fish. The status review for Snake River fall chinook salmon also identified genetic and environmental differences between the Columbia and Snake rivers. Substantial life history and genetic differences distinguish fish in this ESU from stream-type spring chinook salmon from the upper-Columbia River.

The ESU boundaries fall within part of the Columbia Basin Ecoregion. The areas is generally dry and relies on Cascade Range snowmelt for peak spring flows. Historically, this ESU likely extended farther upstream; spawning habitat was compressed down-river following construction of Grand Coulee Dam.

Threats:

Factors influencing the decline include: the present or threatened destruction, modification, or curtailment of the species habitat or range such as loss, damage or change to the species' natural environment through water diversions, forestry, agriculture, mining, and urbanization; over-utilization of the species for commercial, recreational, scientific or educational purposes - particularly over-fishing; predation, introduction of non-native species, and habitat loss or impairment increasing stress on any surviving individuals and thus increasing susceptibility of the species to numerous bacterial, protozoan, viral, and parasitic diseases; the inadequacy of existing regulatory mechanism to prevent the decline of the species. Refer to 63FR11498 for a detailed generic discussion of factors affecting this chinook salmon ESUs.

Lower Columbia River chinook salmon, all runs (*Oncorhynchus tshawytscha*): Proposed threatened status WA, 3/9/98, 63FR11481. (The following life history information is taken from 63FR11488.)

The NMFS on 3/9/98, proposed several chinook salmon ESUs for listing under the ESA (63FR11481). The Lower Columbia River spring-run chinook ESU is proposed-threatened. This ESU includes all naturally spawned chinook populations form the mouth of the Columbia river to the crest of the Cascade Range, excluding populations above Willamette Falls. Designated critical habitat can be found in 63FR, page 11515. The designation is designed to include all river reaches accessible to chinook salmon in Columbia River tributaries between the Grays and White Salmon

Rivers in Washington and the Willamette and Hood Rivers in Oregon, inclusive. Also included are river reaches and estuarine areas in the Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) and the west end of the Peacock jetty (north jetty, Washington side) upstream to The Dalles Dam; with the usual exclusions.

ESU status. Apart form the relatively large and apparently healthy fall-run population in the Lewis River, production in this ESU appears to be predominantly hatchery-driven with few identifiable naturally spawned populations. All basins are affected (to varying degrees) by habitat degradation. Hatchery programs have had a negative effect on the native ESU. Efforts to enhance chinook salmon fisheries abundance in the lower Columbia River began in the 1870s. Available evidence indicates a pervasive influence of hatchery fish on natural populations throughout this ESU, including both spring- and fall-run populations. The large number of hatchery fish in this ESU make it difficult to determine the proportion of naturally produced fish. The loss of fitness and diversity within the ESU is an important concern.

Harvest rates on fall-run stocks are moderately high, with an average total exploitation rate of 65 percent. Harvest rates are somewhat lower for spring-run stocks, with estimates for the Lewis River totaling 50 percent. Previous assessments of stocks within this ESU have identified several stocks as being at risk or of concern. There have been at least six documented extinctions of populations in the ESU, and it is possible that extirpation of other native population has occurred but has been masked by the presence of naturally spawning hatchery fish. NMFS concludes that chinook salmon in this ESU are not presently in danger of extinction but are likely to become endangered in the foreseeable future.

Threats:

Factors influencing the decline include: the present or threatened destruction, modification, or curtailment of the species habitat or range such as loss, damage or change to the species' natural environment through water diversions, forestry, agriculture, mining, and urbanization; over-utilization of the species for commercial, recreational, scientific or educational purposes, particularly over-fishing; predation, introduction of non-native species, and habitat loss or impairment increasing stress on any surviving individuals and thus increasing susceptibility of the species to numerous bacterial, protozoan, viral, and parasitic diseases; the inadequacy of existing regulatory mechanism to prevent the decline of the species. Refer to 63FR11498 for a detailed generic discussion of factors affecting this chinook salmon ESUs.

Upper Willamette River spring-run chinook salmon (*Oncorhynchus tshawytscha*): Proposed threatened status WA, 3/9/98, 63FR11481. (The following life history information is taken from 63FR11489.)

The NMFS on 3/9/98, proposed several chinook salmon ESUs for listing under the ESA (63FR11481). The Upper Willamette River spring-run chinook ESU is proposed-threatened. This ESU includes naturally spawned spring-run chinook salmon populations above Willamette Falls. Fall chinook above the Falls are introduced and although they are naturally spawning, they are not considered a population for purposes of defining this ESU. Critical habitat is designated in 63FR, page 11515. In addition to the area of the Willamette River and its tributaries above the Falls, also included are river reaches and estuarine areas in the Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) and the west end of the Peacock jetty (north jetty, Washington side) upstream to and including the Willamette River in Oregon, with the usual exclusions regarding specific dams and longstanding natural barriers.

ESU status. While the abundance of Willamette River spring chinook salmon has been relatively stable over the long term, and there is evidence of some natural production, it is apparent that at present natural production and harvest levels the natural population is not replacing itself. With natural production accounting for only one-third of the natural spawning escapement, it is questionable whether natural spawners would be capable of replacing themselves even in the absence of fisheries. The introduction of fall-run chinook into the basin and laddering of Willamette Falls have increased the potential for genetic introgression between wild spring- and hatchery fall-run chinook. Habitat blockage and degradation are significant problems in this ESU. Another concern for this ESU is that commercial and recreational harvests are high relative to the apparent productivity of natural populations. Recent escapement is less than 5,000 fish and been declining sharply. NMFS concludes that chinook salmon in this ESU are not presently in danger of extinction but are likely to become endangered in the foreseeable future.

Historic, naturally spawned populations in this ESU have an unusual life history that shares features of both the stream and ocean types. Scale analysis of returning fish indicate a predominantly yearling smolt life-history and maturity at four years of age, but these data are primarily from hatchery fish and may not accurately reflect patterns for the natural fish. Young-of-year smolts have been found to contribute to the returning three year-old year class. The ocean distribution is consistent with an ocean-type life history, and tag recoveries occur in considerable numbers in the Alaskan and British Columbian coastal fisheries. Intra-basin transfers have contributed to the homogenization of Willamette River spring chinook stocks; however, Willamette River spring chinook remain one of the most genetically distinctive groups of chinook salmon in the Columbia River Basin.

The geography and ecology of the Willamette valley is considerably different from surrounding areas. Historically, the Willamette Falls offered a narrow temporal window for upriver migration, which may have promoted isolation from other Columbia River stocks.

Threats:

Factors influencing the decline include: the present or threatened destruction, modification, or curtailment of the species habitat or range such as loss, damage or change to the species' natural environment through water diversions, forestry, agriculture, mining, and urbanization; over-utilization of the species for commercial, recreational, scientific or educational purposes, particularly over-fishing; predation, introduction of non-native species, and habitat loss or impairment increasing stress on any surviving individuals and thus increasing susceptibility of the species to numerous bacterial, protozoan, viral, and parasitic diseases; the inadequacy of existing regulatory mechanism to prevent the decline of the species. Refer to 63FR11498 for a detailed generic discussion of factors affecting this chinook salmon ESUs.

Southern Oregon and California Coastal spring and fall chinook salmon (*Oncorhynchus*

***tshawytscha*):** **Proposed threatened** status WA, 3/9/98, 63FR11481. (The following life history information is taken from 63FR11487).

The NMFS on 3/9/98, proposed several chinook salmon ESUs for listing under the ESA (63FR11481). The Southern Oregon and California Coastal spring- and fall-run chinook ESU is proposed-threatened. This portion of concern for Oregon in this ESU are the very southern coastal watersheds. Critical habitat is designated in 63FR, page 1515 and includes all river reaches and estuarine areas accessible to chinook salmon from the southern Oregon border to Cape Blanco (Elk River). Excluded are the Klamath and Trinity Rivers upstream of their confluence; these stocks are genetically and ecologically distinguishable from those in this ESU.

ESU status. Chinook salmon spawning abundance in this ESU is highly variable among populations. There is a general pattern of downward trends in abundance in most populations for which data are available, with declines being especially pronounced in spring-run populations. Habitat loss and/or degradation is widespread throughout the range of the ESU. The Rouge River Basin in particular has been affected by mining activities and unscreened irrigation diversions in addition to the problems resulting from logging and dam construction. Artificial propagation program contribution to overall abundance is relatively low except for the Rouge River spring run. NMFS concludes that the extremely depressed status of almost all coastal populations south of the Klamath River is an important source of risk to the ESU and that chinook salmon in this ESU are likely to become endangered in the foreseeable future.

Chinook salmon in this ESU exhibit an ocean-type life history; ocean distribution (based on tag recoveries) is predominantly off of the California and Oregon coasts. Life history information on smaller populations, especially in the southern portion of the ESU, is extremely limited. Data show some divergence between chinook populations north and south of the Klamath River, but the available information is incomplete to describe chinook salmon south of the Klamath River as a separate ESU. Life history differences also exist between spring- and fall-run fish in the ESU, but not to the same extent as is observed in larger inland basins.

Ecologically, the majority of the river systems in this ESU are relatively small and heavily influenced by a maritime climate. Low summer flow and high temperature in many rivers result in seasonal physical and thermal barrier bars that block movement by anadromous fish. The Rouge River is the largest river basin in this ESU and extends inland into the Sierra Nevada and Cascades Ecoregions.

Threats:

Factors influencing the decline include: the present or threatened destruction, modification, or curtailment of the species habitat or range such as loss, damage or change to the species' natural environment through water diversions, forestry, agriculture, mining, and urbanization; over-utilization of the species for commercial, recreational, scientific or educational purposes, particularly over-fishing; predation, introduction of non-native species, and habitat loss or impairment increasing stress on any surviving individuals and thus increasing susceptibility of the species to numerous bacterial, protozoan, viral, and parasitic diseases; the inadequacy of existing regulatory mechanism to prevent the decline of the species. Refer to 63FR11498 for a detailed generic discussion of factors affecting this chinook salmon ESUs.

Oregon Coast coho salmon (*Oncorhynchus kisutch*): (The following life history information is taken from NMFS, 1996; and 60FR38011, 63FR42587). **Threatened** OR status 8/10/98, 63FR42587.

The Oregon coast coho ESU was listed as "proposed threatened" on 7/25/95 (60FR38011); the listing was finalized on 8/10/98 (63FR42587). This ESU represents naturally spawning coho inhabiting coastal streams draining the coast Range Mountains between Cape Blanco and the Columbia River. Critical habitat has not been designated.

ESU status. Within the Oregon coast ESU, hatchery populations from the north Oregon coast form a distinctive subgroup. Adult run- and spawn-timing are similar to those along the Washington coast and in the Columbia River, but less variable. While marine conditions off the Oregon and Washington coasts are similar, the Columbia River has greater influence north of its mouth, and the continental shelf becomes broader off the Washington coast. Upwelling off the Oregon coast is much more variable and generally weaker than areas south of Cape Blanco.

Estimated escapement of coho salmon in coastal Oregon was about 1.4 million fish in the early 1900s, with harvest of nearly 400,000 fish. Abundance of wild Oregon coast coho salmon declined during the period from about 1965 to 1975 and has fluctuated at a low level since that time (Nickelson et al., 1992a). Production potential (based on stock-recruit models) shows a reduction of nearly 50 percent in habitat capacity. Recent spawning escapement estimates indicate an average spawning escapement of less than 30,000 adults. Current abundance of coho on the Oregon coast may be less than five percent of that in the early part of this century. The Oregon coast coho salmon ESU is not at immediate danger of extinction but may become endangered in the future if present trends continue (Weitkamp et al., 1995).

For more information on of coho salmon life history, and factors contributing to the decline of the species (threats), refer to the discussion under southern Oregon/northern California coast ESU.

Spawn timing. Most OC coho salmon enter rivers from late September to mid-October with the onset of autumn freshets. Thus, a delay in fall rains will retard river entry and perhaps spawn timing. Peak spawning occurs from mid-November to early February.

Spawning habitat and temperature. Although each native stock appears to have a unique time and temperature for spawning that theoretically maximizes offspring survival, coho salmon generally spawn at water temperatures within the range of 10-12.8 degrees C. (Bell, 1991). Predominant spawning streams are low gradient fourth- and fifth-order, with clean gravel of pea to orange size.

Hatching and emergence. The favorable range for coho salmon egg incubation is 10-12.8 degrees C. (Bell, 1991). Depending on water temperature, eggs incubate for 35 to 50 days and start emerging from the gravel two to three weeks after hatching (Nickelson et al., 1992a).

Parr movement and smoltification. Following emergence, fry move into shallow areas near the stream banks. Their territory seems to be related not only to slack water, but to objects which provide points of reference to which the fry can return (Hoar, 1951). Juvenile rearing usually occurs in low gradient tributary streams, although they may move up to streams of 4 or 5 percent gradient. Juveniles have been found in streams as small as one to two meters wide. When the fry are approximately 4 cm in length, they migrate upstream considerable distances to reach lakes or other rearing areas. Rearing requires temperatures of 20 degrees C. or less, preferably 11.7-14.4 degrees C. (Bell 1991). Coho salmon fry prefer backwater pools during spring. In the summer, juveniles are more abundant in pools than in glides or riffles. During winter, the fishes predominate in off-channel pools of any type. The ideal food channel for maximum coho smolt production is shallow, fairly swift mid-stream flows with numerous back-eddies, narrow width, copious overhanging mixed vegetation (for stream temperature control and insect habitat), and banks permitting hiding places. Rearing in freshwater may be up to 15 months followed by moving to the sea as smolts between February and June (Weitkamp et al, 1995).

Estuary and ocean migration. Little is known about residence time or habitat use in estuaries during seaward migration, although the assumption is that coho salmon spend only a short time in the estuary before entering the ocean (Nickelson et al., 1992a). Growth is very rapid once the smolts reach the estuary (Fisher et al., 1984). While living in the ocean, coho salmon remain closer to their river of origin than do chinook salmon. After about 12 months at sea, coho salmon gradually migrate south and along the coast, but some appear to follow a counter-clockwise circuit in the Gulf of Alaska (Sandercock, 1991). Coho typically spend two growing seasons in the ocean before returning to their natal streams to spawn as three year-olds. Some precocious males ("jacks"), return to spawn after only six months at sea.

Food. The early diets of emerging fry include chironomid larvae and pupae. Juveniles are carnivorous opportunists, eating insects. These fish do not appear to pick stationary items off the substratum.

S. Oregon/N. California Coast (SONC) coho salmon (*Oncorhynchus kisutch*): (The following life history summary is taken form NMFS, 1996; and 62FR24588, 62FR6274). **Threatened** OR status 5/6/97, 62FR24588.

The SONC ESU coho and the Oregon coast coho ESU were both listed as "proposed threatened" on 7/25/95 (60FR38011). On 6 May 1997 (62FR24588), the SONC coho salmon was listed as threatened. On 25 November 1997 the NMFS proposed to designate critical habitat for the SONC coho salmon ESU (62FR6274) as: accessible reaches of all rivers (including estuarine areas and tributaries) between the Mattole River in California and the Elk River (Cape Blanco area) in Oregon, inclusive. NMFS is not proposing to designate critical habitat in marine areas at this time. Excluded areas are above certain dams (Lost Creek Dam on the Rogue River, Applegate Dam on the Applegate, and Iron Gate Dam [in California] on the upper Klamath River) and longstanding, impassable barriers.

ESU status. In the 1940s, estimated abundance of coho salmon in this ESU ranged from 150,000 to 400,000 naturally spawning fish. Today, coho populations in this ESU are very depressed, currently numbering approximately 10,000 naturally produced adults. Although the

Oregon portion of the coho salmon SONC ESU has declined drastically, the Rogue River Basin increased substantially from 1974-1997. The bulk of current coho salmon production in this ESU consists of stocks from the Rogue River, Klamath River, Trinity River, and Eel River in Oregon.

In contrast to the life history patterns of other anadromous salmonids, coho salmon exhibit a relatively simple three-year life cycle.

In migration and spawning. Most SONC coho salmon enter rivers between September and February and spawn from November to January (occasionally into early spring). In migration is influenced by river flow, especially for many small California stream systems that have sandbars at their mouths for much of the year except winter (Weitcamp et al., 1995).

Incubation and rearing. Coho salmon eggs incubate for 35 to 50 days between November and March, and start emerging from the gravel two to three weeks after hatching (Hassler, 1987). Following emergence, fry move into shallow areas near the stream banks. As the fry grow larger, they disperse up- and downstream to establish and defend a territory (Hassler, 1987). During the summer, fry prefer pools and riffles with adequate cover. Juveniles over-winter in large mainstem pools, backwater areas, and secondary pools with large woody debris, and undercut bank areas.

Juveniles primarily eat aquatic and terrestrial insects (Sandercock, 1991). After rearing in freshwater for up to 15 months, the smolts enter the ocean between March and June (Weitcamp et al., 1995).

Estuary and ocean migration. Although coho salmon have been captured several thousand kilometers away from their natal stream, this species usually remains closer to its river of origin than chinook salmon. Coho typically spend two growing seasons in the ocean before returning to spawn as three year-olds; precocious males ("jacks") may return after only six months at sea.

Population trends. In Oregon south of Cape Blanco, Nehlsen et al. (1991) considered all but one coho salmon stock at "high risk of extinction". South of Cape Blanco, Nickelson et al. (1992a) rated all Oregon coho salmon stocks as "depressed".

Threats:

Threats to naturally-reproducing coho salmon throughout its range are numerous and varied. Habitat factors include: Channel morphology changes, substrate changes, loss of in stream roughness, loss of estuarine habitat, loss of wetlands, loss/degradation of riparian areas, declines in water quality (e.g., elevated water temperatures, reduced dissolved oxygen, altered biological communities, toxics, elevated pH, and altered stream fertility), altered stream flows, fish passage impediments, elimination of habitat, and direct take. The major activities responsible for the decline of coho salmon in Oregon are logging, road building, grazing and mining activities, urbanization, stream channelization, dams, wetland loss, beaver trapping, water withdrawals, and unscreened diversions for irrigation.

Agricultural practices have also contributed to the degradation of salmonid habitat on the west coast through irrigation diversions, overgrazing in riparian areas, and compaction of soils in upland areas from livestock. Urbanization has degraded coho salmon habitat through steam channelization, floodplain drainage, and riparian damage. Forestry has degraded coho habitat through removal and disturbance of natural vegetation, disturbance and compaction of soils, construction of roads, and installation of culverts. Timber harvest activities and erosion from logging roads can result in sediment delivered to streams through mass wasting and surface erosion that can elevate the level of fine sediments in spawning gravels and fill the substrate interstices inhabited by invertebrates.

Depletion of storage of natural flows have drastically altered natural hydrological cycles. Alteration of stream flows has increased juvenile salmonid mortality for a variety of reasons: Migration delay resulting from insufficient flows or habitat blockages; loss of usable habitat due to de-watering and blockage; stranding of fish resulting from rapid flow fluctuations; entrainment of juveniles into unscreened or poorly screened diversion; and increased juvenile mortality resulting from increased water temperatures. In addition, reduced flows degrade or diminish fish habitats via increased deposition of fine sediments in spawning gravels, decreased recruitment of new spawning gravels, and encroachment of riparian and nonendemic vegetation into spawning and rearing areas.

Considering over utilization for commercial recreational, scientific, or education purposes: Harvest management practiced by the tribes is conservative and has resulted in limited impact on the coho stock in the Klamath and Trinity Rivers; overfishing in on-tribal fisheries is believed to have been a significant factor in the decline of coho salmon; marked hatchery coho are allowed to be harvested in the Rogue River, all other recreational coho salmon fisheries in the Oregon portion of this ESU are closed; collection for scientific research and educational programs is believed to have had little or no impact on coho populations in the ESU.

Relative to other effects, disease and predation are not believed to be major factors contributing to the overall decline of coho salmon in this ESU. However, disease and predation may have substantial impacts in local areas.

Lower Columbia River/Southwest Washington Coast (LCSW) coho salmon (*Oncorhynchus kisutch*): (The following life history summary is taken fromNMFS, 1996; and 60FR38011). **Candidate** status OR, WA 7/250/95, 66FR38011.

The LCSW coho salmon was proposed as a candidate ESA species in 7/25/95 (60FR38011). NMFS concludes that historically this ESU included coho salmon from all tributaries of the Columbia River below approximately the Klickitat and Deschutes Rivers, as well as coastal drainages in southwest Washington between the Columbia River and Point Grenville. The Columbia River estuary and Willapa Bay and Grays Harbor in southwest Washington all have extensive intertidal mud and sand flats and differ substantially from estuaries to the north and south.

ESU status. At least one ESU of coho salmon probably occurred in the lower Columbia River Basin, but NMFS was unable to identify any remaining natural populations that warranted protection under the ESA. Coho salmon stocks above Bonneville Dam (except Hood River) are classified as extinct. The Clackamas River stock was classified as at moderate risk of extinction.

. While the number of naturally-reproducing fish within the LCSW coast ESU is fairly large, evaluating the risk to this ESU is difficult because of the uncertainty about the relationship of the present natural populations to the historic ESU. The LCSW coho salmon ESU is on the Candidate List until the distribution and status of the native populations can be resolved.

Threats

Refer to the preceding discussions for other coho salmon ESUs for life history information and factors contributing to the decline of the species.

Chum salmon (*Oncorhynchus keta*): Columbia River ESU and [Hood Canal summer-run ESU*] (The following life history information is taken from 63FR11773.) **Proposed Threatened** status OR, WA 3/10/98. 63FR11773.

On 10 March 1998 the NMFS issued a proposed rule and request for comments to list two west coast chum salmon ESUs as threatened. The proposed listings and critical habitat designations are in 63FR16955 (4/7/98). [The **Hood Canal** summer-run ESU chum salmon spawn in tributaries to Hood Canal, Discovery Bay, and Sequim Bay, WA*], and the **Columbia River** ESU chum salmon spawn in tributaries to the lower Columbia River (WA and OR).

Designated critical habitat consists of the water, substrate, and adjacent riparian zone of estuarine and riverine reaches in specific hydrologic units and counties. Accessible reaches are those within the historical range of the ESUs that can still be occupied by any life stage of chum salmon. Columbia River chum salmon critical habitat designation includes all accessible reaches in the Columbia River downstream from Bonneville Dam, excluding Oregon tributaries upstream of Milton Creek at river km 144 near the town of St. Helens.

ESU status. Information on the condition of these chum salmon ESUs is not included in 63FR11773.

Life history information specific to the two above ESUs is not available. The chum salmon or dog salmon is the third most abundant salmon species in the Pacific Northwest. Spawning for chum salmon adults may take place just at the head of tide waters similar to pink salmon, however unlike pinks, chum also migrate upriver to spawn. Spawning occurs from October through December. Most adult females construct their redds near saltwater and are territorially aggressive; therefore, females may "miss out" on male spawners. Because of the location of most redds in lower rivers, an embryo mortality of 70 to 90 percent is possible - due to siltation and decreased dissolved oxygen transfer. Chum salmon benefit from high quality habitat conditions in lower rivers and estuaries.

After emergence, fry do not rear in freshwater. Chum salmon fry migrate immediately (at night) to the estuary for rearing. Out-migration is March through June. Juveniles remain near the seashore during July and August. Juveniles spend from just half a year to four years at sea.

Threats

Factors for the decline in condition of these chum salmon ESUs were not included in the listing document. Similar habitat, harvest, and water quality factors as previously discussed for other threatened or endangered salmon species have affected the listed chum salmon ESUs' integrity.

Steelhead - (*Oncorhynchus mykiss*) Generic Information: (The following information is taken from NOAA, NMFS - 50 CFR Parts 222 and 227; 63FR11797).

A notice of public hearings on proposed ESA listings and critical habitat is found in 63FR16955 (4/7/98).

Steelhead exhibit one of the most complex life histories of any salmonid species. Steelhead may exhibit anadromy or freshwater residency. Resident forms are usually referred to as "rainbow" or "redband" trout, while anadromous life forms are termed "steelhead".

Steelhead typically migrate to marine waters after spending 2 years in freshwater. They then reside in marine waters for 2 ro 3 years prior to returning to their natal stream to spawn as 4- or 5-year-olds. Depending on water temperature, steelhead eggs may incubate in redds for 1.5 to 4 months before hatching as alevins (larval stage dependent on yolk sac as food). Following yolk sac absorption, alevins emerge from the gravel as young juveniles (fry) and begin actively feeding. Juveniles rear in freshwater from 1 to 4 years, then migrate to the ocean as smolts.

Biologically, steelhead can be divided into two reproductive ecotypes, based on their state of sexual maturity at the time of river entry and the duration of their spawning migration. These two ecotypes are termed "stream maturing" and "ocean maturing". Stream maturing steelhead return to freshwater in a sexually immature condition and require several months to mature and spawn. Ocean maturing steelhead enter freshwater with well-developed gonads and spawn shortly after river entry. These two reproductive ecotypes are more commonly referred to by their season of freshwater entry (i.e., summer and winter steelhead).

Two major genetic groups or "subspecies" of steelhead occur on the west coast of the United States: a coastal group and an inland group, separated on the Fraser and Columbia River Basins by the Cascade crest. Historically, steelhead likely inhabited most coastal streams in Washington, Oregon, and California, as well as many inland streams in these states and Idaho. However, during this century, over 23 indigenous, naturally-reproducing stocks of steelhead are believed to have been extirpated, and many more are thought to be in decline in numerous coastal and inland streams.

Threats

Factors contributing to the decline of specific steelhead ESUs are discussed under each ESU. General information for west coast steelhead is summarized here. Forestry, agriculture, mining, and urbanization have degraded, simplified, and fragmented habitat. Water diversions for agriculture, flood control, domestic, and hydropower purposes have greatly reduced or eliminated historically accessible habitat. Washington and Oregon's wetlands are estimated to have diminished by one-third. Loss of habitat complexity as seen in the decrease of abundance of large, deep pools due to sedimentation and loss of pool-forming structures has also adversely affected west coast steelhead (an 80 percent loss for Oregon).

Steelhead are not generally targeted in commercial fisheries but do support an important recreational fishery throughout their range. A particular problem occurs in the main stem of the Columbia River where listed steelhead from the Middle Columbia River ESU are subject to the same fisheries as unlisted, hatchery-produced steelhead, chinook and coho salmon. Infectious disease and predation also take their toll on steelhead. Introductions of non-native species and habitat modifications have resulted in increased predator populations in numerous river systems. Federal and state land management practices have not been effective in stemming the decline in west coast steelhead.

Snake River Basin Steelhead (SRB) (*Oncorhynchus mykiss*): (The following information is taken from NOAA, NMFS - 50 CFR Parts 222 and 227; and 62FR43937). **Threatened** status ID, OR, WA 8/18/97, 62FR43937.

This inland steelhead ESU occupies the Snake River Basin of southeast Washington, northeast Oregon and Idaho. A final listing status of threatened was issued on 18 August 1997 (62FR43937) for the spawning range upstream from the confluence with the Columbia River. No official critical habitat is designated. The Snake River flows through terrain that is warmer and drier on an annual basis than the upper Columbia Basin or other drainages to the north. Geologically, the land forms are older and much more eroded than most other steelhead habitat. Collectively, the environmental factors of the Snake River Basin result in a river that is warmer and more turbid, with higher pH and alkalinity, than is found elsewhere in the range of inland steelhead.

ESU status. SRB steelhead all defined as "B-run" steelhead. Prior to Ice Harbor Dam completion in 1962, there were no counts of Snake River basin naturally spawned steelhead. From 1949 to 1971 counts averaged about 40,000 steelhead for the Clearwater River. At Ice Harbor Dam, counts averaged approximately 70,000 until 1970. The natural component for steelhead escapements above Lower Granite Dam was about 9400 (2400 B-run) from 1990-1994. SRB steelhead recently suffered severe declines in abundance relative to historical levels. Low run sizes over the last 10 years are most pronounced for naturally produced steelhead. The drop in parr densities characterizes many river basins in this region as being underseeded relative to the carrying capacity of streams. Declines in abundance have been particularly serious for B-run steelhead, increasing the risk that some of the life history diversity may be lost from steelhead in this ESU.

Hatchery/natural interactions that occur for SRB steelhead are of concern because many of the hatcheries use composite stocks that have been domesticated over a long period of time. The primary indicator of risk to the ESU is declining abundance throughout the region.

SRB steelhead are summer steelhead, as are most inland steelhead, and comprise two groups, A-run and B-run, based on migration timing, ocean-age, and adult size. SRB steelhead enter freshwater from June to October and spawn in the following spring from March to May. A-run steelhead are thought to be predominately 1-ocean (one year at sea), while B-run steelhead are thought to be 2-ocean (IDFG 1994 IN: 50 CFR Parts 222 and 227). SRB steelhead usually smolt at age 2- or 3-years (Whitt, 1954; BPA, 1992; Hassemer, 1992 IN: 50 CFR Parts 222 and 227).

The steelhead population from Dworshak National Fish Hatchery is the most divergent single population of inland steelhead based on genetic traits determined by protein electrophoresis; these fish are consistently referred to as B-run.

Threats

Similar factors to those affecting other salmonids are contributing to the decline of SRB steelhead. Widespread habitat blockage from hydrosystem management and potentially deleterious genetic effects from straying and introgression from hatchery fish. The reduction in habitat capacity resulting from large dams such as the Hells Canyon dam complex and Dworshak Dam is somewhat mitigated by several river basins with fairly good production of natural steelhead runs.

Upper Columbia River Basin Steelhead (UCRB) (*Oncorhynchus mykiss*): (The following life history information is taken from NOAA, NMFS - 50 CFR Parts 222 and 227; and 62FR43937). **Endangered** WA 8/18/97, 62FR43937.

This inland steelhead ESU occupies the Columbia River Basin upstream from the Yakima River, Washington, to the U.S./Canada border. The geographic area occupied by the ESU forms part of the larger Columbia Basin Ecoregion. This ESU received an endangered listing on 18 August 1997 (62FR43937). Official critical habitat is not designated. Mullan et al. (1992) (IN: 50 CFR Parts 222 and 227) described this area as a harsh environment for fish and stated that "it should not be confused with more studied, benign, coastal streams of the Pacific Northwest.

ESU status. NMFS cites a pre-fishery run size estimate in excess of 5000 adults for tributaries above Rock Island Dam. Runs may have already been depressed by lower Columbia River fisheries at the time of the early estimates (1933-1959). Most of the escapement to naturally spawning habitat within the range of this ESU is to the Wenatchee River, and the Methow and Okanogan Rivers. The Entiat River also has a small spawning run. Steelhead in the Upper Columbia river ESU continue to exhibit low abundances, both in absolute numbers and in relation to numbers of hatchery fish throughout the region. Estimates of natural production of steelhead in the ESU are will below replacement (approximately 0.3:1 adult replacement ratios estimated in the Wenatchee and Entiat Rivers). The proportion of hatchery fish is high in these rivers (65-80 percent) with extensive mixing of hatchery and natural stocks.

Life history characteristics for UCRB steelhead are similar to those of other inland steelhead ESUs. However, some of the oldest smolt ages for steelhead, up to 7 years, are reported from this ESU; this may be associated with the cold stream temperatures (Mullan et al., 1992 IN: 50 CFR Parts 222 and 227). Based on limited data available from adult fish, smolt age in this ESU is dominated by 2-year-olds. Steelhead from the Wenatchee and Entiat Rivers return to freshwater after 1 year in salt water, whereas Methow River steelhead are primarily 2-ocean resident (i.e., 2 years in salt water) (Howell et al., 1985 IN: 50 CFR Parts 222 and 227).

In an effort to preserve fish runs affected by Grand Coulee Dam (blocked fish passage in 1939), all anadromous fish migrating upstream were trapped at Rock Island Dam (Rkm 729) from 1939 through 1943 and either released to spawn in tributaries between Rock Island and Grand Coulee Dams or spawned in hatcheries and the offspring released in that area (Mullan et al., 1992; Chapman et al., 1994 IN: 50 CFR Parts 222 and 227). Through this process, stocks of all anadromous salmonids, including steelhead, which historically were native to several separate sub-basins above Rock Island Dam, were randomly redistributed among tributaries in the Rock Island-Grand Coulee reach. Exactly how this has affected stock composition of steelhead is unknown.

Threats

Habitat degradation, juvenile and adult mortality in the hydrosystem, and unfavorable environmental conditions in both marine and freshwater habitats have contributed to the declines and represent risk factor for the future. Harvest in lower river fisheries and genetic homogenization from composite broodstock collection are other factors that may contribute significant risk to the Upper Columbia ESU.

Middle Columbia Basin Steelhead (*Oncorhynchus mykiss*): Proposed threatened status WA, OR 3/10/98, 63FR11797. (The following life history information is taken from 63FR11797.)

After a comprehensive status review of West Coast steelhead populations in Washington and Oregon, the NMFS identified 15 ESUs. On 3/10/98 the Middle Columbia River steelhead ESU was proposed as threatened (63FR11797). The middle Columbia area includes tributaries from above (and excluding) the Wind River in Washington and the Hood River in Oregon, upstream to, and including the Yakima River, in Washington. Steelhead of the Snake River Basin are excluded. There is no official critical habitat designation.

ESU status. Current population sizes are substantially lower than historic levels, especially in the rivers with the largest steelhead runs in the ESU, the John Day, Deschutes, and Yakima Rivers. At least two extinctions of native steelhead runs in the ESU have occurred (the Crooked and Metolius Rivers, both in the Deschutes River Basin). In addition, NMFS remains concerned about the widespread long- and short-term downward trends in population abundance throughout the ESU.

Genetic differences between inland and coastal steelhead are well established, although some uncertainty remains about the exact geographic boundaries of the two forms in the Columbia River (63FR11801). All steelhead in the Columbia River Basin upstream from The Dalles Dam are summer-run, inland steelhead. Life history information for steelhead of this ESU indicates that most middle Columbia River steelhead smolt at two years and spend one to two years in salt water (i.e., 1-ocean and 2-ocean fish, respectively) prior to re-entering freshwater, where they may remain up to a year before spawning. Within this ESU, the Klickitat River is unusual in that it produces both summer and winter steelhead, and the summer steelhead are dominated by 2-ocean steelhead, whereas most other rivers in this region produce about equal number of both 1- and 2-ocean steelhead.

Threats

The recent and dramatic increase in the percentage of hatchery fish in natural escapement in the Deschutes River Basin is a significant risk to natural steelhead in this ESU. Coincident with this increase in the percentage of strays has been a decline in the abundance of native steelhead in the Deschutes River.

Lower Columbia Basin Steelhead (*Oncorhynchus mykiss*): (The following life history information is taken from NOAA, NMFS - 50 CFR Parts 222 and 227). **Threatened** WA, OR 3/19/98, 63FR13347 and 7/17/98, 63FR32996.

This coastal steelhead ESU occupies tributaries to the Columbia River between the Cowlitz and Wind Rivers in Washington and the Willamette and Hood Rivers in Oregon. Excluded are steelhead in the upper Willamette River Basin above Willamette Falls, and steelhead from the Little and Big White Salmon Rivers in Washington. The Lower Columbia River steelhead ESU is listed as threatened (63FR13347, 3/19/98). Official critical habitat is not designated. The lower Columbia River has extensive intertidal mud and sand flats and differs substantially from estuaries to the north and south. Rivers draining into the Columbia River have their headwaters in increasingly drier areas, moving from west to east. Columbia River tributaries that drain the Cascade mountains have proportionally higher flows in late summer and early fall than rivers on the Oregon coast.

ESU status. Steelhead populations are at low abundance relative to historical levels, placing this ESU at risk due to random fluctuations in genetic and demographic parameters that are characteristic of small populations. There have been almost universal, and in many cases dramatic, declines in steelhead abundance since the mid-1980s in both winter- and summer-runs. Genetic mixing with hatchery stocks have greatly diluted the integrity of native steelhead in the ESU. NMFS is unable to identify any natural populations of steelhead in the ESU that could be considered "healthy".

Steelhead populations in this ESU are of the coastal genetic group (Schreck et al. 1986, Chapman et al., 1994 IN: 50CFR Parts 222 and 227), and a number of genetic studies have shown that they are part of a different ancestral lineage than inland steelhead from the Columbia River Basin. Genetic data also show steelhead in this ESU to be distinct from steelhead in the upper Willamette River and coastal streams in Oregon and Washington. WDFW data show genetic affinity between the Kalama, Wind, and Washougal River steelhead. These data show differentiation between the Lower Columbia River ESU and the Southwest Washington and Middle Columbia River Basin ESUs. The Lower Columbia ESU is composed of winter steelhead and summer steelhead.

Threats

Habitat loss, hatchery steelhead introgression, and harvest are major contributors to the decline the steelhead in this ESU. Details on factors contributing to the decline of west coast steelhead are discussed above.

Upper Willamette River Steelhead (*Oncorhynchus mykiss*): Proposed threatened status WA, OR 3/10/98, 63FR11797. (The following life history information is taken from 63FR11797.)

After a comprehensive status review of West Coast steelhead populations Washington and Oregon, the NMFS identified 15 ESUs. On 3/10/98 the Upper Willamette River steelhead ESU was proposed as threatened (63FR11797). Official critical habitat has not been proposed. This coastal ESU occupies the Willamette River and its tributaries, upstream from Willamette Falls. The Willamette River Basin is zoogeographically complex. In addition to its connection to the Columbia River, the Willamette River historically has had connections with coastal basins through stream capture and headwater transfer events.

Steelhead from the upper Willamette River are genetically distinct from those in the lower river. Reproductive isolation from lower river populations may have been facilitated by Willamette Falls, which is known to be a migration barrier to some anadromous salmonids. For example, winter steelhead and spring chinook salmon (*O. tshawytscha*) occurred historically above the falls, but summer steelhead, fall chinook salmon, and coho salmon did not.

ESU status. Steelhead in the Upper Willamette ESU are distributed in a few, relatively small, natural populations. Over the past several decades, total abundance of natural late-migrating winter steelhead ascending the Willamette Falls fish ladder has fluctuated several times over a range of approximately 5,000-20,000 spawners. However, the last peak occurred in 1988, and this peak has been followed by a steep and continuing decline. Abundance in each of the last five years (to 1998) has been below 4,300 fish, and the run in 1995 was the lowest in 30 years. The low abundance, coupled with potential risks associated with interactions between naturally spawned steelhead and hatchery stocks is of great concern to NMFS.

The native steelhead of this basin are late-migrating winter steelhead, entering freshwater primarily in March and April, whereas most other populations of west coast winter steelhead enter freshwater beginning in November or December. As early as 1885, fish ladders were constructed at Willamette Falls to aid the passage of anadromous fish. As technology improved, the ladders were modified and rebuilt, most recently in 1971. These fishways facilitated successful introduction of Skamania stock summer steelhead and early-migrating Big Creek stock winter steelhead to the upper basin. Another effort to expand the steelhead production in the upper Willamette River was the stocking of native steelhead in tributaries not historically used by that species. Native steelhead primarily used tributaries on the east side of the basin, with cutthroat trout predominating in streams draining the west side of the basin.

Nonanadroumous *O. mydiss* are known to occupy the Upper Willamette River Basin; however, most of these nonanadromous populations occur above natural and man-made barriers. Historically, spawning by Upper Willamette River steelhead was concentrated in the North and Middle Santiam River Basins. These areas are now largely blocked to fish passage by dams, and steelhead spawning is distributed throughout more of the Upper Willamette River Basin than in the past. Due to introductions of non-native steelhead stocks and transplantation of native stocks within the basin, it is difficult to formulate a clear picture of the present distribution of native Upper Willamette River steelhead, and their relationship to nonanadromous and possibly residualized *O. mykiss* withing the basin.

Threats

Habitat loss, hatchery steelhead introgression, and harvest are major contributors to the decline the steelhead in this ESU. Details on factors contributing to the decline of west coast steelhead are discussed above.

Oregon Coast (OC) Steelhead (*Oncorhynchus mykiss*): (The following life history information is taken from NMFS 1996 and NOAA, NMFS - 50 CFR Parts 222 and 227, and 63FR13347).

Proposed threatened OR 8/18/97, 62FR43974. Listing **Not Warranted; Candidate** status OR 3/19/98, 63FR13347.

This coastal steelhead ESU occupies river basins on the Oregon coast north of Cape Blanco, excluding rivers and streams that are tributaries of the Columbia River. Oregon Coast steelhead are under a proposed listing as threatened (8/9/97 61FR41541 with a six month extension invoked on 8/18/97 62FR43937 - under West Coast Steelhead). On 3/19/98 (63FR13347) the NMFS determined that the Oregon Coast, Klamath Mountains Province (KMP), and Northern California ESUs did not warrant listing at that time. This ESU warrants classification as candidate species and NMFS will reevaluate the status of the ESU within four years to determine whether listing is warranted. Official critical habitat designation has not been made. Most rivers in this area drain the Coast Range mountains, have a single peak in flow in December or January, and have relatively low flow during summer and early fall. The coastal region receives fairly high precipitation levels, and the vegetation is dominated by Sitka spruce and western hemlock. Upwelling off the Oregon coast is much more variable and generally weaker than areas south of Cape Blanco. While marine conditions off the Oregon and Washington coasts are similar, the Columbia River has greater influence north of its mouth, and the continental shelf becomes broader off the Washington coast.

Compared with other areas, populations of nonanadromous *O. mykiss* are relatively uncommon on the Oregon coast, occurring primarily above migration barriers and in the Umpqua River Basin (Kostow 1995 IN: 50 CFR Parts 222 and 227).

ESU status. See below under "Population trends."

Little information is available regarding migration and spawn timing of natural steelhead populations within this ESU. Age structure appears to be similar to other west coast steelhead, dominated by 4-year-old spawners. Iteroparity (capable of spawning more than once before death) is more common among Oregon coast steelhead than populations to the north.

Spawn timing. The OC steelhead ESU is primarily composed of winter steelhead. There are only two native stocks of summer steelhead in this ESU (one of which is in the Umpqua River basin stock) (Busby et al. 1996). Limited areas have introduced hatchery runs. Iteroparity is more common among OC steelhead than populations to the north.

Spawning habitat and temperature. Steelhead enter streams and arrive at the spawning ground weeks or even months before they spawn and are vulnerable to disturbance and predation; therefore, in stream and riparian cover is required. It appears that summer steelhead occur where habitat is not fully utilized by winter steelhead (often in upstream areas impassable to winter-run steelhead); consequentially, summer steelhead usually spawn farther upstream than winter steelhead (Wither, 1966; Behnke 1992). Typically, spawning and initial rearing takes place in small, moderate-gradient (3-5 percent) tributary stream (Nickelson et al., 1992a). Steelhead spawn in 3.9-9.4 degree C. water.

Hatching and emergence. Steelhead eggs incubate for 1.5 to 4 months depending on water temperature (61 FR 41542 8/9/96). Bjornn and Reiser (1991) observed a 50 percent hatch rate after only 26 days at 12 degrees C. After two to three weeks, in late spring, and following yolk sac absorption, alevins emerge from the gravel as fry and begin actively feeding along stream margins (Nickelson et al., 1992a). Productive steelhead habitat is characterized by complexity, primarily in the form of large and small wood. Some older juveniles move downstream to rear in larger tributaries and mainstem rivers (Nickelson et al., 1992a).

Parr movement and smoltification. Steelhead prefer water temperatures from 12 to 15 degrees C. (Reeves et al., 1987). Juveniles rear in freshwater from one to four years, then in the spring, migrate to the ocean as smolts (61 FR 41542 8/9/96). OC winter steelhead populations smolt after two years in freshwater (Busby et al., 1996).

Estuary and ocean migration. Steelhead typically reside in marine waters for two or three years prior to returning to their natal stream to spawn as four- or five-year olds (61 FR 41542 8/9/96). Juvenile steelhead tend to migrate offshore during their first summer rather than moving along the coast belt as salmon do. During the fall and winter, juveniles move southward and eastward (Hartt and Dell 1986). OC steelhead tend to be north-migrating (Nicholas and Hankin, 1988; Pearcy et al., 1990,;Pearcy 1992).

Food. Juvenile steelhead feed on a diversity of aquatic and terrestrial insects (Chapman and Bjornn, 1969). These fish hold territories close to the substratum where flows are low and sometimes counter to the main stream. From these localities, juveniles can foray up into surface currents to take drifting food (Kalleberg, 1958).

Population trends. Production of steelhead in nine Oregon coastal river basins (Coquille River north) was probably about 100,000 wild adults annually from 1930-1939. Contemporary (1980s) production in the same basins is about half the previous figure (Nickelson et al. 1992a). The OC steelhead ESU, although not presently in danger of extinction, is likely to become endangered in the foreseeable future (Busby et al., 1996).

Threats

Factors contributing to the decline of steelhead in this ESU include those discussed above. Substantial contribution of non-native hatchery fish to natural escapements in most basins has been a particularly negative influence on native populations.

Klamath Mountain Province (KMP) Steelhead (*Oncorhynchus mykiss*): (The following life history information is taken from NMFS 1996 and NOAA, NMFS - 50 CFR Parts 222 and 227; and from 61FR41541 and 63FR13347). **Proposed threatened** OR 8/18/97, 62FR43974. Listing **Not Warranted; Candidate** status OR 3/19/98, 63FR13347.

This coastal steelhead ESU occupies river basins form the Elk River in Oregon to the Klamath and Trinity Rivers in California, inclusive. The KMP ESU steelhead is proposed-threatened (61FR41541, 8/9/96; six month extension invoked on 8/18/97, 62FR43937 - under West Coast Steelhead). On 3/19/98 (63FR13347) the NMFS determined that the Klamath Mountain Province ESU did not warrant listing at that time. This ESU warrants classification as candidate species and NMFS will reevaluate the status of the ESU within four years to determine whether listing is warranted. No official critical habitat has been designated. Geologically, the KMP is not as erosive as the Franciscan formation terrain south of the Klamath River Basin. Dominant vegetation along the coast is redwood forest, while some interior basins are much drier than surrounding areas and are characterized by many endemic species. Elevated stream temperatures are a factor affecting steelhead and other species in some of the larger river basins. With the exception of major river basins such as the Rogue and Klamath, most rivers in this region have a short duration of peak flows. Strong and consistent coastal upwelling begins at about Cape Blanco and continues south into central California, resulting in a relatively productive nearshore marine environment.

ESU status. See below under "Population trends."

In migration. Variations in migration timing exist between populations. Summer steelhead spawn in January and February and winter steelhead generally spawn in April and May (Barnhart, 1986). The Klamath River has both winter- and summer-run steelhead.

Spawning and rearing. Steelhead spawn in cool, clear streams featuring suitable gravel size, depth, and current velocity. Steelhead are iteroparous, however, spawning more than twice before death is rare. Intermittent streams may be used for spawning (Barnhart, 1986; Everest, 1973). Steelhead eggs incubate between February and June (Bell, 1991), and typically emerge from the gravel two to three weeks after hatching (Barnhart, 1986). After emerging from the gravel, steelhead fry usually inhabit shallow water along perennial stream banks. Older fry establish and defend territories. Juvenile steelhead migrate little during their first summer and occupy a range of habitats featuring moderate to high velocity and variable depths (Bisson et al., 1988). The young fish feed on a wide variety of aquatic and terrestrial insects; the emerging fry are potential prey for older juvenile steelhead. Juveniles spend one to four years in freshwater before smolting and migrating to sea in March and April (Barnhart, 1986). Apparently, most steelhead migrate north and south in the ocean along the continental shelf (Barnhart, 1986).

Steelhead inhabit the ocean for one to four years. Variations in this pattern include the unusual "half-pounder". These steelhead return to freshwater after only a few months at sea, spend the winter in freshwater and then return to sea for several months before returning to freshwater to spawn. Half-pounders occur over a relatively small geographic area of southern Oregon and northern California. (Barnhart, 1986).

Population trends. Historical information on KMP steelhead abundance is scarce. The ODFW description of steelhead runs list only the Winchuck River as "healthy" (Nickelson et al., 1992a). For other rivers, the health of the steelhead runs varies from "low but stable" to "depressed" (for most rivers) to "near extinction". Barnhart (1994) noted that wild stocks of Klamath River steelhead may be at all time low levels.

Threats

Factors contributing to the decline of steelhead in this ESU include those discussed above. Additionally, most natural populations of steelhead within the area of this ESU experience a substantial infusion of naturally spawning hatchery fish each year.

Bull trout (*Salvelinus confluentus*) - Columbia River Basin stock: Threatened OR, WA, ID 6/10/98, 62FR32268. (The following life history information from 62FR32268, 63FR31693 and 63FR31647; and from various USFWS "News Releases").

At the time of the USFWS threatened listing (6/10/98, 63FR 31647) of this bull trout ESU, official critical habitat was not designated. The Columbia River population segment is from the northwestern United States and British Columbia, Canada. This population segment, comprised of 386 bull trout populations in Idaho, Montana, Oregon, and Washington with additional populations in British Columbia is threatened by habitat degradation, passage restrictions at dams, and competition form non-native lake and brook trout. The Columbia River population segment includes the entire Columbia River basin and all its tributaries, excluding the isolated bull trout populations found in the Jarbridge River in Nevada. Bull trout populations within the Columbia River population segment have declined from historic levels and are generally considered to be isolated and remnant. See the following section on bull trout, Klamath Basin stock, for life history information on bull trout.

ESU status. Bull trout are estimated to have occupied about 60 percent of the Columbia River Basin, and presently occur in 45 percent of the estimated historical range. The Columbia River population segment is composed of 141 sub-populations.

Threats

Threats to bull trout include habitat degradation and fragmentation, blockage of migratory corridor, poor water quality, past fisheries management practices, and the introduction of non-native species such as brown, lake, and brook trout.

Bull trout (*Salvelinus confluentus*) - Klamath Basin stock. Threatened status OR 6/10/98, 63FR31647. (The following life history information is taken from 62FR32268, 63FR31693 and 63FR31647; and from various USFWS "News Releases").

The Klamath River population segment from south-central Oregon is now listed as threatened. This population segment, comprised of seven bull trout populations is threatened by habitat degradation, irrigation diversions, and the presence of non-native brook trout. Bull trout in the Klamath River drainage are discrete because of physical isolation due to the Pacific Ocean and several small mountain ranges in central Oregon. Perhaps the most significant threat to the remaining bull trout populations in the Klamath Basin is hybridization with introduced brook trout. The USFWS finds that designation of critical habitat (as per section 3 of the ESA) for this species is not determinable at this time.

ESU status. Limited historical references indicate that bull trout in Oregon were once widely spread in 12 basins in the Klamath and Columbia river systems. No bull trout have been historically observed in Oregon's coastal systems. Bull trout occurred in 15 separate drainages between 1948 and 1979. By 1989, the distribution of the species had been restricted to 10 streams in the basin. The most recent data provided in the 1994 record suggested that in 1991, only seven segregated resident populations still occurred in the basin and were confined to headwater streams in the Sprague, Sycan, and Upper Klamath Lake sub-basins. The largest areas occupied by any of the seven populations is 2.5 stream miles, and basinwide, only 12.5 miles of stream is inhabited by bull trout. Populations in the Upper Klamath Lake subbasin are at precarious abundance levels, and at a high risk of extinction. The remaining populations are disconnected from each other, and are considered to be isolated, remnant groups from a historically larger, more diverse metapopulation; the populations are at a moderate or high risk of extinction.

Although anadromy is not found in Oregon, Bond (1992) believed that it was an important part of the life history and historical distribution patterns, and acted as a mechanism for coastal distribution. The bull trout in Oregon have three life-history patterns represented by resident, fluvial, and adfluvial fish. Resident bull trout are believed to spend their entire lives in the same stream in which they hatched. Resident juvenile bull trout are thought to generally confine their migrations to and within their natal stream. Fluvial populations generally migrate between smaller steams used for spawning and early juvenile rearing and larger rivers used for adult rearing. Fluvial populations can switch to adfluvial under some circumstances. Adfluvial populations generally migrate between smaller streams used for spawning and juvenile rearing and lakes or reservoirs used for adult rearing. Adfluvial individuals can attain sizes over 9 kg in Oregon.

Bull trout display a high degree of sensitivity at all life stages to environmental disturbance and have more specific habitat requirements than many other salmonids. Bull trout growth, survival, and long-term population persistence appear to be particularly dependent upon five habitat characteristics: (1) cover, (2) channel stability, (3) substrate composition, (4) temperature, and (5) migratory corridors.

Spawning/Temperatures. Bull trout, being a resident species means that both adults and juveniles are present in the steams throughout the year. Bull trout adults may begin to migrate from feeding to spawning ground in the spring and migrate slowly throughout the summer (Pratt IN ODEQ, 1994). They spawn in later summer through fall (August-November). Summer temperatures are, therefore, a concern for migration and for spawning in the late summer and early fall. These trout are stenothermal, requiring a narrow range of temperature conditions to reproduce and survive. Bull trout densities are highest at water temperatures of 12 degrees C. or less; no bull trout were found during surveys when water temperatures were above 18 degrees C. (Shepard et al. 1984; ODEQ, 1994). Ratliff (1992) found in the Metolius River, Oregon, that bull trout spawning and the initial 1-year juvenile rearing is limited to streams with temperatures of about 4.5 degrees C. Optimum incubation temperatures are 2-4 degrees C. Such strict temperature tolerances predispose bull trout to declines from any activity occurring in a watershed that leads to increased stream temperatures. From a study of the distribution of juvenile bull trout in a thermal gradient of a plunge pool in Granite Creek, Idaho, these fish chose the coldest water available (8-9 degrees C.). Bonneau.

Hatching and Rearing. Hatching is completed after 100-145 days usually in winter (Pratt, 1992). Bull trout alevins require at least 65-90 days after hatching to absorb their yolk sacs (Pratt, 1992). They remain within the interstices of the streambed as fry for up to three weeks before filling their air bladder, reaching lengths of 25-28 mm, and emerging from the streambed in late April

(McPhail and Murray 1979, Pratt 1992). An extremely long period of residency in the gravel (200) or more days makes bull trout especially vulnerable to fine sediments and water quality degradation.

Juvenile bull trout are closely associated with the streambed and are found immediately above, on, or within the streambed (Pratt 1984, 1992). Goetz (1991) and Pratt (1984, 1992) reported that young bull trout most frequently used woody debris as cover. As fish mature they seek out deep water habitat types such as pools and deep runs (Pratt, 1984; Shepard et al., 1984).

Bull trout less than 110 mm feed on aquatic insects while larger bull trout are primarily piscivorous (Shepard et al., 1984). Juvenile bull trout may migrate from natal areas during spring, summer or fall; almost all migration is nocturnal (Pratt 1992).

Adult Migration. Adfluvial bull trout feed primarily on fish and can exhibit extraordinary growth rates (Shepard et al., 1984; Pratt, 1992). Resident bull trout have much slower growth rates. Adult bull trout rearing and migration patterns are not well documented in Oregon except for the Metolius River and Lake Billy Chinook system. Bull trout migration typically starts in mid-July; fish move quickly upriver and reside near the mouth of the intended spawning tributary. Migration into the spawning tributary, spawning, and migration back to the mainstem usually takes one month. Surveys in Oregon document bull trout spawning from late July through at least October; this pattern is typical of Metolius River bull trout. Most spawning occurs in cold headwaters or spring-fed streams. Spawning adults and initial juvenile rearing is limited to very cold (approximately 4.5 degrees C.) spring-fed tributaries to the Metolius River (Ratliff 1992). Annual and alternate year spawning is documented for bull trout (Shepard et al. 1984).

Habitat. The habitat requirements of bull trout vary by age and season of the year (Rieman and McIntyre, 1993). Young-of-the-year fish initially seek stream margins with heterogenous habitat structure. Bull trout appear to have more specific habitat requirements than other salmonids. Although bull trout may be present throughout large river basins, spawning and rearing fish are often found only in a portion of available stream reaches (Fraley and Shepard, 1989; Shepard et al., 1984, Mullan et al., 1992). Where this habitat is not present or has been lost, juvenile bull trout populations are virtually eliminated.

Seven habitat variables were found to be significant ($P < 0.0001$) descriptors of the presence of juvenile bull trout: (1) high levels of shade, (2) high levels of undercut banks, (3) large woody debris volume, (4) relatively large pieces of woody debris, (5) high levels of gravel in riffles, (6) low levels of fine sediment in riffles, and (7) low levels of bank erosion. Migratory corridors are needed to tie wintering, summering, or rearing areas to spawning areas as well as allowing the movement for interactions of local populations within possible metapopulations.

Threats

Threats to bull trout include habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, past fisheries management practices, and the introduction of non-native species such as brown, lake, and brook trout. See also, "ESU status".

Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*): (The following life history information is taken from ODFW (1996), Species at Risk; and 40FR29863). **Threatened** status OR 7/16/75, 40FR29863.

The Lahontan cutthroat trout is listed as threatened under ESA (35FR16047 10/13/70, 40FR29863 7/16/75). Critical habitat has not been designated.

The range of Lahontan cutthroat trout is primarily in streams of the Lahontan and Coyote Lake basins in southeast Oregon. These fish inhabit isolated desert streams. Some populations of this subspecies inhabited lakes where they attained large size. This subspecies has been reintroduced into several stream systems throughtout the Lahontan Basin, Pyramid and Walker Lakaes. Restoration of habitat and reintroduction in several stream systems allowed USFWS to change the ESA listing from endangered to threatened.

The following information is from Jones, et al. (1998): The Coyote Lake basin has the only native population of Lahontan cutthroat trout in Oregon that is without threat of hybridization and is broadly disributed throughtout a drainage. In October 1994, the number of Lahontan cutthroat in the basin was estimated at 39,500 fish, and fish were limited to 56km of stream habitat available (approximately 25,000 in the Whitehorse Creek drainage and about 15,000 cutthroat occupied the Willow Creek drainage). Distribution was limited by dry channels and thermal and physical barriers to movement, which created two disconnected populations in the Willow Creek and Whitehorse Creek drainages and influenced population density, structure, and life history.

The overall status of Lahontan cutthroat trout is unknown. Riparian and upland habitats have been degraded by intensive grazing by cattle and sheep during the past 130 years. Drought and cold periods during the past decade have further affected the quantity and quality of the aquatic haabitat. The ability of local populations to interact is important to the long-term viability of a metapopulation. The population of Lahontan cutthroat in the Whitehorse Creek subbasin has been fragmented by numerous barriers into four discreet local populations. The Willow Creek subbasin is largely free of migration barriers. Seasonally, all streams in the drainages have disjunct populations because of high summer temperatures (>26°C) or dry channels.

Threats

Lahontan cutthroat trout are listed as threatened under the ESA because of poor habitat conditions including channel modifications, dewatering, passage barriers and loss of riparian vegetation. Introgression with rainbow trout and displacement by introduced brown trout and brook trout have extripated Lahontan cutthroat in several stream systems. Brook trout are a strong competitor for food and space with the Lahontan cutthroat.

Refer to the following discussion for more information about cutthroat trout life histories.

Umpqua River (UR) Cutthroat Trout (*Oncorhynchus clarki clarki*): (The following life history information is taken from NMFS 1996; 61FR41514 and 63FR1388). **Endangered** status OR 8/9/96, 61FR41514.

UR cutthroat trout were listed as an endangered species on 9 August 1996 (61FR41514). Critical habitat designation was finalized on 9 January 1998 (63FR1388).and includes all river reaches accessible to listed Umpqua River cutthroat trout from a straight line connecting the west end of the North Jetty and including all Umpqua River estuarine areas (including the Smith River) and tributaries proceeding upstream from the Pacific Ocean to the confluence of the North and South Umpqua Rivers; the North Umpqua River, including all tributaries, from its confluence with the mainstem Umpqua River to Soda Springs dam; the South Umpqua River, including all tributaries, from its confluence with the mainstem Umpqua River to its headwater (including Cow Creek, tributary to the South Umpqua River). Critical habitat includes all waterways below longstanding, naturally impassable barriers (i.e., natural water falls in existence for over several hundred years). Critical habitat includes the bottom and water of the waterways and adjacent riparian zone. The riparian zone includes those areas within 300 feet (91.4m) of the normal line of the high water mark of the stream channel or from the shoreline of a standing body of water. NMFS recognized that the Umpqua River estuary is an essential rearing area and migration corridor for listed Umpqua River cutthroat trout, and maintained the designation of the estuary as critical habitat in the final rule.

ESU status. See population trends, below.

Cutthroat trout evolved to exploit habitats least preferred by other salmonid species (Johnston 1981). The life history of UR cutthroat trout is probably the most complex and flexible of any Pacific salmonid. Three life history forms are in the Umpqua River basin. The current freshwater distribution of anadromous and potamodromous life forms is thought to be limited primarily to the mainstem, Smith, and North Umpqua Rivers. Resident cutthroat trout appear to remain broadly distributed throughout the Umpqua River basin. Unlike other anadromous salmonids, sea-run forms of the coastal cutthroat trout do not overwinter in the ocean and only rarely make long extended migrations across large bodies of water. They migrate in the nearshore marine habitat and usually remain within 10 km of land.

Anadromous cutthroat trout. Unlike other anadromous salmonids, anadromous cutthroat trout do not over-winter in the ocean and only rarely make long extended migrations across large bodies of water. They migrate in the near shore marine habitat and usually remain within 10 km of land (Sumner, 1972; Giger ,1972, Jones, 1976; Johnston, 1981). While most anadromous cutthroat trout enter seawater as two- or three-year-old fish, some may remain in fresh water for up to five years before entering the ocean (Sumner, 1972; Giger, 1972).

Potamodromous cutthroat trout. The potamodromous life form undertakes freshwater migrations of varying length without entering the ocean, and are sometimes referred to as "fluvial". Potamodromous cutthroat trout migrate only into rivers and lakes (Nicholas, 1978; Tomasson, 1978; Moring et al., 1986; Trotter, 1989), even when they have access to the ocean (Tomasson 1978). The potamodromous life form is most common in rivers with physical barriers to anadromous fish (Johnson et al., 1994), but have also been documented below barriers in the Rogue River (Tomasson ,1978) and the Umpqua River (Johnson et al., 1994).

Resident cutthroat trout. The resident life form does not migrate long distances; instead, the fish remain in upper tributaries near spawning and rearing areas and maintain small home territories throughout their life cycle (Trotter, 1989). Resident cutthroat trout have been observed in the upper Umpqua River drainage (Roth 1937; ECO and OSGC, 1946; ODFW, 1993). During a radio tagging study in three tributaries of Rock Creek (North Umpqua River drainage), Waters (1993) found that fish smaller than 180 mm moved about an average total distance of 27 meters of stream length during the study. Larger fish explored an average total distance of about 166 meters.

Spawning and rearing. Cutthroat trout generally spawn in the tails of pools located in small tributaries at the upper limit of coho salmon and steelhead spawning and rearing sites. Stream conditions are typically low stream gradient. December to May encompasses most spawning times with a peak in February (Trotter, 1989).

Cutthroat trout are iteroparous and may spawn every year for at least five years (Giger, 1972) and some remain in freshwater for at least a year before returning to seawater (Giger, 1972; Tomasson, 1978). Post-spawning mortality is possible. Eggs begin to hatch after one-and-a-half to two months. Alevins remain in the redds for a few more weeks and emerge as fry between March and June.

Parr movements. After emergence from redds, cutthroat trout juveniles generally remain in upper tributaries until they are one year of age, then extensive movements in the stream begin. Directed downstream movement by parr can happen during any month but usually begins with the first spring rains. Some parr from the Alsea River drainage entered the estuary and remained there over the summer; these fish did not smolt. Upstream movement of juveniles from estuaries and mainstem to tributaries begins with the onset of winter freshets during November, December, and January; these one year and older fish averaged less than 200 mm in length.

Smoltification. Time of initial seawater entry of ocean-bound Umpqua River smolts begins as early as March, peaks in May and June, tappers-off by July, with a few stragglers through October. For other "less protected" Oregon coastal areas, cutthroat trout tend to migrate at an older age (age three and four). It is unlikely that Umpqua River cutthroat trout migrate from the upper basin areas to the estuary considering the distance and warm water temperatures (average - mid 20s C. at Winchester Dam).

Estuary and ocean migration. Migratory patterns of sea-run cutthroat trout differ from Pacific salmon in two major ways: few, if any, cutthroat overwinter in the ocean, and; the fish do not usually make long open-ocean migrations. Cutthroat trout, whether initial or seasoned migrants average approximately 90 days at sea.

Adult freshwater migrations. For the Umpqua River, cutthroat trout begin upstream migrations in late June and continue through January (ODFW, 1993).

Food. In streams, drifting terrestrial and aquatic insects are the cutthroat trouts' food source. Small fish and invertebrates constitute the diet in the marine environment; forage areas are around gravel beaches, off the mouths of small creeks and beach trickles, around oyster beds, and patches of eel grass.

Populations. Numbers of returning anadromous UR cutthroat adults passing Winchester Dam on the North Umpqua River varied between a few score to nearly 2000 in the 1940s-1950s. The numbers jumped up a bit during the 1960s-1970s with the artificial release of smolts to augment the population. By the late 1980s to the present, annual adult counts ranged only between a few to some dozens of fish.

Threats

Factors for the decline of this subspecies include: habitat degradation as a result of logging; recreational fishing; predation by marine mammals, birds, and native and non-native fish species; adverse environmental conditions resulting from natural factors such as droughts, floods, and poor ocean conditions; non-point and point pollution source pollution caused by agriculture and urban development; disease outbreaks caused by hatchery introductions and warm water temperatures; mortality resulting from unscreened irrigation inlets; competition in estuaries between native and hatchery cutthroat trout; cumulative loss and alteration of estuarine areas; and loss of habitat caused by the construction of dams.

Sea-run Cutthroat Trout (*Oncorhynchus clarki clarki*): (The following life history information is taken from 59FR46808 and 63FR13832). **Petition to List** status OR 3/23/98, 63FR13832.

Very little information about this subspecies' characteristics has been published in the Federal Register. Sea-run cutthroat trout (called Coastal cutthroat trout by ODFW; Mary Hansen, ODFW, pers. com., 8/25/98). Another subspecies that has a petition to list under the ESA is *O. c. lewisi*, the West Slope cutthroat trout. This latter subspecies is not "coastal"; in Oregon, it is restricted to the John Day Basin (Mary Hansen, ODFW, pers. com., 8/25/98). A general habitat definition for the Oregon segment of west coast sea-run cutthroat trout is the stream systems on the west slope of the Coast Range mountains, exclusive of the Umpqua River system.

On September 12, 1994, NMFS issued a Notice of finding; initiation of status reviews, and request for comments on several salmonid species including sea-run (anadromous) cutthroat trout. NMFS elected to complete the status review for sea-run cutthroat trout last (after the other six salmonids in the notice). In the March 23, 1998 notice of finding and request for information about critical habitat for sea-run cutthroat throughout its range in California, Oregon, and Washington (63FR13832), NMFS stated that the west coast sea-run cutthroat was currently under status review.

No life history or general habitat information was provided. Refer to the above discussion on anadromous cutthroat trout for general life history information. It is reasonable to assume that the ESU for this subspecies has experienced similar negative influences as other west coast salmonids. Specific information on the health of the subspecies, or its rate of decline was not included in the notices.

Hutton Spring tui chub (*Gila bicolor* ssp.): (The following life history information is taken from Fed. Regis. 50:60, 28 March 1985; and USFWS Recovery Plan, 1998). **Threatened** status OR 3/28/85, 50FR12302.

There is very little information regarding the ecology of the Hutton tui chub. A small to medium sized minnow, the Hutton Spring tui chub inhabits this spring and one nearby spring (part of the Hutton spring system) in Lake County, south-central Oregon; critical habitat is not designated under the ESA for this species.

Preferred habitat conditions for tui chub may be inferred from research on the tui chub from the Upper Klamath basin which showed a thermal mean maximum of 32.2 +/- 0.2 degrees C. and a DO mean minimum of 0.59 +/- 0.04 mg/l (Castleberry & Cech, 1993). DO levels as low as 0.3 mg/l have been measured in Upper Klamath Lake (Scoppetone, 1986). These figures should be considered only as guidance since the most sensitive life stage may not have been tested and the relative sensitivity of tui chub stocks from these geographically separate areas is unknown.

Examination of gut contents from Hutton tui chub showed this fish to be omnivorous with a majority of food eaten being filamentous algae. It appears that dense aquatic algae are needed for spawning and rearing of young.

Threats

Although the habitat quality of the primary spring is well maintained, the extremely limited distribution in a water sparse area, naturally low population numbers (450, estimate), vulnerability to introductions of exotic species, and threat of contamination from a toxic waste dump along the southwest shore of Alkali Lake, are reasons for listing under the ESA as threatened (50FR12302, 3/28/85). Hutton Spring is fenced from livestock, however, the second spring is vulnerable to damage by livestock and human activities. Occurring on private land, the Hutton tui chub is threatened by actual or potential modification of its habitat.

Borax Lake chub (*Gila boraxobius*): (The following life history information is taken fromerpts from USFWS (1987) Borax Lake chub recovery plan, and NBS Borax Lake and Borax Lake Chub Study). Emergency endangered listing status on 5/28/80 (45FR35821), final **endangered** listing OR 10/5/82 (47FR43957).

The Borax Lake chub was listed as endangered under an emergency rule (45FR35821 5/28/80). The Borax Lake chub is endemic to Borax Lake and adjacent wetlands in the Alvord Basin, Harney County, Oregon; this waterbody is officially designated as critical habitat under ESA. The Borax Lake area is a part of the Great Basin physiographic province, and as such, is characterized by an endorheic (i.e., internal) water drainage pattern. Critical habitat is officially presented in 47FR43960 part 19.95(e). The lake is naturally fed from waters of several thermal springs and is perched atop large sodium-borate deposits in the Alvord Desert. The temperature of the springs is 35-40 degrees C.; lake temperatures vary from 17 to 35 degrees C. but are often 29 to 32 degrees C. Borax Lake has brôad temperature fluctuations due to its large surface to volume ratio (Scoppettone, 1995). The lake is less than one meter deep, 4.1 ha in size, with a pH of 7.3.

Borax Lake chubs appear to have a broad thermal tolerance. The fish avoid lake temperatures above 34°C In laboratory experiments, Borax Lake chub lose equilibrium in water above about 34.5° C. If adequate water levels in Borax Lake are not maintained, chubs are forced into potentially lethal hot spring inflows at the bottom of the lake. Fish kills occurred when lake temperatures have locally exceeded 38° C. If adequate water levels in Borax Lake are not maintained, chubs are forced into potentially lethal hot spring inflows at the bottom of the lake.

The Borax Lake chub is also recorded from Lower Borax Lake, the marsh area between Borax and Lower Borax Lake, the smaller southern marsh, and adjacent ponds, as well as the southwest outflow creek. In a survey of lake conditions from 1991-1993, DO measurements ranged form 4.98 to 8.66 mg/l and pH ranged from 7.3 to 7.9 (Scoppettone, 1995).

Early investigators considered the Borax Lake chub so distinct that the fish might be set apart in a new genus. Because of the striking differentiation of these chubs, they were considered to be geographically isolated from their nearest relatives in adjacent basins, since the Pliocene. The Borax Lake chub was described as a dwarf (33-50 mm length, for typical adults) relative of the Alvord chub endemic to Borax Lake. The Alvord chub is widespread in the basin. Given the relatively constant thermal environment of Borax Lake, the Borax Lake chub spawns throughout the year (most spawning occurs in March and April). Individual females may spawn twice annually.

Young-of-the-year are prominent in Borax Lake during May and June. They are most often found in the very shallow coves around the margin of the lake. No young-of-the-year (YOY) have been collected from Lower Borax Lake and are seldom observed in adjacent marshes, which indicates that most if not all spawning occurs in Borax Lake. Most Borax Lake chub live approximately one year. Adults are fairly evenly distributed throughout the lake, although their primary foraging area appears to be the flocculent layer on the bottom of the lake (Scoppetone, 1995).

Borax Lake chubs are opportunistic omnivores following seasonal fluctuations. The importance of diatoms and microcrustaceans in the diet increases substantially during winter, while the consumption of terrestrial insects decreases dramatically. Chubs often pick foods from soft bottom sediments, but also are observed feeding throughout the water column and at the surface. Within the relatively simple food web in Borax Lake, the Borax Lake chub may function as a "keystone" species controlling the structure in the invertebrate community of Borax Lake by feeding on the most abundant species encountered.

Threats

Borax Lake is located above salt deposits on the valley floor which is quite fragile. Modification of the lake perimeter due to the digging of irrigation channels, and the threat of modified spring flows because of geothermal development, prompted action by the U.S. Fish and Wildlife Service under the ESA. The lake is now owned by the Nature Conservancy, so water diversion for agriculture has ceased. There is interest in geothermal development within two kilometers of Borax Lake, and the possibility that this development could reduce thermal spring inflows to the lake, cooling lake temperatures and making them more conducive for the survival of non-native fish that would out-compete the Borax Lake Chub. The Nature Conservancy, USFWS, ODFW, and BLM have been working since 1983 to protect, maintain, and enhance habitat for Borax Lake chub.

Oregon chub (*Oregonichthys crameri*): (The following life history information is taken from Fed. Regis. 58:199, Oct. 18, 1993; and USFWS draft recovery plan, 1998.). **Endangered** status OR

10/18/93, 58FR53800.

The genus *Oregonichthys* is endemic to the Umpqua and Willamette Rivers. The Oregon chub was formerly distributed throughout the lower elevation backwaters of the Willamette River drainage. Known established populations are now primarily restricted to an 18.6 mile stretch of the Middle Fork Willamette river.

The endangered-status ruling was issued on 10/18/93 (58FR53800). Official critical habitat designation has not been made. The petitioners recommended for critical habitat all water and tributaries of the Middle Fork of the Willamette River from the base of Dexter Dam upstream to its confluence with the North Fork of the Middle Fork. In the early 1990s, two additional populations were located, one downstream of the Dexter Dam within Elijah Bristow State Park and another in a tributary of Lake Creek, Linn County. Surveys of other potential habitat areas were conducted. Population estimates conducted in 1993-1994 ranged from 45 fish in Lower Dell Creek to 7500 in East Fork Minnow Creek.

Habitat at the remaining population sites of the Oregon chub is typified by low- or zero-velocity water flow conditions, depositional substrates, and abundant aquatic or overhanging riparian vegetation. Spawning occurs from the end of April through early August when water temperatures range from 16 to 28 degrees C. In the spring, larger males feed most heavily on copepods, cladocerans, and chironomid larvae.

Threats

Decline of the Oregon chub is attributed to changes in, and elimination of, its backwater habitats. The decline coincides with construction of flood control structures which have altered historical flooding patterns and eliminated much of the river's braided channel pattern. Introduction of non-indigenous species have also contributed to the Oregon chub's decline

Warner sucker (*Catostomus warnerensis*): (The following life history inforomation is taken. from ODFW (1996), Species at Risk; and USFWS Recover Plan, 1998). **Threatened** status OR 9/27/85, 50FR39117.

The threatened status for the Warner sucker was published on 27 September 1985 (50FR39117). Critical habitat is designated (50FR39122-39123) and includes: sections of Twelvemile and Twentymile Creeks; Spillway Canal north of Hart Lake; Snyder and Honey Creeks.

The Warner basin provides two generally continuous aquatic habitat types; a temporally more stable stream environment, and a temporally less stable lake environment. A common phenomenon among fishes is phenotypic plasticity induced by changes in environmental factors. Life history for the Warner sucker is evidently plastic. The lake and stream morphs of the Warner sucker probably evolved with frequent migration and gene exchange between them. The larger, presumably longer-lived, lake morphs are capable of surviving thorough several continuous years of isolation from stream spawning habitats due to drought or other factors. Stream morphs probably serve as sources for recolonization of lake habitats in wet years following droughts, such as the refilling of Warner Lakes in 1993 following their desiccation in 1992. Lake morph Warner suckers occupy the lakes and, possibly, deep areas in the low elevation creeks, reservoirs, sloughs and canals. The loss of either lake or stream morphs to drought, winter kill, excessive flows and a flushing of the fish in a stream, in conjunction with the lack of safe migration routes and the presence of predaceous game fishes (such as croppie), may strain the ability of the species to rebound. Irrigation diversions have also reduced available habitat and blocked migration (A. Munhall, BLM, pers. com., 5/20/98).

Detailed information of population estimates in specific waters of the Warner basin can be found in the USFWS recovery plan, page 32.

Age and Growth. Lake morph suckers are generally much larger than steam morphs, however, growth rates in either habitat have not been studied. Sexual maturity is believed to usually occur at an age of 3-4 years.

Feeding. The feeding habits of the Warner sucker depend to a large degree on habitat and life history stage, with adult suckers becoming less specialized than juveniles and YOY. Larvae have terminal mouths and short digestive tracts, enabling them to feed selectively in mid-water or on the surface. Invertebrates, particularly planktonic crustaceans, make up most of their diet. As the suckers grow, they gradually become generalized benthic feeders. Adult stream morph suckers forage nocturnally over a wide variety of substrates. Adult lake morphs are thought to have a similar diet, though food is taken over predominantly muddy substrates.

Spawning Habitat. Spawning usually occurs in April and May. Temperature and flow cues appear to trigger spawning, with most spawning taking place at 14-20 degrees C. when stream flows are relatively high. Warner suckers spawn in sand, or gravel beds in pools. Possible important spawning habitats and a source of recruitment for lake recolonization are in the upper Honey Creek drainage and the tributary Snyder Creek where the warm, constant temperatures of Source Springs are located. In years when access to stream spawning areas is limited by low flow or by physical in-stream blockages (such as beaver dams), suckers may attempt to spawn on gravel beds along the lake shorelines.

Larval and YOY Habitat. Larvae generally occupy shallow backwater pools or stream margins with abundant macrophytes, where there is little or no current. Larvae venture near higher flows during the daytime to feed on planktonic organisms but avoid the mid-channel water current at night. Spawning habitat may also be used for rearing during the first few months of life because when young eventually become immersed in high stream flows they do not appear to drift large distances downstream; i.e., the YOY remain in spawning habitat areas. YOY are often found over deep, still water from mid-water to the surface, but also move into faster flowing areas near the heads of pools. For both runs and pools, YOY usually occupy quiet water close to shore.

Juvenile and Adult Habitat. Both juveniles and adults prefer areas of the streams which are protected from the main flow, seeking out deep pools. Beaver ponds may offer important refugia. Preferred pools tend to have: undercut banks; large beds of aquatic macrophytes; root wads or boulders; a surface to bottom temperature differential of at least 2 degrees C. (at low flows); maximum depth greater than 1.5 meters; and overhanging vegetation (often *Salix* ssp). Although suckers may be found almost anywhere in calmer sections of streams, the fish will not be far from larger pools (approximately 1/4 mile up- or down- steam).

When submersed and floating vascular macrophytes are present, they often form a major component of sucker-inhabited pools, providing cover and harboring planktonic crustaceans which make up most of the YOY sucker diet. Rock substrates are important in providing surfaces for epilitihic organisms upon which adult stream morph suckers feed, and finer gravel or sand are used for spawning. Embeddedness (e.g., from silt) has been negatively correlated with total sucker density.

Habitat use by lake morph suckers appears similar to that of stream morph suckers in that adult suckers are generally found in the deepest available water where food and cover are plentiful. Deep water also provides refuge from aerial predators.

By day, juveniles and adult suckers take shelter in the deepest available water and/or undercut banks. Deep pools also allow suckers to mitigate temperature extremes by moving vertically in the water column. With the absence of aquatic macrophytes, suckers can be seen schooling near the bottoms of these deep pools during the day. At night they disperse thorough various habitat types and water depths to forage for food.

Exact temperature, dissolved oxygen, or pH requirements for the Warner sucker are lacking. **These fish co-occur with redband trout and, therefore, require cooler water temperatures. When water temperatures rise, dissolved oxygen concentrations may become an additional stressor. Ambient DO data will be collected in some sucker habitats during the summer of 1997. (A. Munhall, BLM, pers. com., 5/20/98)**

Threats

The loss of either lake or stream morphs to drought, winter kill, excessive flows and a flushing of the fish in a stream, in conjunction with the lack of safe migration routes and the presence of predaceous game fishes (such as croppie), may strain the ability of the species to rebound. Irrigation diversions have also reduced available habitat and blocked migration (A. Munhall, BLM, pers. com., 5/20/98).

Lost River sucker (*Deltistes luxatus*) and Shortnose sucker (*Chasmistes brevirostris*): (The following life history information is taken from USFWS 1993). **Endangered** status OR 7/18/88, 53FR27130.

Lost River (LR) and shortnose (SN) suckers were listed as endangered under the ESA in 1988 (FR 50:27). Because the LR sucker is the only species in the genus *Deltistes*, this entire genus is endangered as well. Both species are endemic to the upper Klamath Basin (particularly, Upper Klamath Lake and its tributaries); these fish are large and long-lived.

Poor habitat quality threatens the LR and SN suckers. Monda and Saiki (1993) performed tolerance tests on these fish in the laboratory; compared to field measurements of pH, ammonia, temperature, and DO, the laboratory data indicate that ambient summertime water quality conditions in the Upper Klamath Basin can be acutely toxic to juvenile suckers. Further research to determine acute toxicity due to unionized ammonia, pH, DO, and temperature (96 hour LC-50s bioassays) is presented in the Klamath Tribes (1996) report (IN USBR April, 1997) and is summarized here:

	NH3-N(mg/l)	pH	DO(mg/l)	Temp.(C.)
LR sucker larvae	0.43	9.77	2.0	30.5
juveniles	0.34	10.1	2.0	29.9
SN sucker larvae	0.73	10.01	2.4	31.2
juveniles	0.14	9.76	2.4	27.8

Using adult LR suckers, the LC-50 for DO was determined at 2.8 mg/l. Mortality of large numbers of LR suckers and some SN suckers coincided with high water temperatures, low DO, and high pH during 1986 in Upper Klamath Lake (Scoppettone, 1986). In other research, the critical thermal maximum (where fish could no longer maintain equilibrium) determined for SN sucker adults was 32.7 +/- 0.1 degrees C. (Castleberry and Cech, 1993).

The LR suckers are one of the largest sucker species and may grow to one meter in total length. SN suckers are usually less than 50 cm long. Variations in the morphology of the SN suckers appears related to the two distinct morphologies of the fish associated with Upper Klamath Lake and the Lost River.

LR and SN suckers are large, long-lived and omnivorous suckers that generally spawn in rivers or streams and then return to the lake. However, both species have separate populations that spawn near springs in Upper Klamath Lake. Relatively little information is available on habitat requirements for all life stages. Not much is known about the life history traits of the LR and SN suckers during the winter months.

Age and Growth. Lost River suckers: Lost River suckers from Upper Klamath Lake have been aged up to 43 years old, and are one of the largest sucker species. Sexual maturity occurs between the ages of 6 to 14 years (most mature by age 9). Shortnose suckers: Shortnose suckers of up to 33 years of age have been found. Sexual maturity appears to be between 5 and 8 years with most maturing between age 6 and 7.

Spawning Habitat. Both species of suckers are lake dwelling but spawn in tributary streams or springs. For stream spawning populations, depending on the waterbody in question and the peak flow for any given year, LR and SN suckers begin their spawning migration from February to early March. Water temperatures range from 5.5 to 19 degrees C. LR and SN suckers spawn near the bottom and when gravel is available, eggs are dispersed within the top several centimeters. When spawning occurs over cobble and armored substrate, eggs fall between crevices or are swept downstream. Observations indicate there may be a preference for spawning over gravel; however, the preference may be more flow related.

Larval and Juvenile Habitat. LR and SN suckers usually spend relatively little time in tributary streams and migrate back to the lake shortly after swim-up stage. The majority of suckers emigrate during a six-week period starting in early May. It appears that most larval emigration for both species occurs during the night and twilight hours. During the day, the larvae typically move to shallow shoreline areas in the river. Higher densities of larval suckers seem to occur in pockets of open water surrounded by emergent vegetation. After emigrating from the parental spawning sites in late spring, larval and juvenile LR and SN suckers inhabit near shore waters (mostly under 50 cm depth) throughout the summer months. Larvae seem to avoid area devoid of emergent vegetation. With the strong shoreline orientation displayed by sucker larvae, they use areas such as marsh edges for nursery habitat. In Upper Klamath Lake, juvenile suckers have only been found in sections of the lake where dissolved oxygen concentrations were 4.5 to 12.9 mg/l. Few sites in the lake had juvenile suckers where pH values were 9.0 or higher.

Adult Habitat. Adult LR suckers in Upper Klamath Lake during the warmer seasons apparently seek areas near springs and inflows, with relatively low densities of algae, and consistent water quality. Much of the lake can be stressful or lethal due to dissolved oxygen and pH conditions. LR suckers were found in waters of dissolved oxygen concentrations of at least 6 mg/l.

Threats

Habitat degradation from agricultural practices and grazing can cause loss of critical riparian areas and increases in nutrient input to the lake. Increased nutrients leads to increased primary production and consequent increases in pH. (J.Kann, personal communication) The Bureau of Reclamation operates the lake and has initiated some riparian restoration and associated research projects, although restoration work is in early stages. Water depth is a key factor in separating surface-dwelling sucker larvae from benthic fathead minnows that would prey on them (draft Biological Report for Klamath Project, 1997).

Foskett speckled dace (*Rhinichthys osculus* ssp): (The following life history information is taken from ODFW (1996), Species at Risk; and USFWS Recovery Plan, 1998). **Threatened** status OR 3/28/85, 50FR12302.

The Foskett speckled dace occurs in Foskett Spring, a small spring system found in the Coleman Basin on the west side of the Warner Valley, Lake County, south-central Oregon; this is an arid region with approximately eight inches of annual precipitation. Numbers of this species are estimated at 1500.

Nothing is known about the biology/ecology of the Foskett speckled dace. The only habitat information available regards plant species found around the springs which include rushes, sedges, Mimulus, Kentucky bluegrass, thistle and saltgrass. Foskett Spring is a cool water spring with a constant temperature regime of 18 degrees C (Alan Mundall BLM, pers. com. 5/20/98). BLM monitoring of spring water during the mid-1980s revealed a pH range of 7.2-8.1 and a hardness range of 32.6-48.7 mg/l as $CaCO_3$ (Alan Mundall BLM, pers. com. 5/20/98). No information is available on growth rates, age of reproduction or behavioral patterns.

For speckled dace (not from Foskett spring; life stage/age unknown), the thermal mean maximum was experimentally determined to be 32.4 +/- 0.6 degrees C., and the mean minimum DO to be 0.8 +/- 0.06 mg/l (Castleberry and Cech, 1993).

Threats

Occurring on private land at the time of ESA listing, this dace species was threatened by actual or potential modification of its habitat. These fish have extremely limited distributions, occur in low numbers naturally, and inhabit springs that are susceptible to human disturbance. Factors that may jeopardize the species include: groundwater pumping for irrigation, excessive trampling of the habitats by livestock, channeling of the springs for agricultural purposes, and other mechanical manipulation of the spring habitats. Through a land exchange, the BLM acquired Foskett Spring in 1986 and has since fenced the spring from livestock; water flow and indirect pollution/runoff is still a concern (Alan Munhall BLM, pers. com. 5/20/98).

Oregon Spotted Frog (*Rana pretiosa*) and Columbia Spotted Frog (*Rana luteiventris*): (The following life history information is taken from ODFW/USFWS (1994 & 1997 [Hayes]), ODFW (1996), Richter (1995), Richter and Azous (1995), and WDFW (1997)). Under a proposed rule on 9/19/97, 62FR49397, the USFWS issued a "warranted but precluded" status in Oregon - from a 12-month petition finding that was recycled by the above notice.

After specific information on each species, general life history information is presented; most research has been on the Oregon spotted frog. Available water quality and habitat information follows.

Distribution (Hayes, 1994). As currently understood, the spotted frog has a relatively broad geographic range from northeastern California northward through most of Oregon, Washington, and British Columbia, into the Alaskan panhandle, and eastward through northern Nevada, northern Utah, most of Idaho, western Wyoming, western Montana, and the western edge of Alberta. This view of the geographic distribution ignores unrecognized taxonomic units "within" the spotted frog. The Oregon spotted and Columbia spotted frogs are currently (1997) listed as candidate species under ESA. For the few specimens for which color data are available, individuals of the spotted frog from western Oregon are consistently the red/red-orange-ventered color variant; however, the species name for the Columbia spotted frog, *R. luteiventris*, means yellow-bellied (M. Hayes, pers. com., 1/7/97).

Critical habitat for the Oregon spotted frog is at elevations below about 5,300 feet. This distribution is latitude dependent with the frog found below 600 meters in southern Washington and below about 1,500-1,600 meters in southern Oregon. The Oregon spotted frog has a warmer water requirement than other spotted frogs. The water temperature must be greater than 20 degrees C. for three months. This species is not found in streams and probably requires a freshwater spring for overwintering.

The Columbia spotted frog's habitat in Oregon is at elevations of approximately 4,000 feet or higher; generally in the drier, east-side Cascades and higher plateau inland habitats. Unlike the

Oregon spotted frog, the Columbia spotted frog is not a warm water specialist. The Columbia spotted frog is marsh dwelling and, at times, is also found in streams. There may be a dependancy on a nearby spring.

Spotted frogs inhabit marshy pond or lake edges, or algae-covered overflow pools of streams. Food consists of insects, mollusks, crustaceans, and arachnids.

No verifiable records for either of these spotted frogs, or any other spotted frog, exist for coastal or near coastal areas in western Oregon, the higher Cascade mountains, and the Umpqua drainage basin. The few records for spotted frogs from the Rogue River system are not verified. The lack of coastal and high elevation records for the Oregon spotted frog in western Oregon may be related to a warmer water requirement for postmetamorphic stages (>= 20 degrees C.).

Oregon spotted frogs disappeared from the Willamette valley in the 1950s. The Oregon spotted frog is extant in two protected but vulnerable areas in the Willamette hydrographic basin, Penn Lake and Gold Lake Bog. Although confusing, the historical records for spotted frogs imply their presence (or at least, past presence) in the Warner Lakes Basin, and the Klamath and Deschutes hydrographic basins.

Overwintering (Hayes, 1994). The spotted frog is generally inactive during the winter season, although some individuals may be observed at the water surface on the few relatively warmer days. The spotted frog is characterized as a highly aquatic species as a consequence, the bodies of water that serve as overwintering sites may be the same ones which the spotted frog uses for breeding and in which it spends the summer season, but there are no data to verify this supposition. (Hayes, 1994.)

Reproduction (Hayes, 1994). Emergence from overwintering sites begins as early in the year as the winter thaw allows. In southwestern British Columbia and the Puget Sound region, emergence takes place from late February to mid-March. Emergence dates are lacking for Oregon, but historical records indicate that Oregon spotted frogs were detected on the Willamette valley floor as early as 8 February. These frogs were seen moving on wet nights during February and March, during the interval when the Willamette River experiences its freshets which flood shallow wetland areas. A night-time water temperature measurement of 10.6 degrees C. suggests that even early in the active season, the Oregon spotted frog has been found in relatively "warm" water. (Hayes, 1994.)

Male Oregon spotted frogs arrive at breeding sites several days before the first females appear. Breeding sites are located in the shallow (5-15cm) portions of marshes or ponds or the overflow areas of streams, typically disconnected from the main body of water. Adult males aggregate in small calling groups, which presumably represent leks, and call while floating with their heads at the water surface or while sitting above water on mats of vegetation. Females appear at breeding sites from a few days to over a week after the males. When receptive, females approach male calling groups, gain amplexus with a male, and then deposit eggs in a few inches of water (typically during March-April). The globular egg masses contain several hundred to several thousand eggs. It's likely that the dates of oviposition vary considerably between years because local climatic conditions may affect when water temperatures reach the range suitable for egg laying. Oregon spotted frog embryos have lethal thermal limits of 6 degrees C. and 28 degrees C.; with an average water temperature near the egg masses of 20.7 degrees C. over the interval before hatching.

Spotted frogs exhibit "communal" laying. Masses are deposited unattached, often in water so shallow that only the lower half of each egg mass is submerged, the upper portion being exposed directly to the air. This pattern of oviposition makes mortality of embryos from desiccation (fluctuating water levels) or freezing, relatively frequent; up to 30 percent is not unusual. Ovipositing sites may be reused in successive years, indicating unique characteristics, limited sites, limited flexibility of adults to switch sites, or combinations thereof. This site-dependancy makes the spotted frog particularly vulnerable to oviposition-site modification.

In British Columbia, larvae can hatch in ca. 5-10 days, require ca. 5-7 months to develop to metamorphosis, and after metamorphosis, can reach sexual maturity in two (males) to three (females) years. Data on the developmental schedule in Oregon are lacking, but it is anticipated to be somewhat faster at the lower latitude, given a roughly equivalent elevation, than that observed in British Columbia.

Active Season Habitat Requirements (Hayes 1994). Postmetamorphic stages of the Oregon spotted frog seem to be daytime active. However, observations of spotted frogs made at night, early in the season and during the summer, suggest that frogs may remain active in the evening because warm water conditions are maintained into the night. Observations in Oregon over the past two years strongly suggest that postmetamorphic Oregon spotted frogs are somehow tied to warmer water (20-35 degrees C.; average 28.6 degrees C./83 degrees F.) during the late spring and summer season when frogs are active; this may be the habitat requirement that ties the Oregon spotted frog to warm water marsh habitats. Less than 5 percent of temperatures taken next to active frogs were <68 degrees F. The single feature that united all verifiable spotted frog localities in western Oregon for which habitat data could be retrieved was that each site had a marsh or bog. Moreover, these marshes frequently represented overflow areas of a nearby river or stream. This warm water habitat need for Oregon spotted frogs probably makes this species significantly more vulnerable to potential predation by warm water-loving exotic species (e.g., bullfrogs, southern crayfish, and various catfishes and sunfishes).

Factors affecting amphibian distribution and habitat (Richter and Azous, 1995; Richter, 1995). Research for King County, Washington showed that wetland size and the number of vegetation classes were unrelated to total number of species and thus poor indicators of amphibian richness. Small and structurally simple wetlands often have high value amphibian habitat. Although a greater number of vegetation classes is not proportional to amphibian richness, aquatic bed vegetation and open water vegetation is directly proportional to amphibian richness. Land use impacts are directly related to quality of amphibian habitat. The researchers also found that in terms of hydraulic loading, low amphibian richness is found in wetlands where water level fluctuation (WLF) exceeds 0.2 meters.

Criteria for wetland habitats for lenthic-breeding amphibians (this is not spotted frog specific) (Richter, 1995).

Field and literature research showed that overall, amphibians prefer cool, wet conditions, with northwest species reaching their highest abundance in relatively cool, flat forest stands that are not extremely wet. There is a strong correlation to amphibian distribution with large woody debris, dead and decaying wood and organic matter, and other habitat conditions favorable to thermoregulation, foraging, resting, and aestivating. Also, a clear correlation exists between stand age and downed wood, older stands are ideal habitat patches.

To provide the full range of biological functions of consequence to amphibians, wetland should be located within a watershed basin or sub-basin characterized by land use in which imperviousness (i.e., with urban-like impervious surfaces) does not exceed 10-15 percent. Contiguous wetland habitat patches to provide for passive colonization and self-sustainable occupation, along with migration corridors to terrestrial feeding and overwintering habitats, is important in amphibian success; small wetlands can serve this need.

Given that all other habitat features are equal, wetland size is unrelated to amphibian richness. Hence, there is no minimum wetland size required by breeding amphibians. Smaller wetlands may exhibit greater usage than larger ones by some species because larger, and consequently often permanent wetlands are suitable for predators requiring permanent water. Seasonal availability, interspersion of open water, vegetation, and specific vegetation structure are important breeding criteria; coexistence of these attributes must be reflected over any predetermined wetland size.

Buffers are an essential wetland component for amphibian habitat. Buffers provide: important cover to females and metamorphs, staging habitat for breeding adults, upland terrestrial foraging areas and hibernation sites, and access to migration corridors. Wetland buffer widths of 30 meters are considered minimally prudent.

Most amphibian species avoid both open water and densely vegetated sites. Quantitative comparisons of vegetation cover suggests dense (95-100%) and light (0-5%) cover is avoided. Interspersion of open water and vegetation is selected for oviposition by most species. Ovipositioning amphibians prefer small diameter emergent vegetation stems (1-8mm; average 3-4mm diameter).

Water quality: Amphibians are found in water of widely varying chemical composition. Researchers have generally found water chemistry to not directly limit amphibian distribution and spawning. However, a significant negative correlation exists between amphibian richness and water column conductivity (Azous, 1991 IN Richter, 1995). Moreover, Platin (1994) and Platin and Richter (1995) [IN Richter (1995)] found *R. aurora* (a frog) embryo mortality positively correlated to a principal water quality component comprised of conductivity, Ca, Mg, and pH, and negatively correlated to a second principal component including total P, total suspended solids, Pb, Zn, Al, total organic content, and dissolved oxygen. Interestingly, *A. gracile* (a salamander) egg mortality under similar conditions was uncorrelated to either of these two principal components but rather correlated to total petroleum hydrocarbons and fecal coliforms.

Various research reports suggest that some species distribution and breeding success may locally be predicted by water quality, most notably conductivity, pH Al, total cations, NO2, chemical oxygen demand, and dissolved organic carbon. Other than outright death form toxic spills and sediment flushes (with adsorbed metals, etc.), direct relationships between water quality and amphibian distribution and egg survivorship remains complex, and may be a reason for the absence of water quality criteria for amphibians.

Amphibian egg development is a function of water temperature, and orientation of a wetland in respect to the sun affects solar-induced water temperatures. Consequently, clutch numbers increase with temperature; warmer northern shores exhibit the highest numbers of eggs among spring-breeding species. From Hayes (1997): Water temperature is also affected by beaver. Beaver create small step dams that can provide habitat with decreased water velocities and increased summer water temperatures. Beaver create these aquatic environments favorable to spotted frogs especially where riparian corridors tend to be narrow. Additional information on water temperature characteristics for Oregon spotted frog is found in WDFW (1997) - although Hayes (see above) documented a warm water preference for Oregon spotted frogs, Oregon spotted frogs in western Washington were found active in water consistently <50 degrees F. (10 degrees C.) and frogs were found active under ice (including a pair in amplexus) where the water temperature was 31 degrees F. (-0.5 degrees C.).

Threats

Extirpation from much of the former range for both species coincides with introduction and spread of the highly carnivorous bullfrogs and exotic predatory fish such as carp. Brook trout, the only exotic macropredator present in Penn Lake has had a significant impact on Oregon spotted frog populations. Substantially greater areas and habitat complexity at Gold Lake Bog may allow the relatively large Oregon spotted frog population to co-exist with brook trout. However, during drought conditions, Oregon spotted frog life stages may be placed in closer proximity to brook trout. The opportunity for recolonization is nil due to the isolated nature of these Oregon spotted frog populations. (Hayes 1997.)

Vernal Pool Fairy Shrimp (*Branchinecta lynchi*): in 59FR48135 (9/19/94), listed as **threatened** for California, OR. (The following life history information is taken from 59FR48135 and the EPA Region 9 BA for the State of California's water quality standards ESA consultation.)

The USFWS on 19 September 1994, published a final rule listing the vernal pool fairy shrimp as threatened in its known habitats (all in California). Region 10 EPA received a FWS letter dated 8 April 1998 noting the discovery of the threatened fairy shrimp in vernal pools in southwestern Oregon. Although specific critical habitat in Oregon is not yet designated, the shrimp inhabit several vernal pools in an area known as the Agate Desert, near Medford and White City, Oregon. The shrimp are threatened principally as the result of urban development, conversion of native habitats to agriculture, and stochastic (random) threat of extinction by virtue of the small isolated nature of many of the remaining populations.

The vernal pool fairy shrimp are members of the aquatic crustacean order Anostraca. These branchiopods which range up to an inch in length, are endemic to vernal pools, an ephemeral freshwater habitat. The shrimp are not known to occur in riverine waters, marine waters, or other permanent bodies of water. They are ecologically dependent on seasonal fluctuations in their habitat, such as absence or presence of water during specific times of the year, duration of inundation, and other environmental factors that include specific salinity, conductivity, dissolved solids, and pH levels. Water chemistry is one of the most important factors in determining the distribution of fairy shrimp. The shrimp are sporadic in their distribution, often inhabiting only one or a few pools in otherwise more widespread vernal pool complexes. Populations of these animals are defined by pool complexes rather than by individual vernal pools. In California, the majority of known populations inhabit vernal pools with clear to tea-colored water, most commonly in grass or mud bottomed swales, or basalt flow depression pools in unplowed grasslands. The water in pools inhabited by this species has low TDS, conductivity, alkalinity, and chloride.

Fairy shrimp feed on algae, bacteria, protozoa, rotifers, and bits of detritus. Females carry fertilized eggs that are either dropped to the pool bottom or remain in the brood sac until the female dies and sinks. The "resting" or "summer" eggs are capable of withstanding heat, cold, and prolonged desiccation. When the pools refill in the same or subsequent seasons some, but not all, of the eggs may hatch. The egg bank in the soil may be comprised of the eggs from several years of breeding. The eggs hatch when the vernal pools fill with rainwater. The early stages of the fairy shrimp develop rapidly into adults. These non-dormant populations often disappear early in the season long before the vernal pools dry up. The primary historical dispersal method for the fairy shrimp likely was large-scale flooding resulting form winter and spring rains which allowed the animals to colonize different individual vernal pools and other vernal pool complexes. Waterfowl and shorebirds likely are now the primary dispersal agents for fairy shrimp. Vernal pools form in regions with Mediterranean climates where shallow depressions fill with water during fall and winter rains and then evaporate in the spring. In the Agate Desert area of Oregon, vernal pools form on a hardpan surface during the spring.

Threats

The main treat to the species is habitat loss due to development (Judy Jacobs USFWS, Portland, OR; pers. com. 4/98).

III. PROPOSED ACTIONS

A. Dissolved Oxygen

1. Background

Oregon DO Standards Revisions

Oregon's DO standard revisions include:

- setting up the criteria under four use classes: salmonid spawning, cold water, cool water, and warm water (found in OAR 340-41(2)(a), pages A-1 - A-4 of Appendix B);
- addition of numeric criteria in place of percent saturation (found in OAR 340-41(2)(a), pages A-1 - A-4 of Appendix B);;
- addition of a criterion for intergravel DO (found in OAR 340-41(2)(a), page A-2 of Appendix B); and
- addition of ten definitions (#44 Intergravel Dissolved Oxygen (IGDO), #45 Spatial Median, #46 Daily Mean, #47 Monthly (30day) Mean Minimum, #48 Weekly (seven-day) Mean Minimum, #49 Weekly (seven-day) Minimum Mean, #50 Minimum, #51 Cold-Water Aquatic Life, #52 Cool-Water Aquatic Life, #53 Warm-Water Aquatic Life (found in OAR 340-41-006, page A-7 of Appendix B).

The standards revisions are found in Appendix B. Table 21 in Appendix B summarizes the numeric criteria. The State has clarified (Llewelyn, 1998) where and when salmonid spawning is to be protected in a table attached to the policy letter found in Appendix C. When there are site-specific differences in these spawning periods the State will provide protection via implementation of the antidegradation policy (to protect existing uses that weren't designated) and will make adjustments to their standards as necessary to refine the use designations. These adjustments would be water quality standards revisions that would be submitted for EPA review and approval as well as consultation under Section 7 of ESA. Waters are classified as cool water on an ecoregion basis (see Appendix G for the ecoregion map) as follows:

West side:

Cold Water: Coast Range Ecoregion - all, Sierra Nevada Ecoregion -all, Cascade - all, Willamette Valley - "generally typical" including Willamette River above Corvallis, Santiam (including the North and South), Clackamas, McKenzie, Mid Fork and Coast Fork mainstems.

Cool Water: Willamette Valley Ecoregion - "most typical"

East side (with exception of waters listed under warm water criteria):

Cold Water: Eastern Cascades Slopes and Foothills - "most typical", Blue Mountain - "most typical"

Cool Water: Remainder of Eastern Oregon Ecoregions

("most typical" and "generally typical" refer to subecoregion designations)

The numeric temperature criteria for cold water, cool water, and warm water contain a provision that allows that, "At the discretion of the Department, when the Department determines that adequate information exists," lower criteria values may be applied. ODEQ has clarified that in making this determination the beneficial uses of the water body (including species present, listing status of those species, locations, time periods and presence of sensitive early life stages) will be considered. Based on the presence of early life stages or threatened and endangered species this provision for lower DO criteria would not be applied. (Llewelyn, 1998).

Objective of Oregon's Revisions

Because of concerns that the previous criteria were perhaps overly stringent in some cases and not protective enough in others, the State embarked on reexamining the oxygen requirements of the protected uses in the waterbodies (including life-stage specific requirements), and the level of risk that would be appropriate in setting protective dissolved oxygen criteria. The form of the criterion was also examined, statistical criteria allowing for more flexibility in permitting, although not allowing for as great a margin of safety.

How Do the Revisions Compare with Previous Standards

The previous standards were established by basin and were expressed as an absolute minimum in the form of percent saturation, and occasionally a specific numeric concentration. The new criteria are expressed primarily as statistical numeric criteria. There are more categories of use protection, and more attention to salmonid spawning protection by creating a criterion based on intergravel DO, which indirectly measures the effect of sediment accumulation in spawning redds, a major cause of spawning mortality.

2. EPA Proposed Action

Under Section 303(c) of the Clean Water Act EPA proposes to approve all of the DO revisions adopted by the State of Oregon.

3. Effect of Action on Listed Species

Dissolved oxygen water quality criteria have been established to protect communities and populations of fish and aquatic life against mortalities as well as prevent adverse effects on eggs, larvae, and population growth. While many adult stages of fish can survive at relatively low dissolved oxygen concentrations, the survival of embryos and larvae often requires much higher levels (Welch 1980). For most aquatic species, the time to hatching increases, growth and survival decrease as dissolved oxygen decreases, with the greatest reduction in survival observed at approximately 5.0 mg/L (Carlson and Siefert 1974; Carlson and Herman 1974). In addition, reductions in dissolved oxygen decrease swimming performance in both adult and larval fish (Davis et al. 1963) affecting a species' ability to migrate, forage and avoid predators.

As reported in the Final Issue Paper on Dissolved Oxygen (ODEQ, 1995(a)) low DO levels increase the acute toxicity of various toxicants such as metals (e.g., zinc) and ammonia. At low intergravel dissolved oxygen (IGDO) and water velocity, ammonia exposure can cause problems with eggs in redds, such as inadequate IGDO to nitrify ammonia and depressed IGDO after nitrification. Carson (1985) reports that rainbow trout eggs excrete most of their nitrogenous wastes as ammonia. Ammonia is also a common pollutant. Adverse impacts of other toxicants may be compounded by low levels of DO or may increase sensitivity to low levels of DO. For example, any toxicant which damages the gill epithelium can decrease the efficiency of oxygen uptake. Fish can detect and avoid reduced levels of DO. For instance, brook trout preferentially selected environments with DO levels ranging from 7 to 8 mg/l and avoided those with DO levels below 5 to 6 mg/l. Juvenile coho exhibited erratic behavior at 6.0 mg/l. Laboratory studies show that the blood is not fully saturated with oxygen at levels near 6.5 mg/l, because at that level, changes in oxygen transfer efficiency occur. Productive streams, either natural systems or nutrient enriched, exhibit diurnal cycles in DO due to photosynthesis and respiration. Average measures of DO do not reflect the damage that can occur during diurnal minimums. Other important factors include the length and frequency of fish exposure to the low DO level. Delayed emergence, reduced alevin growth rates and increased susceptibility to disease and predation are discussed in the following sections. Three mechanisms by which low DO and a toxicant in combination cause effects are apparent:

- Increased ventilation of the gill associated with low DO can increase uptake of waterborne toxics;

- Any toxic which damages the gill epithelium and decreases efficiency of oxygen uptake will increase sensitivity to low DO; and

- A number of toxics, such as pentachlorophenol (a common wood preservative for in-water structures), increase oxygen consumption due to interference with oxidative phosphorylation.

Any agent with the modes of action just discussed can increase sensitivity to low DO.

A. **Chinook Salmon (Snake River fall- and spring-/summer- run, spring run Upper Willamette River, spring run Upper Columbia River, all runs of Lower Columbia River, spring and fall runs of Southern Oregon/California Coastal), Coho Salmon (Lower Columbia River and Southwest Washington, Coastal, and Southern Oregon/Northern California), Columbia River Chum Salmon, Steelhead Trout (Snake River Basin, Upper, Middle, and Lower Columbia, Upper Willamette, Oregon Coast, and Klamath Mountains Province), Bull Trout (Columbia and Klamath Basins), and Cutthroat Trout (Lahontan, Umpqua River, and West Slope).**

1. The Oregon water quality standards applicable to salmonid spawning are: dissolved oxygen not less than 11 mg/l. However, if the minimum IGDO, measured as a spatial median, is 8.0 mg/l or greater, then the DO criterion is 9.0 mg/l. Where conditions of barometric pressure, altitude, and temperature preclude attainment of the 11.0 mg/l or 9.0 mg/l criteria, DO levels shall not be less than 95% saturation. From spawning until fry emergence from the gravels, the spatial median IGDO shall not fall below 6.0 mg/l. A spatial median IGDO of 8.0 mg/l is to be used to identify where the beneficial uses may be impaired and require action by the Department. The Department may, in accordance with established priorities, then evaluate the water quality and initiate pollution control

strategies.

The early life stages of fish are recognized as being the most sensitive and requiring relatively high DO concentrations. The oxygen demand by embryos depends on temperature and on the stage of development with the greatest DO required just prior to hatching. At near 15°C, IGDO requirements for steelhead will exceed 10 mg/l (Rombough, 1986; Carlson, 1980). Rombough (1986) and other researchers have shown that critical oxygen concentration increases with temperature and with the stage of development of the fish. At 15°C, the critical level of DO (where ambient levels meet metabolic needs) for steelhead increases from 1.0 mg/l shortly after fertilization to greater than 9.7 mg/l prior to hatching (implies an IGDO of at least 6.7 mg/l). The crucial timing of IGDO, stream temperature, and flow rate varies with each salmonid ESU's specific characteristics. Sowed and Power (1985) observed that survival in field studies is negligible when IGDO falls below 5 mg/l. This is consistent with other studies. Phillips and Campbell (1962) observed no survival in a field study where IGDO fell below 8.0 mg/l. They suggest that embryos of newly-produced fry at moderately reduced oxygen levels may not survive well in nature.

In field testing of brown trout spawning habit in Idaho, Maret et al. (1993) found a significant relationship between IGDO and survival. Survival was negligible when mean IGDO fell below 8.0 mg/l. Maret et al. (1993) suggest that growth and survival relate to IGDO above 8.0 mg/l when seepage velocities exceed 100 cm/hr. Survival also inversely relates to the amount of fines present. The research suggests that sediment in excess of 15 percent fines may reduce IGDO to unacceptable levels for survival and incubation. EPA (1986) recommendations for DO criteria in the water column assume a loss of at least 3 mg/l from surface water to the intergravels. Skaugset (1980) and others report that IGDO is inversely related to the percent organic fines, thus, the estimated loss of 3 mg/l may underestimate the loss in degraded systems.

Field studies in Oregon showed similar results as the work by Maret et al. (1993) in Idaho. Survival was negligible for juvenile salmonids when IGDO fell below 6 mg/l, especially at relatively low intergravel velocities (ODEQ, 1995(a)). Hollender (1981) studying wild brook trout, observed that IGDO was usually above 6.0 mg/l, and found survival of embryos directly related to mean IGDO up to 8.0 to 9.0 mg/l in natural redds. The artificial redds used in this study produced much lower survival, but also indicated negligible survival below about 8.0 mg/l. Phillips and Campbell (1962) studied steelhead in stream-bed gravels and recovered few or no sac fry from containers placed where the mean oxygen concentrations recorded were below about 8 mg/l. In studying juvenile trout, Turnpenny and Williams (1980) found only about 35 percent survival at IGDOs of 6 mg/l and approximately 95 percent survival when IGDO was 8 mg/l. Results from Sowden and Power (1985), Phillips and Campbell (1962), and Turnpenny and Williams (1980) suggest IGDO concentrations less than 5 mg/l are lethal.

Apparent velocity and observed DO are also related, making separation of the influence of these parameters on observed survival difficult (Coble, 1961). From field work with rainbow trout, Sowden and Power (1985) concluded that water in contact with the eggs with a DO of 8 mg/l and seepage velocities exceeding 100 cm/hr resulted in 50 percent survival of embryos. The study also indicates that survival is negligible below velocities of 20 cm/hr.

Any reduction in IGDO from saturation appears to reduce the likelihood of survival to emergence or post-emergent survival for embryos (ODEQ, 1995(a)). Turnpenny and Williams (1980) also observed that alevin size was positively correlated with IGDO. Maret et al. (1993) reported relatively lower growth, measured as alevin length and corrected for thermal units, at moderate IGDO levels near 6 to 7 mg/l, as compared to those alevins incubated at 9 to 10 mg/l. Brannon (1965) found that alevins raised at low DO concentrations were smaller, however, the fish eventually reached nearly the same weight as fish exposed to higher concentrations of DO. Reiser and White (1983) also observed compensatory growth after about two months, for chinook salmon and steelhead. The ability of fry to survive in their natural environment may be related to the size of fry at hatch (ODEQ, 1995(a)). Results from several researchers [Mason (1969); and Chapman and McLeod (1987)] with coho salmon show that late emerging alevins and small sized fry are poor competitors and face almost certain death from predation, disease, starvation or, most likely, a combination of these.

The State of Oregon's salmonid spawning water column DO criteria meet or exceed EPA's guidance (U.S.EPA, 1986). During the time that waters support salmon embryo and larval stages, EPA recommends a water column DO of 11 mg/l for no production impairment, 9 mg/l for slight production impairment, and 8 mg/l for moderate production impairment. Assuming the 3 mg/l surface to gravel differential (as described above), the IGDO levels are 8 mg/l, 6 mg/l, and 5 mg/l respectively. EPA (1986) gives 6.5 mg/l as an IGDO 7-day mean criterion. The extra 0.5 mg/l is meant as a safety factor, however, the large variation of IGDO within a spawning bed is a consideration. An IGDO of 5 mg/l is recommended as a 1-day minimum for early life stages. EPA (1986) goes on to state that for embryonic, larval, and early life stages (ELSs) in general, the averaging period for DO should not exceed 7-days. This short time is needed to adequately protect these often short duration, most sensitive life stages. Thirty-day averages can probably adequately protect other life stages. The studies summarized here indicate that adverse effects occur about 8 mg/l for IGDO and that 5 mg/l is in the lethal zone.

Studies reviewed for this determination, where adverse effects may begin to occur at IGDOs of less than 8 mg/l or, as applicable to the discussion below on water column DO, below 10 mg/l (water column), generally have controlled conditions with minor variations in either IGDO or DO. This contrasts with the natural environment where IGDO varies within a redd and where DO levels cycle diurnally. Oregon's criteria are more protective than the EPA(1986) criteria since the 9 mg/l for water column DO, the 8 mg/l IGDO action level, and the 6 mg/l IGDO absolute minimum are not week-long averages but apply any time.

Based on the studies summarized above, EPA concludes that Oregon's intergravel dissolved oxygen criterion of a spatial median of 6 mg/l is likely to adversely affect Chinook Salmon (Snake River fall- and spring-/summer- run, spring run Upper Willamette River, spring run Upper Columbia River, all runs of Lower Columbia River, spring and fall runs of Southern Oregon/California Coastal), Coho Salmon (Lower Columbia River and Southwest Washington, Coastal, and Southern Oregon/Northern California), Columbia River Chum Salmon, Steelhead Trout (Snake River Basin, Upper, Middle, and Lower Columbia, Upper Willamette, Oregon Coast, and Klamath Mountains Province), Bull Trout (Columbia and Klamath Basins), and Cutthroat Trout (Lahontan, Umpqua River, and West Slope),

particularly since a spatial median allows for other values lower than 6 mg/l within the redd. The 8 mg/l IGDO action level is a more appropriate target for protection of ESA-listed salmonids. However, the language in the Oregon rules does not mandate follow up on this action level.

2. As discussed above for IGDO, water column DO concentrations below about 9 mg/l will adversely affect habitat designated for salmonid spawning, and water column DO levels averaging above 10 mg/l are required to avoid adverse effects. Oregon's criteria for salmonid spawning water column DO are more protective at 11 mg/l as a 7-day average and 9 mg/l minimum (at any time). The 11 mg/l DO concentration corresponds to EPA's highest defined level of protection where even slight production impairment would not occur.

Based on available information, EPA has determined that Oregon's water column DO criteria for salmonid spawning are not likely to adversely affect Chinook Salmon (Snake River fall- and spring-/summer- run, spring run Upper Willamette River, spring run Upper Columbia River, all runs of Lower Columbia River, spring and fall runs of Southern Oregon/California Coastal), Coho Salmon (Lower Columbia River and Southwest Washington, Coastal, and Southern Oregon/Northern California), Columbia River Chum Salmon, Steelhead Trout (Snake River Basin, Upper, Middle, and Lower Columbia, Upper Willamette, Oregon Coast, and Klamath Mountains Province), Bull Trout (Columbia and Klamath Basins), and Cutthroat Trout (Lahontan, Umpqua River, and West Slope).

3. At times when spawning, incubation, and emergence do not occur, the coldwater criteria apply to the waters listed above, by ecoregion, that are designated for cold water aquatic life use. EPA (1986) recommends a 30-day mean of 6.5 mg/l, a 7-day mean minimum at 5 mg/l, and a 1-day minimum of 4 mg/l. The information presented here indicates that at water column DO concentrations near the levels presented in EPA's criteria, stress, avoidance, behaviorial effects, and possibly more severe effects are expected in salmonids. Invertebrates, the salmonid food base, are also sensitive to low DO levels. Although acutely lethal concentrations of DO appear to be higher for invertebrates than for fish, chronic effects occur near 6 to 8 mg/l (ODEQ, 1995(a)). Oregon's coldwater criterion of an absolute minimum of 8 mg/l corresponds with EPA's recommendation of a 1-day minimum to protect early life stages of coldwater biota (EPA, 1986). It is also equivalent to "no production impairment" for other than early life stages of salmonids. As clarified by the State (Llewelyn, 1998), the lower DO criteria for the seven-day minimum mean and absolute minimum (6.5 mg/l and 6 mg/l respectively), will not be applied where threatened and endangered species are present.

Therefore, EPA has determined that Oregon's water column DO criteria for cold water aquatic life are not likely to adversely affect Chinook Salmon (Snake River fall- and spring-/summer- run, spring run Upper Willamette River, spring run Upper Columbia River, all runs of Lower Columbia River, spring and fall runs of Southern Oregon/California Coastal), Coho Salmon (Lower Columbia River and Southwest Washington, Coastal, and Southern Oregon/Northern California), Columbia River Chum Salmon, Steelhead Trout (Snake River Basin, Upper, Middle, and Lower Columbia, Upper Willamette, Oregon Coast, and Klamath Mountains Province), Bull Trout (Columbia and Klamath Basins), and Cutthroat Trout (Lahontan, Umpqua River, and West Slope).

4. The cool water classification is not designed for all possible salmonid uses. Oregon's cool-water criteria classification was created to protect cool-water species where coldwater biota may be present during part or all of the year but would not form the dominant component of the community structure (ODEQ, 1995(a)). When salmonid spawning occurs, these waters would be protected by the salmonid spawning DO criteria (Llewelyn, 1998). The coolwater criterion of 6.5 mg/l, as an absolute minimum, is higher than the EPA 1-day coldwater criterion for other than early life stages, of 4.0 mg/l. Oregon acknowledges that at the coolwater DO criterion concentration, there is a potential for a slight risk to coldwater species present (the criterion is 0.5 mg/l higher than an EPA criterion that represents "slight production impairment" for other than early life stages of salmonids). Per Llewelyn (1998) the lower criteria applicable to "when the Department determines that adequate information exists" (5.0 mg/l as a seven-day minimum and 4.0 as an absolute minimum) will not be applied when a threatened or endangered species is in that water body.

Therefore, EPA has determined that the coolwater biota DO criteria are not likely to adversely affect Chinook Salmon (Snake River fall- and spring-/summer- run, spring run Upper Willamette River, spring run Upper Columbia River, all runs of Lower Columbia River, spring and fall runs of Southern Oregon/California Coastal), Coho Salmon (Lower Columbia River and Southwest Washington, Coastal, and Southern Oregon/Northern California), Columbia River Chum Salmon, Steelhead Trout (Snake River Basin, Upper, Middle, and Lower Columbia, Upper Willamette, Oregon Coast, and Klamath Mountains Province), Bull Trout (Columbia and Klamath Basins), and Cutthroat Trout (Lahontan, Umpqua River, and West Slope).

B. Oregon chub, Hutton Spring tui chub, Borax Lake chub

The Oregon chub is endemic to the Umpqua and Willamette Rivers. Habitat where the remaining populations reside is typified by low- or zero-velocity water flow conditions. The Oregon cool water dissolved oxygen criteria apply to the habitat of the Oregon chub in the Willamette and require that dissolved oxygen concentrations not be less than 6.5 mg/L at an absolute minimum. The Oregon cold water dissolved oxygen criteria apply to the habitat of the Oregon chub in the Umpqua River and require that dissolved oxygen concentrations not be less than 8.0 mg/L.

The Hutton Spring tui chub inhabits the Hutton Spring and a nearby spring that is part of the Hutton Spring system in the Goose and Summer Lakes basin. The Borax Lake chub is endemic to Borax Lake and adjacent wetlands in the Malheur Lake basin. The warm water dissolved oxygen criteria apply to these basins and require dissolved oxygen concentrations not less than 5.5 mg/L as an absolute minimum. As clarified by ODEQ (Llewelyn, 1998), the lower DO criteria that might be applied "When the Department determines that adequate information exists," will not be applied where threatened or endangered species are present.

The dissolved oxygen requirements of the Oregon chub are unknown. Reconnaissance investigations in the Middle Fork Willamette and Santiam River drainages (Scheere and Apke, 1997) observed Oregon chub at sites with dissolved oxygen concentrations ranging from 3.0 mg/L to 9.9 mg/L. Information about the dissolved oxygen requirements of the Hutton Spring tui chub may be inferred from research on the tui chub from the Upper Klamath basin. Castleberry and Cech (1993) reported mean minimum dissolved oxygen concentrations for the tui chub to be 0.59 ±0.04 mg/L. Dissolved oxygen levels in Upper Klamath Lake have been reported to be as low as 0.3 mg/L (Scoppettone 1986). These dissolved oxygen values should be considered as guidance, as the most sensitive life stage may not have been tested and the relative sensitivity of tui chub stocks from these geographically separate areas is unknown. In a survey of Borax Lake conditions from 1991 to 1993, dissolved oxygen measurements ranged from 4.98 to 8.66 mg/L (Scoppettone et al, 1995). These species currently reside in habitats with dissolved oxygen concentrations that are less than those required under the Oregon rules. Research on related species has demonstrated that the chub are able to withstand extremely low concentrations of dissolved oxygen (<1.0 mg/L).

Therefore, EPA has determined that the Oregon cold water and cool water dissolved oxygen criteria are not likely to adversely affect the Oregon chub, and that the warm water criterion is not likely to adversely affect the Hutton Spring tui chub and the Borax Lake chub or the Borax Lake chub critical habitat.

C. Lost River sucker, Shortnose sucker, Warner sucker

The Lost River sucker and the Shortnose sucker reside in the upper Klamath basin. Oregon's cool water dissolved oxygen criteria apply to the critical habitat of these species and require that the dissolved oxygen concentrations not fall below 6.5 mg/L as an absolute minimum. The Warner sucker's critical habitat includes sections of Twelvemile and Twentymile Creeks, the spillway Canal north of Hart lake and Snyder and Honey Creeks. This critical habitat is within the Goose and Summer Lakes basin where the Oregon warm water dissolved oxygen criteria apply, requiring that dissolved oxygen concentrations maintain 5.5 mg/L as an absolute minimum.

Studies by Monda and Saiki (1993), the U.S. Bureau of Reclamation (1997) and Scoppettone (1986) indicate that the lethal dissolved oxygen concentrations for Lost River and Shortnose suckers are approximately 2.0 to 2.4 mg/L for larval and juvenile life stages and 2.8 mg/L for adults. Adult and juvenile Lost River and Shortnose suckers have been found in Upper Klamath and Agency lakes (critical habitat for these species) in waters where the dissolved oxygen ranges from 4 to 13 mg/L (Simon 1998) with the largest frequency of suckers observed in waters with concentrations of dissolved oxygen approximately 9 mg/L.

Adult and larval forms of these sucker species have been found in waters where the dissolved oxygen concentrations were less than those in the Oregon water quality standards. In addition, laboratory studies demonstrate that lethal dissolved oxygen concentrations for larval and juvenile life stages of these species are significantly less than those required under the Oregon rules.

Therefore, EPA finds that the Oregon cool water criteria for dissolved oxygen in the Klamath basin are not likely to adversely affect the Shortnose Sucker and Lost River Sucker.

The dissolved oxygen requirements of the Warner sucker are unknown. The Warner sucker resides in the Goose and Summer Lakes basin in south central Oregon, an area known for its hot springs, summer maximum air temperatures average 80°F and an 80% to 90% chance of sunshine during

July (ODEQ 1995(a)). Larval Warner suckers are found in shallow backwater pools or on stream margins in still water, often among or near macrophytes (USFWS, 1998). Juvenile suckers are usually found at the bottom of deep pools or in other relatively cool and permanent habitats such as near springs. Adult suckers use stretches of stream where low gradients allow formation of long pools (50 meters or longer) that tend to have undercut banks, large beds of aquatic macrophytes, root wads or boulder, a maximum depth of 1.5 meters, and overhanging vegetation. While Warner suckers have been found in smaller or shallower pools, they were only found in the smaller pools when larger pools were within approximately 0.4 kilometers upstream or downstream of the site (USFWS, 1998).

Reports (Monda and Saiki 1993; U.S. Bureau of Reclamation 1997; Scoppettone 1986) indicate that the lethal dissolved oxygen concentrations of the Lost River and Shortnose suckers' are approximately 2.0 to 2.8 mg/L. While one must be cautious when applying a test species' requirements to a surrogate species, in this case, the surrogate species (the Warner sucker) resides in a habitat that is naturally subjected to lower dissolved oxygen concentrations (warm, slow moving stream margins and pools) than that of the test species (the Shortnose and Lost River sucker). Consequently, one can be more confident that the test species' dissolved oxygen requirements are applicable to the surrogate species. In this case, the minimum dissolved oxygen requirements of the test species (the Shortnose and Lost River sucker) are almost two times lower than the absolute minimum required under the Oregon rules for the Warner sucker.

Therefore, EPA has determined that the Oregon warm water dissolved oxygen criteria are not likely to adversely affect the Warner sucker.

D. Foskett speckled dace

The Foskett speckled dace occurs in Foskett Spring on the west side of the Warner Valley in the Goose and Summer Lakes basin. The warm water dissolved oxygen criteria apply and require that concentrations of dissolved oxygen not fall below 5.5 mg/L as an absolute minimum.

Foskett Spring has the only known native population of Foskett speckled dace and consists of a pool that is about 5 meters across and a shallow channel that flows toward Coleman Lake. The outflow channel eventually turns into a marsh and finally dries up before reaching the bed of Coleman Lake. Castle and Cech (1993) have reported that the mean minimum dissolved oxygen requirements for speckled dace in general are 0.8 ± 0.06 mg/L. However, these values should be considered as guidance as the most sensitive life stage may not have been tested and the relative sensitivity of speckled dace stocks from various geographic areas is unknown. Despite the lack of specific information on the dissolved oxygen requirements for the Foskett speckled dace, the Oregon dissolved oxygen criteria are greater than four times the minimum requirements for speckled dace in general.

Therefore, EPA has determined that the warm water dissolved oxygen criteria are not likely to adversely affect the Foskett speckled dace.

E. Oregon spotted frog, Columbia spotted frog

Critical habitat for the Oregon spotted frog is at elevations below about 5,300 feet. This distribution is latitude dependent with the frog found below 600 meters (1,970 feet) in southern Washington and below 1,500-1,600 meters (4,920 - 5,248 feet) in southern Oregon. The Columbia spotted frog's critical habitat in Oregon is at elevations of approximately 400 feet or higher, generally drier east-side Cascades and higher plateau inland habitats. Of notable importance is that there are no records of either of these frogs existing in coastal or near coastal areas in western Oregon, the higher Cascade mountains, and the Umpqua drainage basin, possibly due to a warmer water requirement for the frog's postmetamorphic states (≥20°C). The Oregon spotted frog is nearly always found in, or near, a perennial water body such as a spring, pond, lake or sluggish stream (Leonard et al. 1993).

These spotted frogs inhabit waterbodies that would be regulated by Oregon's cold, cool and warm water dissolved oxygen criteria. The exact dissolved oxygen requirements of the Oregon and Columbia spotted frogs, are unknown. Hayes (1998) noted some evidence that concentrations of dissolved oxygen of 5.0 mg/L and less could detrimentally affect spotted frogs, in general. It is believed that the immune system of spotted frogs is compromised under these low dissolved oxygen conditions.

As the lowest dissolved oxygen concentrations that would be allowed under the Oregon rules for areas inhabited by spotted frogs would be 5.5 mg/L, EPA has determined that the Oregon dissolved oxygen criteria are not likely to adversely affect the Oregon and Columbia spotted frogs.

F. Vernal Pool fairy shrimp

The Vernal Pool fairy shrimp is listed as threatened in California. On 8 April 1998, EPA Region 10 received a letter from the USFWS noting the discovery of the threatened species in vernal pools that form on hardpan surfaces during the spring in the Agate Desert, in southwestern Oregon. The Agate Desert is located in the Rogue Basin where the cold water dissolved oxygen criteria apply, requiring an absolute minimum, 8.0 mg/L dissolved oxygen concentration.

The Vernal Pool fairy shrimp is a branchiopod, not known to occur in riverine, marine, or other permanent water bodies. Ecologically the shrimp depend on seasonal fluctuations in their habitat, such as absence or presence of water during specific times of the year, duration of inundation, and other environmental factors that include specific salinity, conductivity, and dissolved solids. Eggs of this species are capable of withstanding heat, cold, and prolonged periods of desiccation. When the pools refill, some, but not all, of the eggs may hatch. The egg bank in the soil may be comprised of eggs from several years of breeding. Once hatched, the larval stages of the fairy shrimp develop rapidly into adults.

Vernal Pool fairy shrimp inhabit waters with low total dissolved solids, conductivity, alkalinity and chloride. While the dissolved oxygen requirements of this species are unknown, all of the larger branchiopods can regulate their oxygen consumption and live at low oxygen concentrations (Thorp and Covich 1991). Horne (1971) reported that a related species (*Branchinecta mackini*) was able to tolerate dissolved oxygen concentrations as low as 1.3 mg/L. As the fertilized eggs from this species can withstanding desiccation and remain viable, we may presume that the eggs do not have any minimum dissolved oxygen requirements. While the dissolved oxygen requirements for larval and adult Vernal Pool fairy shrimp are unknown, by nature, these shrimp are able to survive in harsh, temporary habitats. Despite the lack of definitive information on the dissolved oxygen requirements of the fairy shrimp, the EPA believes the life history of these shrimp demonstrates that they are able to withstand extremely low concentrations of dissolved oxygen.

Therefore, EPA has determined that the Oregon cold water dissolved oxygen criteria are not likely to adversely affect the Vernal Pool fairy shrimp.

B. Temperature

1. Background

Oregon Temperature Standards Revisions

Oregon's temperature standard revisions include:

- the addition of four definitions (# 54 Numeric Temperature Criteria, #55 Measurable Temperature Increase, #56 Anthropogenic, and # 57 Ecologically Significant Cold-Water Refuge on page A-25 of Appendix B);
- changes to numeric and narrative criteria applicable to each basin (found under OAR 340-41(2)(b) , pages A-10 - A-13 of Appendix B);
- the addition of some policies and guidelines applicable to all basins (OAR 340-41-026, pages A-14 - A-19 of Appendix B); and
- an implementation program applicable to all basins (OAR 340-41-120, pages A-20- A-24 of Appendix B).

The numeric criteria amendments replace a single basin or sub-basin-specific numeric temperature criterion with new criteria applicable to specific species and life stages. The tables in Appendix D show the applicable criteria for each species, by basin, compared with the previous numeric criteria. The numeric criteria provide that "unless specifically allowed under a Department-approved surface water temperature management plan ..., no measurable surface water temperature increase resulting from anthropogenic activities is allowed:

(I) In a basin for which salmonid fish rearing is a designated beneficial use, and in which surface water temperatures exceed **64.0° F(17.8C)**;

(ii) In the Columbia River or its associated sloughs and channels from the mouth to river mile 309 when surface water temperatures exceed **68.0F (20.0C)**;

(iii) In the Willamette River or its associated sloughs and channels from the mouth to river mile 50 when surface water temperatures exceed **68.0F(20.0C)**;

(iv) In waters and periods of the year determined by the Department to support native salmonid spawning, egg incubation, and fry emergence from the egg and from the gravels in a basin which exceeds **55.0F(12.8C)**;

(v) In waters determined by the Department to support or to be necessary to maintain the viability of native Oregon bull trout, when surface water temperatures exceed **50.0F (10.0C)**"

These provisions apply to both existing activities as well as any proposed new or expanded activities.

The State has not identified adult salmonid migration, adult holding, smoltification, or juvenile salmonid emigration as distinct use designations. The State includes these aspects of salmonid life history under the salmonid rearing designated use. The State has clarified where and when salmonid spawning is to be protected in a table attached to the policy letter (Llewelyn, 1998) found in Appendix C. Waters to be protected for bull trout, as a special category of salmonids with more stringent criteria, are also described in the policy letter and illustrated on an accompanying map from the Oregon Department of Fish and Wildlife publication, "Status of Oregon Bull Trout"(1997) (Appendix F).

Narrative criteria state verbally what conditions or limits will apply, but need to be determined on a case-by-case basis. The narrative criteria, which follow the numeric criteria quoted above in the rules, allow "no measurable surface water temperature increase resulting from anthropogenic activities...

(vi) In waters determined by the Department to be ecologically significant cold-water refugia;

(vii) In stream segments containing federally listed Threatened and Endangered species if the increase would impair the biological integrity of the Threatened and Endangered population;

(viii) In Oregon waters when the dissolved oxygen (DO) levels are within 0.5 mg/L or 10 percent saturation of the water column or intergravel DO criterion for a given stream reach or subbasin;

(ix) In natural lakes."

Provision (vi) above will be applied by the Department utilizing definition # 57 (Ecologically Significant Cold-Water Refuge). The Department will be applying provision (vii) when they have specific temperature information for a listed species. Application of provision (viii) resulted in the placement of several waters on the draft 1998 303(d) listing of water quality limited water bodies. In those cases the dissolved oxygen measurements were the trigger for the listing for temperature. Waterbodies that in the previous standards had criteria to protect warm-water biota, inadvertently had the numeric criteria removed, with no replacement numeric criteria adopted in this triennial review. The State has clarified its intent to protect these waters with provisions vii - ix, as appropriate, and to develop and adopt site-specific numeric temperature criteria to protect these waters during the upcoming triennial review (1998 - 2000) (Llewelyn, 1998). These site-specific criteria will be submitted to EPA for review and approval, and consultation under Section 7 of ESA.

Not all policies, guidelines and implementation program elements fall under the purview of the CWA Section 303(c) water quality standards review. Within each basin's standards in OAR 340-41 there is a provision to not count an exceedance of surface water temperature criteria an exceedance if it occurs "when the air temperature during the warmest seven-day period of the year exceeds the 90th percentile of the seven-day average daily maximum air temperature calculated in a yearly series over the historic record." This is enforcement/compliance discretion allowed the State. To assure that this provision does not allow extensive periods of water temperature violation EPA conferred with the State regarding how this provision would be implemented. The State noted that no waterbodies were removed from the 1998 303(d) list of impaired waters because of this provision (Schaedel, personal communication, 1998).

The temperature standards also contain a provision to allow a source an exception from the numeric and narrative criteria if "designated beneficial uses would not be adversely impacted; or a source is implementing all reasonable management practices or measures; its activity will not signficantly affect the beneficial uses; and the environmental cost of treating the parameter to the level necessary to assure full protection would outweigh the risk to the resource." The State has clarified in its policy letter (Llewelyn, 1998), that this will be handled as a variance for that source until a TMDL is developed or a site-specific criterion will be developed for the water body. In the former case, the documentation to support a variance must meet the requirements of the federal regulations found at 40CFR131.10(g), which require a demonstration of why the criteria to support the use cannot be met. For a site-specific criterion, the documentation must follow one of EPA's approved methods for site-specific criteria development or some other scientifically defensible method (40CFR131.11(b)). In either case a public review process would be required, as well as submittal of the site-specific criterion to EPA for review, approval, and consultation under Section 7 of ESA.

The narrative temperature criterion for marine and estuarine waters was not changed and therefore is not part of this EPA action.

In a section of the Oregon water quality standards entitled "Policies and Guidelines Generally Applicable to all Basins" there are provisions pertaining to the development of TMDLs and the permitting of sources in waters that have been identified as water-quality limited. These provisions are only reviewable under Section 303(c) of the Clean Water Act where they create or result in a change to the water quality standards. The provisions direct that the anthropogenic sources "develop and implement a surface water temperature management plan describing the best management practices, measures and/or other control technologies which will be used to reverse the warming trend of the basin, watershed, or stream segment" (OAR 340-41-026 (3)(a)(D)(i)). These sources are to "continue to maintain and improve" the plan in order to maintain the cooling trend until the criterion is achieved or the Department has determined that "all feasible steps have been taken to meet the criterion and that the designated beneficial uses are not being adversely impacted." The "temperature achieved" will then be the temperature criterion for the surface waters covered by the plan. In the policy letter (Llewelyn, 1998) the State has clarified that in this circumstance the Department will develop a site-specific criterion (which is a change in the water quality standards) that will be submitted to EPA for review, approval and consultation under Section 7 of ESA.

The Policies and Guidelines section also contains provisions F, G and H that allow a source (or sources cumulatively) to increase the waterbody temperature by a set amount while a TMDL is developed, as long as the increase will not "conflict with or impair the ability of a surface water temperature management plan to achieve the temperature criteria" ultimately and will not "result in a measurable impact on beneficial uses" or "beneficial uses would not be adversely impacted." The policy letter (Llewelyn, 1998) clarifies that provision H will be handled as a variance which will be submitted to EPA for review, approval, and consultation under Section 7 of ESA each time it is applied to a particular permit. The policy letter indicates that provisions F and G will result in permits written to meet the criteria.

The provisions in OAR 340-41-120, Implementation Program Applicable to all Basins, include statements of policy (e.g. regarding minimizing risk to cold-water aquatic ecosystems) and implementation, particularly for waters exceeding the applicable numeric criterion. These provisions do not fall under the purview of the CWA Section 303(c) review as they do not explicitly pertain to designation of uses, criteria, antidegradation policy, or other aspects of the water quality standards program that are specified for review under the EPA water quality standards regulations at 40CFR 131. Provision (11)(c) in this Section of the Oregon regulations allows the natural surface water temperature to become the numeric criterion. While this does pertain to a criterion change, it is not a change from previous provisions in Oregon's water quality standards and therefore is not being reviewed in this action. The concluding provision (g) of this Section addresses maintaining "low stream temperatures to the maximum extent practicable" and emphasizes that any measureable increase in surface water temperature resulting from anthropogenic activities "shall be in accordance with the antidegradation policy contained in OAR 340-41-026."

Objective of Oregon's Revisions

Setting the stage for DEQ's revisions to its temperature criteria, the Final Issue Paper for Temperature (ODEQ 1995 (b)) notes that, "The objective of the temperature standard is to achieve the objective of the Clean Water Act and to "fully protect" the beneficial use. DEQ interprets this to mean that a viable, sustainable population should be maintained at levels that fully utilize the habitat potential of a basin or ecoregion. A sustainable population possesses the ability to survive natural fluctuations in environmental conditions and localized natural events that may impact or eliminate local sub-populations." (page 1-4) The Endangered Species Act (Section 2) sets forth the purpose of the Act as providing "a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species." The Act goes on to define "conservation" as "use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary." Oregon's objective appears to be fully in line with the Endangered Species Act purposes. The terms "viable" and "sustainable" are important. To achieve a viable and sustainable population requires restoration of populations (and habitats) to a level where there is a sufficient gene pool and habitat linkages to maintain the population in the face of natural disturbance regimes as well as unavoidable human impacts. Listed populations generally do not have that resilience, and are therefore declining. In sum, the objectives of the Clean Water Act, Oregon's program and ESA can be interpreted as not just to protect the remnant of the beneficial use or listed species that is there now, but to restore it to viable and sustainable levels.

According to Oregon's Final Issue Paper for Temperature (ODEQ 1995 (b)), many streams in Oregon have high temperatures that are impacting beneficial uses (page 1-5). The temperature exceedances documented on Table 1-2 (ODEQ 1995, p1-7), include a daily maximum in the Grande Ronde River of 82 F. Oregon's draft 1998 303(d) list includes 862 streams (12,146 stream miles) as exceeding the temperature criteria. There is an acknowledgement in ODEQ 1995 (b) that the Department of Environmental Quality was not implementing or enforcing the existing (pre-1996) temperature standards to any extent (p 1-5).

The previous Oregon temperature standard (which was adopted in 1967) provided a maximum temperature above which no measureable increase due to human activity was allowed. This varied by basin with 58 F (14.4C) or 64 F (17.8C) as the maximum in salmonid producing streams in western Oregon and the Cascades, and 68 F (20C) for salmonid producing streams in eastern Oregon, the exception being the Willamette with a maximum of 70 F (21C). The standard was felt to be unnecessarily stringent is some cases, difficult to interpret (no measurement units were specified) and hard to apply to nonpoint sources. A 1967 document (discussed in ODEQ 1995 (b) but not specifically referenced) is said to have stated, "An upper temperature limit must be set for the benefit of anadromous fishes; they show definite signs of physiological insult at temperatures above 68 F (20 C)." Considerably more studies have been conducted since that time relative to temperature requirements as well as the interaction of temperature and other habitat features. Oregon reviewed this literature, as well as EPA's criteria guidance, in its Temperature Technical Advisory Committee before making recommendations to the DEQ for revisions to the standards.

How Do the Revisions Compare with Previous Standards

The revisions to the temperature standards provide more protection for salmonid spawning and bull trout through adoption of colder temperatures than previously applied. For salmonid rearing the temperatures are cooler than before under the new criteria for the eastside basins and warmer than before for some portions of the westside. However, with implementation of antidegradation, the westside basins that were meeting the previous criteria should receive protection from degradation under the High Quality Waters Policy (OAR340-41-026(1)(a)(A). There are new provisions in the revised standards that allow exceedances of, or exceptions to, the numeric criteria under certain circumstances requiring a technical determination by the Department, including "designated beneficial uses would not be adversely impacted." DEQ recognized that water quality standards have their real effect on the environment when they are implemented, therefore there is a far more detailed approach to implementation, particularly where a waterbody is water quality limited for temperature. DEQ with other Designated Management Agencies (DMA's) from the State is responsible for seeing that a temperature management plan is developed for each water-quality limited stream (or basin) to address how the temperature will be brought down to meet the criteria. The anthropogenic sources in the effected waterbody or basin are required to develop and implement the plan (OAR 340-41-026(3)(D)(i).

2. EPA Proposed Action

EPA proposes under Section 303(c) of the Clean Water Act to approve all of Oregon's temperature revisions with the exception of the numeric criteria for the Willamette River (mouth to river mile 50). The warmer temperature adopted for the Willamette (68° F, 20°C), even though it is cooler than what previously applied (70F), is not consistent with the temperature criterion adopted elsewhere to protect salmonid rearing (64° F, 17.8°C), a use designated for the Willamette. This difference is not technically supported either by a site-specific criterion or an adjustment to the uses designated for the Willamette, therefore EPA determined that this provision would be disapproved as not fully protecting the designated uses. The Willamette is water-quality limited for temperature and the State intends to revisit the temperature criterion for that waterbody as it develops the TMDL (Llewelyn, 1998). In making the 303(c) draft determination EPA had concerns about the adequacy of the 64° F rearing criterion in light of the some of the technical information in the ODEQ Final Issue Paper on Temperature (1995 (b)) and the exacerbating factor that salmonids are already stressed by numerous factors such as loss of habitat. Because of this, EPA commissioned a more extensive technical review of the temperature criteria (see Berman, 1998 and Coutant (1998) in Appendix H).

3. Effect of Action on Listed Species

The ODEQ Final Issue Paper on Temperature (1995) notes that aquatic life uses are the uses most sensitive to water temperature, and further, that salmonid fish and amphibians appear to be the most temperature-sensitive aquatic life uses (p2-1). The following overview discussion regarding temperature (drawn from Berman, 1998) is therefore couched in terms of salmonids.

Overview of Temperature and its Effects on Biota

Please refer to Berman (1998) and Coutant (1998), Appendix H, for an in-depth analysis of temperature. That analysis is only briefly summarized here.

Temperature directly governs the metabolic rate of fish and directly influences the life history traits of Pacific salmon. Natural or anthropogenic fluctuations in water temperature can induce a wide array of behavioral and physiological responses in salmonids. Mechanisms have evolved to synchronize the timing of salmonid life history events with their physical environment, and are believed to have been a major factor in the development of specific populations or stocks.

Previous research on temperature sensitivity of fishes emphasized lethal limits and temperature preferences. However, current concerns have centered on the effects of sublethal temperatures and ecological context. Holtby (1988) reported that virtually all effects of an altered thermal regime on Carnation Creek coho salmon were associated with relatively small temperature increases. Alteration of tissue and blood chemistry as well as behavioral changes may occur in association with exposure to sublethal elevated temperatures. These alterations may lead to impaired functioning of the individual and decreased viability at the organism, population, and species levels. Feeding, growth, resistance to disease, successful reproduction, and sufficient activity for competition and predator avoidance are all necessary for survival. Inability to maintain any of these activities at moderately extreme temperatures may be as decisive to continued survival as more extreme temperatures are to immediate survival. Duration and intensity of exposure is related to unique species characteristics and environmental context. Maximized species distribution and diverse life history strategies in combination with broadly distributed and interconnected habitat elements are critical in defining the response and effect of altered thermal regimes on native salmon and charr.

Water temperature varies both spatially and temporally. Ambient water temperatures may periodically or annually approach cold-water biota thresholds for chronic or acute species response. However, system heterogeneity provides alternatives in the form of refugia. In these instances, the abundance, distribution, and accessability of cold water refugia play a critical role in population and species level persistence. Where annual temperatures approach thermal thresholds, species variability in the form of unique life history strategies allows individuals to utilize these systems during periods when suitable conditions exist. Shifts in annual thermal regimes and loss of thermal refugia would expose these populations to sublethal or lethal temperatures thereby negatively affecting population viability.

Processes controlling air temperature, channel morphology, riparian structure, hyporheic zones and ground water, wetland complexes, and flow volume shape stream temperature. Alteration of one or more of these parameters leads to thermal alteration through the following mechanisms: increased solar radiation intensity per unit surface area; increased stream surface area; increased energy imparted to the stream per unit volume; and decreased cold water inflow.

There are numerous threats to the remaining populations of native salmon and charr (Quigley 1997, Ratliff and Howell 1992). However, the present or threatened destruction, modification, or curtailment of habitat or range has been cited by numerous authors as the single most important factor in the decline as well as recovery of these species (Quigley 1997, Nehlsen et al. 1991). Critical to defining species range and habitat suitability is temperature. Historical distribution of native salmon and charr has been significantly reduced. In the process, population extinctions with concomitant loss in genetic and life history variability have occurred. Nehlsen et al. (1991) provide a partial list of extinct native salmonid stocks in Oregon including spring/summer chinook salmon in the Sprague River, Williamson River, Wood River, Klamath River, Umatilla River, Metolius River, Priest Rapids, Walla Walla River, Malheur River, and Owyhee River; Fall chinook in the Sprague River, Williamsom River, Wood River, Klamath River, Umatilla River, Willamette River, Snake River and tributaries above Hells Canyon Dam, and Walla Walla River; coho salmon in the Grande Ronde River, Wallowa River, Walla Walla River, Snake River, Columbia River small tributaries from Bonneville Dam to Priest Rapids Dam, Umatilla River, and Euchre Creek; sockeye salmon from the Metolius River and Wallowa River; chum salmon from the Walla Walla River; and steelhead from the Owyhee River, Malheur River, Sandy River (summer), Powder River, Burnt River, and South Umpqua River (summer).

Numeric Temperature Criteria Measurement

There are several new definitions that have been added to the Oregon water quality standards related to both the temperature and dissolved oxygen criteria. While EPA proposes to approve the definitions, the real effect of those definitions is dependent on the specific numeric criteria that have been adopted by the State. Therefore the determination of effects of the definitions is inherently included in the determinations on each numeric criterion. Included below, however, is a separate discussion of definition #54 Numeric Temperature Criteria, because it was examined fairly extensively on its own. This evaluation should then be folded into the effects determinations that follow.

From OAR 340-41-006:
"(54) Numeric Temperature Criteria are measured as the seven-day moving average of the daily maximum temperatures. If there is insufficient data to establish a seven-day average of maximum temperatures, the numeric criteria shall be applied as an instantaneous maximum. The measurements shall be made using a sampling protocol appropriate to indicate impact to the beneficial uses."

The basis of the Oregon temperature standard rests on the assumption that the criteria represent a "maximum" condition, given diurnal variability. The June 22, 1998, letter from the State (Llewelyn, 1998) provides clarification of the standard. The letter states, "A review of the literature indicates that it is difficult to establish a temperature criteria for waters that experience diurnal temperature changes that would assure no effects due to *C. columnaris*...the technical committee has recommended a temperature range (58-64°F; 14.4-17.8°C) as being protective of salmonid rearing. While 64°F is the upper end of the range, the key to this recommendation is the temperature unit that is used in the standard - the seven-day moving average of the daily maximum temperatures." A 64°F (17.8°C) threshold was selected as it was believed that "the criteria represent a "maximum" condition, given diurnal variability..." Buchanan and Gregory (1997), in describing the technical considerations and the process that went into the Oregon water quality standards revisions, note that, "This 7-day average maximum is usually 0.5° - 2.0° C lower than the highest daily maximum temperature during the summer."

A hypothetical seven-day period can be constructed to evaluate potential time spent at or above sublethal thresholds under a criteria measurement framed as the seven-day moving average of the daily maximum, and that would still meet the criterion of 64°F (17.8°C).

Example: "Stream XYZ" - Rearing Criterion 64°F (17.8°C)

Day 1: daily temperatures:
16.5°C, 17.7°C, 18°C, 18.5°, 18.3°C, 17.7°C, 16.6°C
maximum temperature: 18.5°C
mean temperature: 17.6°C

Day 2: daily temperatures:
15.5°C, 15.8°C, 16.8°C, 17.2°C. 17°C, 16.8°C, 16.2°C
maximum temperature: 17.2°C
mean temperature: 16.5°C

Day 3: daily temperatures:
15.5°C, 15.8°C, 16.9°C, 17.2°C. 17°C, 16.8°C, 16.3°C
maximum temperature: 17.2°C
mean temperature: 16.5°C

Day 4: daily temperatures:
16°C, 17.2°C, 17.8°C, 18.3°C, 17.9°C, 17.5°C, 16.9°C
maximum temperature: 18.3°C
mean temperature: 17.4°C

Day 5: daily temperatures:
16.8°C. 17.3°C. 17.9°C. 18°C. 17.8°C. 17.4°C. 16.9°C
maximum temperature: 18°C
mean temperature: 17.4°C

Day 6: daily temperatures:
16.2°C, 17.2°C, 17.6°C, 17.8°C, 17.8°C, 17.2°C, 16.9°C
maximum temperature: 17.8°C
mean temperature: 17.2°C

Day 7: daily temperatures:
16.8°C, 17.4°C, 17.7°C, 17.8°C, 17.8°C, 17.5°C, 16.9°C
maximum temperature: 17.8°C
mean temperature: 17.4°C

Seven-Day Moving Average of the Daily Maximum Temperature: 17.8°C

This example demonstrates that the "seven-day moving average" can mask the magnitude of temperature fluctuation and the duration of exposure to daily maximum temperatures as well as neglecting mean temperatures and cumulative exposure history. From the example, on five of the seven days, the daily maximum temperature is at or above the rearing criterion. Although daily mean temperatures do not exceed the criterion, they are less than 1°C from the criterion on five of the seven days. Where daily maximum temperatures are 17.8°C or greater, organisms are exposed to temperatures equal to or greater than the criterion over a potentially significant portion of the day. The "seven-day moving average of the daily maximum temperature" meets the rearing criterion of 17.8°C even though the cumulative exposure history of an organism in "Stream XYZ" is often at or above the standard and is within the sublethal to lethal range for the species..

The magnitude of fluctuation and the duration of elevated temperatures is greater in an altered system. Concomitantly, the abundance and distribution of cold-water refugia is decreased. Based on Oregon's 303(d) list, which contains many streams limited for temperature, it is likely that the diel fluctuation in many Oregon streams is reflective of altered systems. Establishing conservative numeric temperature criteria would lessen concerns surrounding the potential magnitude of fluctuation and temperature cumulative exposure of salmonids.

A. Snake River Sockeye Salmon:

1. The Oregon Water Quality Standards contain the following criterion for salmonid spawning, egg incubation, and fry emergence from the egg and the gravel: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin which exceeds 55°F (12.8°C).

Snake River sockeye salmon do not spawn in waters of the State of Oregon. They migrate almost 900 miles from the Pacific Ocean to spawn in Redfish Lake, Idaho. Therefore the Oregon spawning criteria are not applicable to the spawning habitat of this species, or to its migratory route in the Columbia River.

Therefore, the spawning criterion of 12.8°C is not likely to adversely affect Snake River sockeye salmon.

2. The Oregon Water Quality Standards contain the following criterion for salmonid rearing: no

measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin for which salmonid rearing is a designated beneficial use, and in which surface waters exceed 64.0 °F (17.8°C). In addition, no measurable surface water temperature increase resulting from anthropogenic activities is allowed in the Columbia River or its associated sloughs and channels from the mouth to river mile 309 when surface water temperatures exceed 20°C.

Snake River sockeye salmon migrate up the Columbia River to spawn in Redfish Lake. The temperature criteria applicable to the Columbia River were not changed during this triennial review and therefore are not the subject of this evaluation. However, the new rearing criteria do apply to waters in the Columbia drainage in Oregon. In the eastern part of the State, the new criterion of 17.8°C is colder than the previous criterion of 20°C, therefore this has the potential to decrease temperatures in the Columbia River, which would reduce the likelihood of adverse effects on Snake River sockeye salmon in the Columbia River.

The rearing criterion of 17.8°C therefore is not likely to adversely affect Snake River sockeye salmon.

3. The Oregon Water Quality Standards contain narrative criteria for temperature (provisions "vi" through "ix" described above) whose application will be determined on a case-by-case basis. Each of these provisions provides for "no measurable temperature increase resulting from anthropogenic activities" in ecologically significant cold-water refugia, stream segments containing Threatened and Endangered species, waters with low DO, and natural lakes. These provisions provide the State with the legal authority to provide extra protection beyond the numeric criteria where warranted, and therefore provide potential additional protection for listed salmonid species.

Therefore EPA has determined that the narrative criteria provisions for temperature are not likely to adversely affect the Snake River sockeye salmon.

B. Snake River Spring/Summer Chinook Salmon, Southern Oregon and California Coastal Spring Chinook Salmon, Lower Columbia River Spring Chinook Salmon, Upper Willamette River Spring Chinook Salmon:

1. The Oregon Water Quality Standards contain the following criterion for salmonid spawning, egg incubation, and fry emergence from the egg and the gravel: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin which exceeds 55.0°F (12.8°C).

Spring chinook spawning preferences of 5.6°C to 14.4°C (Olson and Foster 1955), 5.6°C to 13.9°C (Spence et al. 1996, Bell 1986), and 5.6°C to 12.8°C (ODEQ 1995 (b)) have been recorded. Temperature preferences for spawning summer chinook have been cited as 5.6°C to 14.4°C (Olson and Foster 1955), 6.1°C to 18.0°C (Olson and Foster 1955), and 5.6°C to 13.9°C (Spence et al. 1996, Bjornn and Reiser 1991). A spawning optimum of 10°C with a range of 8.0°C to 13°C has been reported by the Independent Scientific Group (1996). Stressful conditions begin at temperatures greater than 15.6°C, lethal effects occur at 21°C (Independent Scientific Group 1996).

The National Marine Fisheries Service's Chinook Habitat Assessment provides a 10°C to 13.9°C range for "properly functioning" condition and a range of 14°C to 15.5°C as "at risk" with reference to spawning.

Spring chinook incubation optimum of 5°C to 14.4°C (Spence et al 1996, Bell 1986) and 4.5°C to 12.8°C (ODEQ 1995(b)) have been cited. The optimum temperature range for summer chinook incubation is 5.0°C to 14.4°C (Spence et al. 1996, Bjornn and Reiser 1991). The Independent Scientific Group (1996) cites temperatures of less than 10°C as optimum for incubation with a range of 8.0°C to 12.0°C. Stressful conditions begin at temperatures greater than 13.8 C, lethal effects occur at temperatures greater than 15.6°C (Independent Scientific Group 1996). The National Marine Fisheries Service's Chinook Habitat Assessment cites temperatures of 10°C to 13.9°C as "properly functioning."

EPA has also considered where the salmonid spawning use is designated as well as the timing periods specified for application of that criterion (see Llewelyn, 1998, Salmonid SpawningTable). The Snake River Spring Chinook spawn in higher elevation waters tributary to the Snake and Salmon rivers. Oregon developed their Salmonid Spawning Table in conjunction with regional fisheries biologists in the Oregon Department of Fish and Wildlife.

Based on cited temperature preferences, effects studies for spawning, incubation, and emergence, and the information on timing and location of spawning for these species EPA has determined that the 12.8°C spawning criterion is protective of the Snake River spring/summer chinook salmon, Southern Oregon and California Coastal spring chinook salmon, Lower Columbia River spring chinook salmon, and Upper Willamette River spring chinook salmon.

The spawning criterion of 12.8° C therefore is not likely to adversely affect Snake River spring/summer chinook salmon, Southern Oregon and California Coastal spring chinook salmon, Lower Columbia River spring chinook salmon, and Upper Willamette River spring chinook salmon.

2. The Oregon Water Quality Standards contain the following criterion for salmonid rearing: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin for which salmonid rearing is a designated beneficial use, and in which surface waters exceed 64.0° (17.8°C).

The temperature preference range for migrating adult spring chinook salmon is 3.3°C to 13.3°C (Spence et al. 1996, Bjornn and Reiser 1991, Bell 1986). At temperatures of 21°C, migratory inhibition occurs (ODEQ 1995(b)). Migrating adult summer chinook temperature preferences have been cited as 13.9°C to 20°C (Spence et al. 1996, Bjornn and Reiser 1991, Bell 1986).

The Independent Scientific Group (1996) cites 10°C as the optimum temperature for chinook migration with a range of 8.0°C to 13.0°C. Stressful conditions begin at temperatures greater than 15.6°C and the lethal temperature is °21 C (Independent Scientific Group 1996). "Properly functioning" condition is reported by the National Marine Fisheries Service Chinook Habitat Assessment to occur at 10°C to 13.9°C with riverine systems "at risk" for migrating chinook salmon at temperatures between 14°C and 17.5°C. Spence et al. (1996) cite 26.2°C as the upper lethal temperature for chinook salmon acclimated to 20°C while Brett (1952) reports an upper lethal temperature of 25.1°C. At these temperatures 50% mortality occurs.

In addition to migratory preference, spring chinook salmon research has addressed the role of temperature during adult holding in freshwater. As spring chinook salmon spend extended periods in freshwater prior to spawning, water temperature during this period is critical to successful reproduction. The Oregon Water Quality Standards Review (ODEQ 1995(b)) cites temperatures of 8.0°C to 12.5°C as appropriate for adult spring chinook salmon holding. In addition, the ODEQ 1995(b) states that temperatures between 13.0°C and 15.5°C could produce pronounced mortality in adult spring chinook. Marine (1992) cites information demonstrating that temperatures between 6.0°C and 14.0°C provided optimal pre-spawning survival, maturation, and spawning. Marine (1992) and Berman (1990) identified a sublethal temperature range of 15°C to 17°C. Lethal temperatures for adult spring chinook holding in freshwater have been reported as 18°C to 21°C (Marine 1992) and greater than or equal to 17.5°C (Berman 1990).

Rearing preferences for spring chinook salmon of 11.7°C (Coutant 1977, Ferguson 1958, Huntsman 1942), 10°C to 12.8°C (Bell 1986), and 10°C to 14.8°C (ODEQ 1995(b)) have been recorded. Optimum production occurs at 10°C, and maximum growth at 14.8°C (ODEQ 1995(b)). Summer chinook rearing preference is cited as 11.7°C (Coutant 1977, Ferguson 1958, Huntsman 1942) and 10°C to 12.8°C (Bell 1986). Temperatures greater than 15.5°C increase the likelihood of disease-related mortality in chinook salmon (ODEQ 1995(b)).

The Independent Scientific Group (1996) report an optimum rearing temperature for chinook salmon of 15°C, with a range of 12°C to 17°C. Stressful conditions begin at temperatures greater than 18.3°C and the lethal temperature is 25°C (Independent Scientific Group 1996). "Properly functioning" condition is cited by the National Marine Fisheries Service Chinook Habitat Assessment as 10°C to 13.9°C with riverine systems "at risk" for rearing chinook salmon at temperatures between 14°C and 17.5°C.

Smoltification and outmigration preference for spring chinook range from 3.3°C to 12.2°C (ODEQ 1995(b)). Lethal loading stress occurs between 18.0°C and 21°C (ODEQ 1995(b), Brett 1952).

Exposing Snake River spring/summer chinook salmon, Southern Oregon and California Coastal spring chinook salmon, Lower Columbia River spring chinook salmon, and Upper Willamette River spring chinook salmon to the 17.8°C temperature criterion (measured as a rolling average of the daily max) during migration, rearing, and smoltification poses a risk to their viability. EPA has reviewed the literature concerning lethal and sublethal effects of temperature on salmonids as well as the compounding effect of habitat simplification and loss. Based on this review, there is reason to believe that mortality from both lethal and sublethal effects (e.g., reproductive failure, prespawning mortality, residualization and delay of smolts, decreased competitive success, disease resistance) will occur.

The rearing criterion of 17.8°C is likely to adversely affect Snake River spring/summer chinook salmon, Southern Oregon and California Coastal spring chinook salmon, Lower

Columbia River spring chinook salmon, and Upper Willamette River spring chinook salmon.

3. The Oregon Water Quality Standards contain narrative criteria for temperature (provisions "vi" through "ix" described above) whose application will be determined on a case-by-case basis. Each of these provisions provides for "no measurable temperature increase resulting from anthropogenic activities" in ecologically significant cold-water refugia, stream segments containing Threatened and Endangered species, waters with low DO, and natural lakes. These provisions provide the State with the legal authority to provide extra protection beyond the numeric criteria where warranted, and therefore provide potential additional protection for listed salmonid species.

Therefore the narrative temperature provisions are not likely to adversely affect Snake River spring/summer chinook salmon, Southern Oregon and California Coastal spring chinook salmon, Lower Columbia River spring chinook salmon, and Upper Willamette River spring chinook salmon.

C. Snake River Fall Chinook Salmon, Southern Oregon and California Coastal Fall Chinook Salmon, Lower Columbia River Fall Chinook Salmon:

1. The Oregon Water Quality Standards contain the following criterion for salmonid spawning, egg incubation, and fry emergence from the egg and the gravel: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin which exceeds 55°F (12.8°C).

Fall chinook spawning preferences of 10°C to 12.8°C (Bell 1986), 10°C to 16.7°C (Olson and Foster 1955), and 5.6°C to 13.9°C (Spence et al. 1996) have been recorded. The National Marine Fisheries Service's document (NMFS, 1995) states that "properly functioning" riverine systems exhibit temperatures of 10°C to 14 C, between 14 C and 15.5 C they are "at risk" with reference to spawning, and at temperatures greater than 15.5°C they are "not properly functioning" with reference to spawning. The optimum temperature for spawning is 10°C with a range of °8 C to °13 C (Independent Scientific Group 1996). Stressful conditions occur at temperatures greater than 15.6°C and lethal temperatures occur at 21°C (Independent Scientific Group 1996).

Incubation optima have been cited as 10°C to 12.8°C (Bell 1986), 10°C to 16.7°C (Olson and Foster 1955), 10°C to 12°C (Neitzel and Becker 1985, Garling and Masterson 1985, Heming 1982), and 5°C to 14.4°C (Spence et al. 1996). Temperatures greater than 12°C may reduce alevin survival (Ringler and Hall 1975). Smith et al. (1983) found that temperatures greater than 15.6°C produce significant mortality. The Independent Scientific Group (1996) cites temperatures less than 10°C as optimum for incubation with a range of 8°C to 12°C. Stressful conditions occur at temperatures greater than 13.3°C and lethal temperatures occur at 15.6°C (Independent Scientific Group 1996).

EPA has also considered where the salmonid spawning use is designated as well as the timing periods specified for application of that criterion (see Llewelyn, 1998, Salmonid Spawning Table). Oregon developed the table in conjunction with regional fisheries biologists in the Oregon Department of Fish and Wildlife.

Based on cited temperature preferences, effects studies for spawning, incubation, and emergence, and the timing and location of spawning for these species EPA has determined that the criterion is protective of Snake River fall chinook salmon, Southern Oregon and California Coastal fall chinook salmon, and Lower Columbia River fall chinook salmon.

The 12.8°C spawning criterion is not likely to adversely affect Snake River fall chinook salmon, Southern Oregon and California Coastal fall chinook salmon, and Lower Columbia River fall chinook salmon.

2. The Oregon Water Quality Standards contain the following criterion for salmonid rearing: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin for which salmonid rearing is a designated beneficial use, and in which surface waters exceed 64.0°F (17.8°C).

The temperature preference range for migrating adult fall chinook salmon is 10.6°C to 19.4°C (Spence et al. 1996, Bell 1986). The optimum migration temperature is 10°C with a range of 8°C to 13°C (Independent Scientific Group 1996). Stressful conditions occur at temperatures greater than 15.6°C and lethal effects occur at 21°C. The National Marine Fisheries Service's document (NMFS, 1995) states that "properly functioning" riverine systems exhibit temperatures of 10°C to 13.9°C-14°C; between 14°C and 17.5°C-17.8°C they are "at risk" with reference to migratory and rearing life history stages; and at temperatures greater than 17.5°C-17.8°C they are "not properly functioning" with reference to migratory and rearing life history stages. The preferred rearing temperature range is 12°C to 14°C (Bell 1986). At temperatures of 15.5 °C or greater, disease-related mortality increases (ODEQ 1995(b)).

Fall chinook salmon research on temperature - smoltification interactions has been conducted. ATPase activity, an indicator of smoltification, is important to the maintenance of electrolyte balance and is related to tne ability of smolts to adapt to saline waters from freshwater. At 8°C and 13°C, ATPase activity over a six week period increased. However, at 18°C, ATPase activity decreased over this same period (Sauter unpublished data). Hicks (1998) reported that smolts held at 6.5°C and 10°C responded to a seawater challenge with increased levels of ATPase activity, whereas, individuals held at 15°C and 20°C responded with low levels of ATPase activity. Results demonstrate the inhibitory effect of elevated water temperatures on smoltification. The lethal loading stress occurs between 18°C and 21°C (ODEQ 1995(b), Brett 1952).

Exposing Snake River fall chinook salmon, southern Oregon and California coastal fall chinook salmon, and Lower Columbia River fall chinook salmon to the 17.8°C temperature criterion (measured as a rolling average of the daily max) during migration, rearing, and smoltification poses a risk to their viability. EPA has reviewed the literature concerning lethal and sublethal effects of temperature on salmonids as well as the compounding effect of habitat simplification and loss. Based on this review, there is reason to believe that mortality from both lethal and sublethal effects (e.g., reproductive failure, prespawning mortality, residualization and delay of smolts, decreased competitive success, disease resistance) will occur.

The 17.8° C rearing criterion is likely to adversely affect Snake River fall chinook salmon, southern Oregon and California coastal fall chinook salmon, and Lower Columbia River fall

chinook salmon.

3. The Oregon Water Quality Standards contain narrative criteria for temperature (provisions "vi" through "ix" described above) whose application will be determined on a case-by-case basis. Each of these provisions provides for "no measurable temperature increase resulting from anthropogenic activities" in ecologically significant cold-water refugia, stream segments containing Threatened and Endangered species, waters with low DO, and natural lakes. These provisions provide the State with the legal authority to provide extra protection beyond the numeric criteria where warranted, and therefore provide potential additional protection for listed salmonid species.

Therefore the narrative temperature criteria provisions are not likely to adversely affect Snake River fall chinook salmon, southern Oregon and California coastal fall chinook salmon, and Lower Columbia River fall chinook salmon.

D. Snake River Basin Steelhead, Middle Columbia River Steelhead, Lower Columbia River Steelhead, Upper Willamette River Steelhead:

1. The Oregon Water Quality Standards contain the following criterion for salmonid spawning, egg incubation, and fry emergence from the egg and the gravel: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin which exceeds 12.8°C.

Cited preferred spawning temperatures are 3.9°C to 9.4°C (Spence et al. 1996, Bell 1986) and 4.4°C to 12.8°C (Swift 1976). A general preferred temperature range of 10°C to 13°C was reported by Bjornn and Reiser (1991). The Independent Scientific Group (1996) provides temperature ranges for chinook salmon. However, the authors state that, "other salmon species are not markedly different in their requirements." They cite 10°C as the optimum spawning temperature with a range of 8°C to 13°C. Stressful conditions occur at temperatures equal to or greater than 15.6 C and lethal temperature effects occur at 21°C (Independent Scientific Group 1996). Few references to optimum incubation temperatures were located. The Washington State hatchery program reported optimal steelhead egg survival from 5.6°C to 11.1°C (Hicks 1998). The Independent Scientific Group's general criteria (1996) cites temperatures less than 10°C as the optimum for incubation with a range of 8°C to 12°C. Stressful conditions occur at temperatures equal to or greater than 13.3°C and lethal effects occur at temperatures greater than 15.6°C (Independent Scientific Group 1996).

EPA has also considered where the salmonid spawning use is designated as well as the timing periods specified for application of that criterion (see Llewelyn, 1998, Salmonid Spawning Table). Oregon developed their table in conjunction with regional fisheries biologists in the Oregon Department of Fish and Wildlife.

Based on available information, EPA has determined that the 12.8°C criterion for spawning, incubation, and emergence adequately protects Snake River Basin steelhead, Middle Columbia River steelhead, Lower Columbia River steelhead, and Upper Willamette River steelhead.

The 12.8°C criterion is not likely to adversely affect Snake River Basin steelhead, Middle Columbia River steelhead, Lower Columbia River steelhead, and Upper Willamette River

steelhead.

2. The Oregon Water Quality Standards contain the following criterion for salmonid rearing: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin for which salmonid rearing is a designated beneficial use, and in which surface waters exceed 64.0°F (17.8°C).

Migration preference data specific to steelhead were not found. However, Beschta et al. (1987), note that migratory inhibition occurred at 21°C. Hicks (1998) reported that the upper incipient lethal limit for steelhead is between 21°C and 22°C. Spence et al. (1996) report an upper lethal temperature for steelhead acclimated to 20°C of 23.9°C. At this temperature, 50% mortality occurs. The National Marine Fisheries Service document (NMFS, 1995) states that "properly functioning" riverine systems exhibit temperatures of 10°C to 14°C; between 14°C to 17.8°C they are "at risk" with reference to migration, and at temperatures greater than 17.8°C they are "not properly functioning" with reference to migration. The Independent Scientific Group (1996) provides a general recommendation for salmonid migration with an optimum of 10°C and a range of 8°C to 13°C. Stressful conditions occur at temperatures greater than 15.6°C and lethal temperature effects occur at 21°C (Independent Scientific Group 1996). A general preferred temperature range of 10°C to 13°C was reported by Bjornn and Reiser (1991).

As summer steelhead enter freshwater in June and spawn the following spring, adult holding temperatures are likely critical to successful reproduction. Similar sublethal effects as described for spring chinook salmon are likely. Reproductively mature spring chinook salmon held at temperatures between 17.5° and 19°C produced a greater number of pre-hatch mortalities and developmental abnormalities, as well as smaller eggs and alevins than adults held at temperatures between 14°C to 15.5°C (Berman 1990). Smith et al. (1983) observed that rainbow trout brood fish must be held at water temperatures below 13.3°C and preferably not above 12.2°C for a period of 2 to 6 months before spawning to produce eggs of good quality. Additionally, Bouck et al. (1977) determined that adult sockeye salmon held at 10°C lost 7.5% of their body weight and had visible fat reserves. However, at 16.2°C, they lost 12% of their body weight and visible fat reserves were essentially depleted. As energy reserves are important to successful reproductive efforts, elevated temperatures during migration or on the spawning ground can directly affect population and species viability.

Preferred rearing temperatures were reported by Bell (1986) as 10°C to 12.8°C. Beschta et al. (1987) reported preferred temperatures of 7.3°C to 14.6°C with 10°C as the optimum. The Independent Scientific Group (1996) cites general recommendations for salmonid rearing with 15°C as the optimum and a range of 12°C to 17°C. Stressful conditions occur at temperatures equal to or greater than 18.3°C and lethal effects occur at 23°C (Independent Scientific Group 1996). The National Marine Fisheries Service document (NMFS, 1995) states that "properly functioning" riverine systems exhibit temperatures of 10°C to 14°C; between 14°C and 17.8°C they are "at risk" with reference to rearing, and at temperatures greater than 17.8°C they are "not properly functioning" with reference to rearing.

Tests conducted on steelhead found that downstream movement could be stopped by placing smolts in temperatures between 11°C and 12.2 C from a starting temperature of 7.2 C (Hicks 1998). Additionally, temperatures above 12°C were found to be detrimental to the migratory behavior and saltwater adaptive responses of Toutle River hatchery steelhead. Exposure of smolts to temperatures of 13°C resulted in migratory delays, decreased emigration behavior, and lower ATPase activity (Hicks 1998). In an additional study, steelhead smolts were held at 6.5°C, 10°C, 15°C, and 20°C. Smolts from the 6.5°C and 10°C groups exposed to a seawater challenge responded with increased levels of ATPase activity, whereas, individuals from the 15°C and 20°C groups responded with low levels of ATPase activity (Hicks 1998). All four of the smolts held at 20°C and three of the four smolts held at 15°C died within three day of the saltwater challenge. No mortalities occurred at 6.5°C or 10 C (Hicks 1998). Given study results, 12 C was recommended as the limit to safe downstream migration of steelhead smolts.

Exposing Snake River Basin steelhead, Middle Columbia River steelhead, Lower Columbia River steelhead, and Upper Willamette River steelhead to the 17.8°C temperature criterion (measured as a rolling average of the daily max) during migration, rearing, and smoltification poses a risk to their viability. EPA has reviewed the literature concerning lethal and sublethal effects of temperature on salmonids and the compounding effect of habitat simplification and loss. Based on this review, there is reason to believe that mortality from both lethal and sublethal effects (e.g., reproductive failure, prespawning mortality, residualization and delay of smolts, decreased competitive success, disease resistance) will occur.

The rearing criterion of 17.8° C is likely to adversely affect Snake River Basin steelhead, Middle Columbia River steelhead, Lower Columbia River steelhead, and Upper Willamette River steelhead.

3. The Oregon Water Quality Standards contain narrative criteria for temperature (provisions "vi" through "ix" described above) whose application will be determined on a case-by-case basis. Each of these provisions provides for "no measurable temperature increase resulting from anthropogenic activities" in ecologically significant cold-water refugia, stream segments containing Threatened and Endangered species, waters with low DO, and natural lakes. These provisions provide the State with the legal authority to provide extra protection beyond the numeric criteria where warranted, and therefore provide potential additional protection for listed salmonid species.

Therefore the narrative temperature criteria are not likely to adversely affect Snake River Basin steelhead, Middle Columbia River steelhead, Lower Columbia River steelhead, and Upper Willamette River steelhead.

E. Southern Oregon/Northern California Coast and Oregon Coastal Coho Salmon:

1. The Oregon Water Quality Standards contain the following criterion for salmonid spawning, egg incubation, and fry emergence from the egg and the gravel: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin which exceeds 55.0°F (12.8°C.

Coho salmon spawning preferences of 4.4°C to 9.4°C (Reiser and Bjornn 1973, Brett 1952), 10°C to 12.8°C (Bell 1986), and 7.2°C to 12.8°C (Hicks 1998) have been recorded. The Independent

Scientific Group (1996) provides temperature ranges for chinook salmon. However, the authors state that, "other salmon species are not markedly different in their requirements." They cite 10°C as the optimum spawning temperature with a range of 8°C to 13 C. Stressful conditions occur at temperatures greater than 15.6°C and lethal temperature effects occur at 21 °C (Independent Scientific Group 1996).

Cited optimum incubation temperatures are 4.4°C to 13.3°C (Reiser and Bjornn 1973, Brett 1952), 10°C to 12.8°C (Bell 1986), 8 C to 9 C (Sakh 1984), 4 C to 6.5 C (Dong 1981), and 2 C to 8 C (Tang et al. 1987). The temperature range producing the highest survival rates for eggs and alevins was 1.3°C to 10.9°C (Tang et al. 1987). Increasing egg mortality has been reported at temperatures greater than 11°C (Murray and McPhail 1988), greater than 12 C (Allen 1957 in Murray and McPhail 1988), and at approximately 14°C (Reiser and Bjornn 1973, Brett 1952). An upper lethal limit of 12.5°C to 14.5°C for University of Washington coho and 10.9°C to 12.5°C for Dungeness River, Washington coho was reported by Dong (1981). The lower lethal temperature has been recorded as 0.6°C to 1.3°C (Dong 1981). The Independent Scientific Group's general criteria (1996) cites temperatures less than 10°C as the optimum for incubation with a range of 8 C to 12 C. Stressful conditions occur at temperatures equal to or greater than 13.3°C and lethal effects occur at temperatures greater than 15.6°C (Independent Scientific Group 1996).

EPA has also considered where the salmonid spawning use is designated as well as the timing periods specified for application of that criterion (see Llewelyn, 1998, Salmonid Spawning Table). Oregon developed their table in conjunction with regional fisheries biologists in the Oregon Department of Fish and Wildlife.

Based on the available information, EPA has determined that the 12.8° C criterion for spawning, incubation, and emergence adequately protects Southern Oregon and Northern California Coast and Oregon Coastal coho salmon. Although some optimum temperatures for spawning for this species are well below the 12.8°C, the species has a peak spawning period of November to February. Meeting the spawning criterion of 12.8°C in the basins earlier in the fall, as is required for other salmonid species present, will assure that temperatures are likely lower when the coho spawning actually occurs.

The 12.8° spawning criterion is not likely to adversely affect Southern Oregon and Northern California Coast and Oregon Coastal coho salmon.

2. The Oregon Water Quality Standards contain the following criterion for salmonid rearing: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin for which salmonid rearing is a designated beneficial use, and in which surface waters exceed 64.0°F (17.8°C).

The temperature preference range for migrating adult coho salmon is 7.2°C to 15.6°C (Reiser and Bjornn 1973, Brett 1952). A general preferred temperature range of 12°C to 14°C with temperatures greater than 15°C generally avoided is reported by Brett (1952). The National Marine Fisheries Service document (NMFS, 1995) states that "properly functioning" riverine systems exhibit temperatures of 10°C to 14°C; between 14°C to 17.8°C they are "at risk" with reference to migration.

and at temperatures greater than 17.8°C they are "not properly functioning" with reference to migration. The Independent Scientific Group (1996) provides a general recommendation for salmonid migration with an optimum of 10°C and a range of 8°C to 13°C. Stressful conditions occur at temperatures greater than 15.6°C and lethal temperature effects occur at 21 C (Independent Scientific Group 1996). Adult coho final temperature preferences are reported as 11.4°C when conducted in a laboratory and 16.6°C in Lake Michigan (Coutant 1977). Brett (1952) reports an incipient upper lethal temperature of 26°C (i.e., 50% mortality in 16.7 hours) while the Oregon Water Quality Standards Review (ODEQ 1995(b)) reports an upper lethal limit of 25°C.

Sandercock (1991) reports that there appears to be little correlation between the time of entry to a spawning stream and the spawning data. Early-run fish may spawn early, but many will hold for weeks or even months before spawning. adult holding temperatures are likely critical to successful reproduction. Similar sublethal effects as described for spring chinook salmon are likely. Reproductively mature spring chinook salmon held at elevated temperatures produced a greater number of pre-hatch mortalities and developmental abnormalities, as well as smaller eggs and alevins than adults held at preferred temperatures (Berman 1990). Additionally, Bouck et al. (1977) determined that adult sockeye salmon held at preferred temperatures lost less of their body weight and maintained visible fat reserves while those held at elevated temperatures lost greater quantities of body weight and visible fat reserves were essentially depleted. As energy reserves are important to successful reproductive efforts, elevated temperatures during migration or on the spawning ground can directly affect population and species viability.

Cited rearing temperature preferences are 11.8°C to 14.6°C (Reiser and Bjornn 1973, Brett 1952), 11.4°C (Coutant 1977), 12°C to 14°C (Bell 1986), and 11.8°C to 14.6°C (Beschta et al. 1987). Cessation of growth occurs at temperatures greater than 20.3°C (ODEQ 1995(b), Reiser and Bjornn 1973, Brett 1952). Beschta et al. (1987) report an upper lethal temperature of 25.8°C. The Independent Scientific Group (1996) cites general recommendations for salmonid rearing with 15°C as the optimum and a range of 12°C to 17°C. Stressful conditions occur at temperatures equal to or greater than 18.3°C and lethal effects occur at 25°C (Independent Scientific Group 1996). The National Marine Fisheries Service document (NMFS,1995) states that "properly functioning" riverine systems exhibit temperatures of 10°C to 14°C; between 14°C and 17.8°C they are "at risk" with reference to rearing, and at temperatures greater than 17.8°C they are "not properly functioning" with reference to rearing.

A preferred smoltification temperature range is 12°C to 15.5°C (Brett et al. 1958). Spence et al. (1996) report migration temperatures of 2.5°C to 13.3 C with most fish migrating before temperatures reach 11°C to 12°C.

Based on available information, it is likely that exposure of Southern Oregon/Northern California Coast and Oregon Coast coho salmon to the 17.8° C temperature criterion during migration, rearing, and smoltification poses a risk to their viability. EPA has reviewed the literature concerning lethal and sublethal effects of temperature on salmonids and the compounding effect of habitat simplification and loss. Based on this review, there is reason to believe that mortality from both lethal and sublethal effects (e.g., reproductive failure, prespawning mortality, residualization and delay of smolts, decreased competitive success, disease resistance) will occur.

The 17.8° C rearing criterion is likely to adversely affect Southern Oregon/Northern California Coast and Oregon Coast coho salmon.

3. The Oregon Water Quality Standards contain narrative criteria for temperature (provisions "vi" through "ix" described above) whose application will be determined on a case-by-case basis. Each of these provisions provides for "no measurable temperature increase resulting from anthropogenic activities" in ecologically significant cold-water refugia, stream segments containing Threatened and Endangered species, waters with low DO, and natural lakes. These provisions provide the State with the legal authority to provide extra protection beyond the numeric criteria where warranted, and therefore provide potential additional protection for listed salmonid species.

Therefore the narrative temperature criteria are not likely to adversely affect Southern Oregon/Northern California Coast and Oregon Coast coho salmon.

F. Columbia River Chum Salmon:

A. The Oregon Water Quality Standards contain the following criterion for salmonid spawning, egg incubation, and fry emergence from the egg and the gravel: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin which exceeds 55.0°F (12.8°C).

A preferred spawning temperature range of 7.2°C to 12.8°C is reported by Bjornn and Reiser (1991). The Independent Scientific Group (1996) provides temperature ranges for chinook salmon. However, the authors state that, "other salmon species are not markedly different in their requirements." They cite 10°C as the optimum spawning temperature with a range of 8°C to 13°C. Stressful conditions occur at temperatures equal to or greater than 15.6°C and lethal temperature effects occur at 21°C (Independent Scientific Group 1996).

Cited optimum incubation temperatures are 8°C (Beacham and Murray 1985) and 4.4°C to 13.3°C (Bjornn and Reiser 1991). The Independent Scientific Group's general criteria (1996) cites temperatures less than 10°C as the optimum for incubation with a range of 8°C to 12°C. Stressful conditions occur at temperatures equal to or greater than 13.3°C and lethal effects occur at temperatures greater than 15.6°C (Independent Scientific Group 1996). The maximum efficiency for conversion of yolk to tissue is reported as 6°C to 10 C (Beacham and Murray 1985). Temperatures of 12°C produced alevin mortality one to three days after hatching (Beacham and Murray 1985).

EPA has also considered where the salmonid spawning use is designated as well as the timing periods specified for application of that criterion (see Llewelyn, 1998, Salmonid Spawning Table). Oregon developed their table in conjunction with regional fisheries biologists in the Oregon Department of Fish and Wildlife.

Based on the available information. EPA has determined that the criterion for spawning, incubation, and emergence adequately protects Columbia River chum salmon.

The 12.8° spawning criterion is not likely to adversely affect Columbia River chum salmon.

2. The Oregon Water Quality Standards contain the following criterion for salmonid rearing: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin for which salmonid rearing is a designated beneficial use, and in which surface waters exceed 64.0°F (17.8°C).

Cited preferred migration temperatures are 8.3°C to 15.6°C (Bjornn and Reiser 1991). The National Marine Fisheries Service document (NMFS, 1995) states that "properly functioning" riverine systems exhibit temperatures of 10°C to 14°C; between 14 C to 17.8 C they are "at risk" with reference to migration, and at temperatures greater than 17.8°C they are "not properly functioning" with reference to migration. The Independent Scientific Group (1996) provides a general recommendation for salmonid migration with an optimum of 10°C and a range of 8 C to 13 C. Stressful conditions occur at temperatures greater than 15.6°C and lethal temperature effects occur at 21°C (Independent Scientific Group 1996).

Rearing temperature preferences of 14.1°C (Coutant 1977, Ferguson 1958, Huntsman 1942), 10°C to 12.8°C (Bell 1986), 12°C to 14°C (Brett 1952), and 11.2°C to 14.6°C (Beschta et al. 1987) have been reported. The Independent Scientific Group (1996) cites general recommendations for salmonid rearing with 15°C as the optimum and a range of 12°C to 17°C. Stressful conditions occur at temperatures equal to or greater than 18.3°C and lethal effects occur at 25 C (Independent Scientific Group 1996). The National Marine Fisheries Service document (NMFS, 1995) states that "properly functioning" riverine systems exhibit temperatures of 10°C to 14°C; between 14°C and 17.8°C they are "at risk" with reference to rearing, and at temperatures greater than 17.8°C they are "not properly functioning" with reference to rearing. The optimum temperature is 13.5°C and the upper lethal temperature is 25.8°C (Beschta et al. 1987). Brett (1952) reports an upper incipient lethal temperature of 25.4°C (acclimation 20°C, 50% mortality in 16.7 hours). The final temperature preference for underyearlings and yearlings is 14.1°C (Coutant 1977, Ferguson 1958, Huntsman 1942). Data related to smoltification were not found.

Based on available information, it is likely that exposure of Columbia River chum salmon to the temperature criterion during migration, rearing, and smoltification poses a risk to their viability. EPA has reviewed the literature concerning lethal and sublethal effects of temperature on salmonids and the compounding effect of habitat simplification and loss. Based on this review, there is reason to believe that mortality from both lethal and sublethal effects (e.g., reproductive failure, prespawning mortality, residualization and delay of smolts, decreased competitive success, disease resistance) will occur.

Therefore the 17.8°C rearing criterion is likely to adversely affect Columbia River Chum salmon.

3. The Oregon Water Quality Standards contain narrative criteria for temperature (provisions "vi" through "ix" described above) whose application will be determined on a case-by-case basis. Each of these provisions provides for "no measurable temperature increase resulting from anthropogenic activities" in ecologically significant cold-water refugia, stream segments containing Threatened and

Endangered species, waters with low DO, and natural lakes. These provisions provide the State with the legal authority to provide extra protection beyond the numeric criteria where warranted, and therefore provide potential additional protection for listed salmonid species.

Therefore the narrative temperature criteria are not likely to adversely affect Southern Oregon/Northern California Coast and Oregon Coast coho salmon.

G. Umpqua River Cutthroat Trout:

1. The Oregon Water Quality Standards contain the following criterion for salmonid spawning, egg incubation, and fry emergence from the egg and the gravel: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin which exceeds 55.0°F (12.8°C).

There is a paucity of temperature preference data for cutthroat trout in general and Umpqua cutthroat trout specifically. A preferred spawning temperature range for sea-run cutthroat trout of 6.1°C to 17.2°C is reported by Beschta et al. (1987) and Bell (1986). Preferred spawning temperature ranges of 4.4°C to 12.8°C and 5.5°C to 15.5°C have been reported for resident cutthroat trout (Spence et al. 1996). Taranger and Hansen (1993) and Smith et al. (1983) determined that high water temperatures during the spawning season inhibit ovulation and are detrimental to gamete quality in cutthroat trout.

The Independent Scientific Group (1996) provides temperature ranges for chinook salmon. However, the authors state that, "other salmon species are not markedly different in their requirements." They cite 10°C as the optimum spawning temperature with a range of 8°C to 13°C. Stressful conditions occur at temperatures greater than 15.6°C and lethal temperature effects occur at 21°C (Independent Scientific Group 1996). In addition, the Independent Scientific Group's general criteria (1996) cites temperatures less than 10°C as the optimum for incubation with a range of 8°C to 12°C. Stressful conditions occur at temperatures equal to or greater than 13.3°C and lethal effects occur at temperatures greater than 15.6°C (Independent Scientific Group 1996).

EPA has also considered where the salmonid spawning use is designated as well as the timing periods specified for application of that criterion (see Llewelyn, 1998, Salmonid Spawning Table). Oregon developed their table in conjunction with regional fisheries biologists in the Oregon Department of Fish and Wildlife.

Based on the available information, EPA has determined that the criterion for spawning, incubation, and emergence adequately protects Umpqua River cutthroat trout.

The 12.8° C spawning criterion is not likely to adversely affect Umpqua River cutthroat trout.

2. The Oregon Water Quality Standards contain the following criterion for salmonid rearing: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin for which salmonid rearing is a designated beneficial use, and in which surface waters exceed 64.0°F (17.8°C).

Adult migration preference data specific to Umpqua cutthroat trout were not found. A preferred migration temperature for resident cutthroat trout of 5°C has been reported by Spence et al. (1996). The National Marine Fisheries Service document (NMFS,1995) states that "properly functioning" riverine systems exhibit temperatures of 10°C to 14°C; between 14°C to 17.8°C they are "at risk" with reference to migration, and at temperatures greater than 17.8°C they are "not properly functioning" with reference to migration. The Independent Scientific Group (1996) provides a general recommendation for salmonid migration with an optimum of 10°C and a range of 8°C to 13°C. Stressful conditions occur at temperatures greater than 15.6°C and lethal temperature effects occur at 21°C (Independent Scientific Group 1996).

The upper lethal temperature range for cutthroat trout is 18°C to 22.8°C (Kruzic 1998, Spence et al. 1996). Beschta et al. (1987) report an upper lethal temperature of 23°C. Kruzic (1998) observed Umpqua River cutthroat trout in upper reaches of the Dumont Creek where water temperatures were 13.5°C, but absent in the lower reaches where temperatures approached 18°C. Westslope cutthroat trout females held in fluctuating temperatures between 2°C and 10°C produced significantly better quality eggs than females held at a constant 10°C. Elevated temperatures experienced by mature females adversely affected subsequent viability and survival of embryos (Smith et al. 1983).

Preferred rearing temperatures of 10°C (Bell 1986) and 9.5°C to 12.9°C (Beschta et al. 1987) have been reported. The Independent Scientific Group (1996) cites general recommendations for salmonid rearing with 15°C as the optimum and a range of 12°C to 17°C. Stressful conditions occur at temperatures equal to or greater than 18.3°C and lethal effects occur at 25 C (Independent Scientific Group 1996). The National Marine Fisheries Service document (NMFS,1995) states that "properly functioning" riverine systems exhibit temperatures of 10°C to 14°C; between 14°C and 17.8°C they are "at risk" with reference to rearing, and at temperatures greater than 17.8°C they are "not properly functioning" with reference to rearing. Data concerning smoltification/juvenile emigration were not located.

Based on available information, it is likely that exposure of Umpqua River cutthroat trout to the temperature criterion during migration, rearing, and smoltification poses a risk to their viability. EPA has reviewed the literature concerning lethal and sublethal effects of temperature on salmonids and the compounding effect of habitat simplification and loss. Based on this review, there is reason to believe that mortality from both lethal and sublethal effects (e.g., reproductive failure, prespawning mortality, residualization and delay of smolts, decreased competitive success, disease resistance) will occur.

Therefore the rearing criterion of 17.8° C is likely to adversely affect Umpqua River cutthroat trout.

3. The Oregon Water Quality Standards contain narrative criteria for temperature (provisions "vi" through "ix" described above) whose application will be determined on a case-by-case basis. Each of these provisions provides for "no measurable temperature increase resulting from anthropogenic activities" in ecologically significant cold-water refugia, stream segments containing Threatened and Endangered species, waters with low DO, and natural lakes. These provisions provide the State with the legal authority to provide extra protection beyond the numeric criteria where warranted, and therefore provide potential additional protection for listed salmonid species.

Therefore the narrative temperature criteria are not likely to adversely affect Umpqua River cutthroat trout.

H. Columbia River Basin Bull Trout, Klamath Basin Bull Trout:

1. The Oregon Water Quality Standards contain the following criterion for bull trout: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in waters determined by the Department to support or to be necessary to maintain the viability of native Oregon bull trout, when surface water temperatures exceed 50°F (10°C). The temperature criterion applies to waters containing spawning, rearing, or resident adult bull trout. Migration corridors are not considered.

A preferred migration temperature range of 10°C to 12°C has been reported (Administrative Record, July 21, 1997, ODEQ 1995(b)). Numerous authors have addressed temperature related to successful bull trout spawning. Temperatures less than 9°C to 10°C are required to initiate spawning in Montana (ODEQ 1995(b)) and less than 9°C in British Columbia (Spence et al. 1996, ODEQ 1995(b), Pratt 1992). Peak spawning activities occur between 5°C and 6.5°C (Administrative Record, July 21, 1997). In the Metolius River, Oregon, a spawning temperature of 4.5°C is cited (Spence et al. 1996, ODEQ 1995(b)). A spawning range of 4°C to 10°C is reported in the Oregon Water Quality Standards Review (ODEQ 1995(b)).

The Oregon Water Quality Standards Review (ODEQ,1995(b)) reports an optimum incubation temperature range of 4°C to 6°C in Montana systems. In a study of temperature effect on embryo survival in British Columbia, 8°C to 10°C, produced 0-20% survival to hatch, 6°C, produced 60-90% survival to hatch, and 2°C to 4°C, produced 80-95% survival to hatch (ODEQ 1995(b)). Based on individual studies, Spence et al. (1996) report an optimum temperature range of 2°C to 6°C and the Oregon Water Quality Standards Review (ODEQ 1995(b)) report an optimum temperature range of 1°C to 6°C.

The optimal temperature for juvenile growth has been reported as 4°C in British Columbia and 4.5°C in the Metolius River, Oregon (ODEQ 1995(b)). The temperature range for optimum fry growth is reported as 4°C to 4.5°C (ODEQ 1995(b)). Observed rearing temperatures less than 10°C are reported for the Metolius River, Oregon (Administrative Record, July 21, 1997). The Oregon Water Quality Standards Review (ODEQ 1995(b)) reports a final optimum juvenile growth range of 4°C to 10°C. Temperatures equal to or greater than 14°C are a barrier in the closely related Arctic charr (Pratt 1992).

Adult resident bull trout in Montana were assessed to determine temperature preferences. At 19°C no bull trout were present; between 15°C and 18°C bull trout were present; and at temperatures less than 12°C the highest densities of bull trout were located (ODEQ 1995(b)). In the John Day Basin, bull trout occurred at temperatures less than 16°C (ODEQ 1995(b)). The adult temperature preference range is 9°C to 13°C with the highest number of individuals at temperatures less that or equal to 12°C (ODEQ 1995(b)). In addition, investigators found that reaches in the Metolius River system are susceptible to brook trout invasion at temperatures equal to or greater than 12°C.

Locations for bull trout spawning, rearing, and resident bull trout were determined by the Oregon Department of Fish and Wildlife, and published after extensive review by technical staff in ODFW, the U.S. Forest Service, Oregon Chapter of the American Fisheries Society, Portland General Electric Company, U. S. Fish and Wildlife Service, Plum Creek Timber Company, Confederated Tribes of the Warm Springs Reservation , Idaho Department of Fish and Game, and the Washington Department of Fish and Wildlife (ODFW, 1997). Based on this broad review and input, EPA concludes that the locations for spawning, rearing and resident bull trout have been appropriately determined given the information available.

Based on the above information, the criterion for spawning, rearing, and resident adult bull trout adequately protects these life history stages. Bull trout spawn in late summer through fall (late August - November) and have an egg incubation period lasting from early fall until April. Bull trout require temperatures less than 10°C for successful spawning, incubation, and rearing. The criterion applied as a summer maximum should be protective of life history stages occurring at other times of the year when temperatures are cooler.

However, migration corridors must be adequately protected to safeguard remaining populations and to restore species distribution and integrity. Although the numeric criterion of 10°C adequately protects migrating bull trout, Oregon has not designated migration corridors for protection. The temperature technical subcommittee for the Oregon water quality standards review recommended that "no temperature increase shall be allowed due to anthropogenic activity in present bull trout habitat, or where historical cold water habitat is needed to allow a present bull trout population to remain viable and sustainable in the future" (Buchanan and Gregory 1997).. In an evaluation of Oregon's bull trout, Pratt (1992) determined that elevated temperatures had reduced species distribution with populations becoming largely fragmented and isolated in the upper reaches of drainages. Population fragmentation has resulted in decreased species fitness and viability. It is unclear how much the low spawning criteria applied in bull trout spawning and resident areas in headwaters will help to maintain downstream temperatures to protect migratory corridors for Columbia River Basin bull trout and Klamath Basin bull trout.

As migratory corridors are omitted from the designation, the bull trout criterion of 10 °C is likely to adversely affect Columbia River Basin bull trout and Klamath Basin bull trout.

Because other salmonid species co-occur with bull trout in the upper reaches of some basins, the bull trout criterion, when applied to these waters, will take precedence as the most stringent temperature criterion and provide even greater protection than the salmonid rearing (17.8° C) and salmonid spawning (12.8°C) criteria. **Therefore the bull trout criteria are not likely to have an adverse effect on listed coho, chum, chinook, sockeye, and steelhead that reside in the same waters.**

2. The Oregon Water Quality Standards contain narrative criteria for temperature (provisions "vi" through "ix" described above) whose application will be determined on a case-by-case basis. Each of these provisions provides for "no measurable temperature increase resulting from anthropogenic activities" in ecologically significant cold-water refugia, stream segments containing Threatened and Endangered species, waters with low DO, and natural lakes. These provisions provide the State with the legal authority to provide extra protection beyond the numeric criteria where warranted, and

therefore provide potential additional protection for listed salmonid species.

Therefore the narrative temperature criteria are not likely to adversely affect the Columbia River Basin bull trout and Klamath Basin bull trout.

I. Lahontan Cutthroat Trout

1. The Oregon Water Quality Standards contain the following criterion for salmonid spawning, egg incubation, and fry emergence from the egg and the gravel: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin which exceeds 55.0°F (12.8°C).

Lahontan cutthroat trout inhabit isolated desert streams in southeast Oregon which are protected for salmonid spawning and rearing. Lahontan cutthroat trout are considered to be tolerant of high temperatures because they evolved in a high desert environment, however there has been little systematic study of their temperature tolerances to confirm that point (Dickerson and Vinyard, in press).

From studies based on constant temperature, Lahontan cutthroat trout have a spawning tolerance range of 41 - 61°F (5 - 16°C) and a preferred spawning temperature of 55°F (12.8°C) (Coffin, USFWS, personal communication).

The spawning location of the Lahontan cutthroat trout, as determined from the Oregon Natural Heritage Program data base and the Interior Columbia Basin Ecosystem Management Project data base, is protected for salmonid spawning (Salmonid Spawning Table, Llewelyn, 1998).

Based on the available information EPA has determined that the 12.8°C salmonid spawning criterion is not likely to adversely affect the Lahontan cutthroat trout.

2. The Oregon Water Quality Standards contain the following criterion for salmonid rearing: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin for which salmonid rearing is a designated beneficial use, and in which surface waters exceed 64.0°F (17.8°C).

In a study of young-of-the-year (3 - 7 months old) Lahontan cutthroat trout (from lake stock) Dickerson and Vinyard (in press) found that fish acclimated to 13°C suffered no significant mortality at temperatures of 24°C and below. There was no difference in growth of fish held at 22°C relative to fish held at cooler temperatures. Fish exposed to fluctuating temperatures similar to field conditions (20 - 26°C) did not grow as much as fish maintained at a constant temperature of 13°C or 20°C. They concluded from the chronic stress experiments that the upper limit for growth and survival in Lahontan cutthroat trout is between 22°C and 23°C, when food availability is high.

Based on this study of young-of-the-year trout, EPA has detemined that the rearing criterion for salmonids is protective of Lahontan cutthroat trout. While the data is limited, the temperature of the upper thermal limit is considerably above the criterion.

The rearing criterion of 17.8°C is not likely to adversely affect Lahontan cutthroat trout.

3. The Oregon Water Quality Standards contain narrative criteria for temperature (provisions "vi" through "ix" described above) whose application will be determined on a case-by-case basis. Each of these provisions provides for "no measurable temperature increase resulting from anthropogenic activities" in ecologically significant cold-water refugia, stream segments containing Threatened and Endangered species, waters with low DO, and natural lakes. These provisions provide the State with the legal authority to provide extra protection beyond the numeric criteria where warranted, and therefore provide potential additional protection for listed salmonid species.

Therefore the narrative temperature criteria provisions are not likely to adversely affect the Lahontan cutthroat trout.

J. Oregon Chub

The Oregon chub is found primarily in the Willamette River. Some populations are in the waters designated for protection under the 20°C criterion for the Willamette (mouth to river mile 50), the remainder occur in waters protected for salmonid rearing (17.8° C) and salmonid spawning (12.8° C).

Spawning occurs from the end of April until early August when water temperatures range from 16 to 28° C. Scheerer and Apke (1997) reported that the maximum lethal water temperature for the Oregon chub determined through laboratory experimentation were approximately 31°C (87.8°F). Spawning of the Oregon chub was monitored in shallow vegetated areas of a pond in the Willamette river valley at temperatures that ranged from 16.5°C (61.7°F) to 20.5°C (68.9°F) during June, July and August. There is no information available regarding the sublethal effects of temperature on the Oregon chub.

Based on the laboratory data reported by Scheereer and Apke (1997), the upper thermal tolerance of adult Oregon chub is significantly higher than the maximum allowable water temperatures under the Oregon criteria. The maximum allowable water temperatures under the Oregon criteria for the Willamette river (mouth to river mile 50), are approximately equal to the maximum observed Oregon chub spawning temperatures, however EPA is proposing to disapprove the Willamette temperature criterion of 20°C as too warm to support salmonid uses. This will lead to adoption of a cooler temperature more protective of the Oregon chub spawning in the same reach.

Therefore the 12.8°C salmonid spawning and 17.8° C salmonid rearing temperatures are not likely to adversely affect the Oregon chub.

The Oregon Water Quality Standards contain narrative criteria for temperature (provisions "vi" through "ix" described above) whose application will be determined on a case-by-case basis. Each of these provisions provides for "no measurable temperature increase resulting from anthropogenic activities" in ecologically significant cold-water refugia, stream segments containing Threatened and Endangered species, waters with low DO, and natural lakes. These provisions provide the State with the legal authority to provide extra protection beyond the numeric criteria where warranted, and therefore provide potential additional protection for listed Oregon chub.

Therefore EPA has determined that the narrative temperature criteria are not likely to adversely affect the Oregon chub.

K. Hutton Spring tui chub, Borax Lake chub, Warner sucker, Shortnose sucker, Lost River sucker, Foskett speckled dace, Vernal pool fairy shrimp

These species occur in portions of Oregon that ODEQ has designated as warm water habitat. During the revisions to the standards the numeric criteria, which previously were applied by basin, were withdrawn. The new numeric temperature criteria that were adopted focused on the urgent need to protect cold water biota in the face of the warming trend in the State's waters. Inadvertently, new criteria were not adopted to cover the warm water waterbodies. Instead, the State intends to utilize its narrative standards for temperature as well as its antidegradation policy to protect these water bodies until site-specific criteria can be developed. Three provisions under the narrative criteria are particularly applicable (Llewelyn, 1998):

"no surface water temperature increase resulting from anthropogenic activities is allowed:

- In stream segments containing federally listed Threatened and Endangered species if the increase would impair the biological integrity of the Threatened and Endangered population;

- In Oregon waters when the dissolved oxygen (DO) levels are within 0.5 mg/L or 10 percent saturation of the water column or intergravel DO criterion for a given stream reach or subbasin;

- In natural lakes."

The State has committed to developing site-specific temperature criteria during the 1998 - 2000 triennial review for these waters either in the context of a TMDL or as a separate action. Each of these adoptions of a site-specific criterion will be submitted to EPA for review and approval, and will be consulted on under Section 7 of ESA. As needed, in the interim, species specific temperature information will be used to make determinations on biological integrity when an action is proposed.

With implementation of the three narrative temperature criteria, as well as the antidegradation policy, the temperature criteria revisions are not likely to adversely affect the Hutton Spring tui chub, Borax Lake chub, Warner sucker, Shortnose sucker, Lost River sucker, Foskett speckled dace, or Vernal Pool fairy shrimp.

L. Columbia spotted frog, Oregon spotted frog

Habitat for the Oregon spotted frog is at elevations below about 5,300 feet. This distribution is latitude dependent with the frog found below 600 meters (1,970 feet) in southern Washington and below 1,500-1,600 meters (4,920 - 5,248 feet) in southern Oregon. The Columbia spotted frog's habitat in Oregon is at elevations of approximately 400 feet or higher, generally drier east-side

Cascades and higher plateau inland habitats. There are no records of either of these frogs existing in coastal or near coastal areas in western Oregon, the higher Cascade mountains, and the Umpqua drainage basin, possibly due to a warmer water requirement for the frog's postmetamorphic states (≥20°C). The Oregon spotted frog is nearly always found in, or near, a perennial water body such as a spring, pond, lake or sluggish stream (Leonard et al. 1993).

The specific thermal tolerances of the Oregon and Columbia spotted frog are unknown. Limited, generalized information about the spotted frog *(Rana pretiosa)* does exist and has been summarized by Hayes (1994). Hayes noted that while there may be minor variations in behavior, seasonal or otherwise, most of the information that is reported, is applicable to the spotted frogs that inhabit Oregon. Hayes reports that western spotted frog embryos have lethal thermal limits of 6°C (42.8°F) and 28°C (82.4°F). Hayes noted that there is evidence that postmetamorphic western spotted frogs are tied to waters that are 20°C (68°F) to 35°C (95°F) during the late spring and summer seasons.

The Oregon and Columbia spotted frogs reside in areas that are regulated by Oregon's salmonid rearing numeric temperature criteria and narrative criteria to protect lakes and warm waters. The salmonid rearing temperatures are protective of both the embryo and postmetamorphic stages. **The high upper thermal tolerance of the postmetamorphic frogs indicates that the protection applied to warm waters is not likely to adversely affect the Oregon spotted frog or the Columbia spotted frog.**

The Oregon Water Quality Standards contain narrative criteria for temperature (provisions "vi" through "ix" described above) whose application will be determined on a case-by-case basis. Each of these provisions provides for "no measurable temperature increase resulting from anthropogenic activities" in ecologically significant cold-water refugia, stream segments containing Threatened and Endangered species, waters with low DO, and natural lakes. These provisions provide the State with the legal authority to provide extra protection beyond the numeric criteria where warranted, and therefore provide potential additional protection for the Oregon and Columbia spotted frog.

Therefore EPA has determined that the narrative temperature criteria are not likely to adversely affect the Oregon spotted frog or the Columbia spotted frog.

C. pH

1. Background

Oregon pH Standards Revisions

- Addition of a separate criterion for "Cascade Lakes above 3,000 feet altitude" in the Umpqua, Rogue, Willamette, Sandy, Hood, Deschutes basins, and 5,000 feet in the Klamath basin. (found under OAR 340-41(2)(d), pages A-27 - A-31 of Appendix B):

  "pH values shall not fall outside the range of 6.0 to 8.5"

- The upper limit of the pH range for eastside basins (John Day, Umatilla, Walla Walla, Grande Ronde, and Powder) was raised to 9.0. A value of 8.7 is included as an "action level" -- "when greater than 25 percent of the ambient measurements taken between June and September are greater than pH 8.7, and as resources are available according to priorities set by the Department, the Department shall determine whether the values higher than 8.7 are anthropogenic or natural in origin. (found under OAR 340-41(2)(d), pages A-31 - A-33 of Appendix B);

- An exception was included for dams -- "Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria." (found under OAR 340-41(2)(d), pages A-27 - A-35 of Appendix B); and

- Lowering of the lower end of the pH range in the Klamath basin from pH 7.0 to pH 6.5. (found under OAR 41-340(2)(d), page A-31 of Appendix B).

Objective of Oregon's Revisions

Oregon's pH criteria were based on the technical guidance issued by EPA in 1976. This guidance was carried forward into the EPA Gold Book (1986). The EPA recommended a pH range of 6.5-9.0 for chronic exposure of freshwater aquatic life. This range did not appear to bracket the full range of natural variability in pH within Oregon. During the winter when rain dominates streamflow, many coastal steams, including those in undisturbed areas, have pHs below 6.5. Conversely, some interior streams in alkaline basins have pHs in the mid-9s. Further, many Cascade lakes in small basins without thick soils or forest litter can not buffer the lower pHs of rain and runoff, and have pHs below 6.

A Technical Advisory Committee for pH reviewed ambient pH data as well as biological requirements of sensitive species to determine if the criteria ranges should be widened to account for more of the natural variability while still fully protecting beneficial uses. Salmonid and resident fish have historically been considered the most sensitive beneficial uses (ODEQ, 1995), but this supposition was also reexmined in the review of available scientific literature.

How Do the Revisions Compare with Previous Standards

The pH standards continue to be expressed as specific to each basin. The lower end of the numeric criteria for Cascade Lakes was lowered from pH 6.5 to pH 6.0; the upper limit for eastside basins was raised from pH 8.5 to pH 9.0; the lower end of the Klamath basin range was lowered from pH 7.0 to pH 6.5; and an exception was included for dams. Both the Cascade Lakes and eastside revisions were analyzed by the State and determined to be adjustments warranted as being more representative of natural conditions. The pH criteria applicable to the majority of eastside basin waters are unchanged. Marine criteria are unchanged.

2. EPA Proposed Action

Under Section 303(c) of the Clean Water Act EPA proposes to approve all of the pH revisions adopted by the State of Oregon.

3. Effect of Action on Listed Species

The pH is a measure of the concentration (activity) of hydrogen, or hydronium, ions in water. Specifically, pH is the negative log of the hydrogen ion concentration. The pH of natural waters is a measure of the acid-base equilibrium achieved by the various dissolved compounds, salts, and gases, and is an important factor in the chemical and biological systems of natural waters. Changes in pH affect the degree of dissociation of weak acids and bases, and thus, directly affect the toxicity of many compounds. In addition pH affects the solubility of metal compounds present in the water column and sediments of aquatic systems, thereby increasing and decreasing the exposure dose of metals to aquatic species.

On the pH scale of 0-14, waters with values up to 7 are acidic, and from 7-14, alkaline. Rainwater without anthropogenic acids has a pH generally between 5.0 and 5.6. The buffering capacity of a waterbody is related to alkalinity, a trait that varies by location. Waters with high alkalinity are able to neutralize acidic inputs. For example, a basin with alkaline soils or geology buffers acid rain. Many basins are poorly buffered (low resistance to a change in pH) and may reflect the effect of rainwater (lower pH), or the effect of alkaline producing geology such as limestone formations (higher pH). Buffering capacity in Oregon water increases from west to east across the state. Discharge of water from reservoirs also impacts downstream waters' alkalinity. Typically, reservoir water is stored up during spring runoff and has a low alkalinity. Alkalinities are lowest during periods of high surface runoff (winter and spring) and highest during periods when groundwater discharge dominates stream flow (summer and fall).

Human activities, such as acid drainage from mines, may cause low pH. Other anthropogenic influences such as higher salt (e.g., calcium) loads from agricultural runoff or nutrient enrichment from fertilizers or animal waste may also raise pH levels.. Nutrients in runoff can cause increased algal growth, reducing the water column CO_2 concentration, which raises the pH during the day. At night, plant respiration lowers the pH often causing large diurnal pH swings in productive waters. Diurnal fluctuations occur seasonally, primarily in the summer and fall.

Oregon's Water Quality Standards Review document (ODEQ, 1995(c)) presents data and analysis of pH standard exceedances, primarily due to natural variation in Oregon's aquatic systems. In summary:

- Several eastern Oregon basins have the highest percent violations of the old pH standards. The primary human activities in these basins include forestry and range land grazing. Frequent pH criteria exceedances occur in basins which have minimal nutrient enrichment. Consistent violations in the upper portions of these watersheds occur in areas of minimal human impacts. Such pH characteristics in low- to non-impacted aquatic systems indicate that the old pH criteria may be near or below natural pH ranges in these watersheds. (ODEQ, 1995(c))

- Low end pH violations in flowing waters exist almost exclusively in the coastal streams. These violations occur primarily during winter high rainfall events. Field data show these streams are poorly buffered and groundwater contributions to flow are minimal. No recognized human activities occur in these watersheds that would easily account for low pH in the streams. Therefore, it is likely that the previous low end pH criteria in the coastal basins of 6.5 is above the natural pH conditions in coastal streams during high rainfall events.

  Lake survey data indicate that coastal lakes could occasionally have natural pH values below 6.5, but above 6.0. Incidences of pH values greater than 8.5 do not appear to be natural. (ODEQ, 1995(c))

- Many Cascade lake watersheds are poorly buffered. Cascade lake pHs vary naturally from about 5.5 to 9.5. Alpine lakes are expected to have low pHs due to low alkalinity (Eugene Welch U. of Wash., pers. comm.). Data from the Western Lakes Survey showed that 98 percent of the randomly sampled lakes had pHs below neutrality under natural conditions (Alan Herlily EPA-ORD Corvallis, OR, 3/3/98 teleconference).

Based on the information provided, EPA concurs that waterbodies in many areas of Oregon have naturally varying pHs above 8.5 or below 6.5. It is also reasonable to conclude that the biota in these waterbodies have adapted to the conditions.

Although pH itself may have toxic or deleterious effects on aquatic biota, other chemical and physical factors generally affect the biota first or more directly (e.g., dissolved oxygen, temperature, sedimentation).

Ammonia toxicity increases with increasing pH. Un-ionized ammonia (NH_3), not ammonium (NH_4^+), is toxic to aquatic organisms. Salmonids are especially sensitive. The proportion of un-ionized ammonia to total ammonia is a pH and temperature dependent equilibrium. Although the toxicity of unionized ammonia decreases somewhat with increasing pH, the unionized ammonia fraction of total ammonia increases with increasing pH. Thus, there is more of the toxic un-ionized ammonia present at high pHs. EPA (1986) also states that unionized ammonia is likely to be even more toxic above pH 9.0.

pH activity has a significant impact on the availability and toxicity of metals. The following is summarized from ODEQ (1995). Metal-hydroxide complexes tend to precipitate (i.e., reduced ability to remain suspended) and are quite insoluble under natural water pH conditions. Because of this, the metal is not able to exert a toxic effect. However, the solubility of these complexes increases sharply as pH decreases. pH activity also impacts the sensitivity of organisms to a given amount of metal. There are two types of metals: type I metals (e.g., cadmium, copper, and zinc), that are less toxic as the pH decreases; and type II metals (e.g., lead), that are more toxic at lower pH values. Each metal has its own range where pH and site-specific conditions become factors in the metal's bioavailability. Aluminum is the metal of greatest concern at low pH values. Both the direct toxicity of pH and that of aluminum result in osmoregulatory failure. The effects of low pH are also more pronounced at low concentrations of calcium. In general, increasing concentrations of calcium tend to mitigate the toxicity of aluminum (Baker et al. 1990). In summary, reductions in pH below "natural" levels will tend to increase metal availability and toxicity. No adverse effects to listed species due to pH-driven changes in metal toxicity (where the metals comply with the respective metals criteria) would occur in the range of Oregon's pH criteria.

A. **Chinook Salmon (Snake River fall- and spring-/summer- run, all runs of Lower Columbia River, spring run Upper Willamette River, spring and fall runs of Southern Oregon/California Coastal), Coho Salmon (Lower Columbia River and Southwest Washington, Oregon Coast, and Southern Oregon/Northern California), Columbia River Chum Salmon, Steelhead Trout (Snake River Basin, Upper, Middle, and Lower Columbia, Upper Willamette, Oregon Coast, and Klamath Mountains Province), Bull Trout (Columbia Basins and Klamath), and Cutthroat Trout (Lahontan, Umpqua River, and West Slope).**

Since species-specific information on pH requirements is not available for each salmonid species, this evaluation covers all listed salmonid species. Many of the listed salmonids migrate and consequently, may be exposed to different pH criteria depending on which basins they use. Rearing and feeding areas, and spawning habitat are generally species specific, therefore, the most sensitive life stage of one salmonid species may be exposed to different conditions than another salmonid species using the same basin. Therefore, this analysis takes into consideration how each listed salmonid species may use basins where the pH criteria were revised .

Although most studies have looked at the effects of pH on older fish, the life stages most sensitive to effects from pH are spawning, egg incubation, and alevin/fry development. Data regarding the effects of pH on the aquatic biota are limited and dated. Studies on the effects of pH on salmonids are usually ancillary to other objectives of the research.

In the development of EPA's (1976, 1986) criteria (6.5-9.0, freshwater chronic exposure), two bioassay references on freshwater fish cited by EPA showed a lower limit of about 6.5 for normal development (EIFAC, 1969; Mount 1973, IN EPA, 1986). Vulnerable life stages of chinook salmon are sensitive to pHs below 6.5 and possibly at pHs greater than 9.0 (Marshall et al., 1992). For chinook salmon, Rombough (1983) reported that low pH decreases egg and alevin survival, but specific values are lacking. Adult salmonids are at least as sensitive as most other fish to low pH; these species include rainbow, brook and brown trout, and chinook salmon (ODEQ, 1995(c)). In studies of biological changes with surface water acidification, Baker et al. (1990) found that decreased reproductive success may occur for highly acid-sensitive fish species (e.g., fathead minnow, striped bass) at pH 6.5 to 6.0. At pHs between 6.0 and 5.5, Baker et al. (1990) found decreased reproductive success in lake trout. The critical value of pH for rainbow trout presence, at the low end, is about 5.5 (Baker et al., 1990). Considering the salmonid food base, some insect larvae including those of the mayflies, stoneflies, and caddis flies are sensitive to low pHs in the range of 5.5 to 6.0 (ODEQ, 1995(c)).

Based on the EPA criteria documents and Baker et al. (1990), salmonids will be protected in Oregon basins where the low end of pH criteria are in the range of 6.5-7.5. However, the information summarized here indicates that, aquatic systems with pHs below 6.0 could affect some species of developing salmonids. Basins where the pH criteria would be less than 6.5 (pH criterion of 6.0) are Cascade lakes above 3000 feet elevation (5,000 feet in the Klamath basin). This pH criterion applies to alpine lakes in the Umpqua, Rogue, Willamette, Sandy, Hood, Deschutes, and Klamath Basins. Although some population segments of ESA-listed cutthroat trout and bull trout could theoretically be exposed to lakes protected by the 6.0 pH criterion, EPA concludes that biotic systems developed within naturally acidic alpine lakes would preclude the presence of low pH sensitive trout (bull trout adfluvial populations migrate to lakes and reservoirs for adult rearing but are unknown for Cascade alpine lakes) (Mary Hansen, ODFW, pers. com., 8/25/98). No other ESA-listed salmonids have the potential to be in an area where the low-end pH criterion is 6.0.

At the higher end of the pH scale, even less is known regarding effects on fish. In EPA's review for water quality criteria development, the upper limit of 9.0 was obtained from only one reference (EIFAC, 1969). The larvae of aquatic insects were apparently more tolerant than fish. No recent data exist, but studies conducted earlier in the century show salmonids, including both trout and salmon species, to be sensitive to pHs in the range of 9.2 to 9.7, depending on the life stage (ODEQ, 1995(c)). Non-salmonid fishes are, with some exceptions, more tolerant of high pH, with sensitivity appearing at or over pH 10 for most species tested (EIFAC, 1969). Levels of pH greater than 9.0 may adversely affect benthic invertebrate populations, thereby altering the food base for salmonids. A pH of 9.0 seems to be the cutoff for the start of noticeable adverse effects for some species of salmonids and invertebrates.

The new high end pH criterion of 9.0 applies to the John Day, Umatilla, Grande Ronde, Walla Walla, and Powder basins. ESA-listed salmonids, including Snake River and Upper Columbia, chinook salmon runs; and Snake River, Middle and Upper Columbia steelhead trout use one or more of these areas. Because bull trout have such a general habitat distribution description, this species could be in any basin.

Given the lack of information on the effects to salmonids at pHs greater than 9.0, there is no reliable margin of safety at this end of the criterion. Oregon has included an action limit which triggers a follow-up study if the pH from enough samples taken during the growing season is greater then 8.7. This "action limit" in the standards applies to all basins with an upper pH criterion of 9.0. The Oregon 303(d) listing criteria set 8.7 as the pH criterion for listing for these waters. This will help to assure that waters that are at this action limit will receive attention to determine if additional management measures are needed to lower the pH.

The pH criteria exception for waters impounded by dams has been clarified by ODEQ in the policy letter explaining their standards implementation (Llewelyn, 1998). In the cases where this exception would be applicable, the state will develop either a TMDL for the watershed, develop a site specific criterion for the waterbody, or develop a use attainability analysis to modify the uses for portions of the reservoir. Any exception will therefore be treated as a water quality standards revisions and require EPA review and approval and consultation under Section 7 of ESA.

Based on the available information, EPA has determined that the pH criteria are not likely to adversely affect Chinook Salmon (Snake River fall- and spring-/summer- run, spring run Upper Willamette River, all runs of Lower Columbia River, spring and fall runs of Southern

Oregon/California Coastal), Coho Salmon (Lower Columbia and Southwest Washington Coast, Oregon Coast, and Southern Oregon/Northern California), Columbia River Chum Salmon, Steelhead Trout (Snake River, Upper, Middle, and Lower Columbia Basins; Upper Willamette River; and Klamath Mountains Province), Bull Trout (Columbia and Klamath Basins), and Cutthroat Trout (Lahontan, Umpqua River, and West Slope).

B. Oregon chub, Hutton Spring tui chub, Borax Lake chub, Warner sucker and Foskett speckled dace

The Oregon chub, Hutton Spring tui chub, Borax Lake chub, Warner sucker, and Foskett speckled dace are not in basins or waterbodies where the revisions to the pH criteria apply, with the possible exception of the pH exception for waters impounded by dams. As explained above, this exception will be handled as a water quality standards revision on a case-by-case basis as these instances occur, and the EPA decision in each of these cases will involve ESA consultation.

EPA has therefore determined that the revisions to the pH criteria are not likely to adversely affect the Oregon chub, Hutton Spring tui chub, Borax Lake chub, Warner sucker, and Foskett speckled dace.

C. Lost River sucker, Shortnose sucker

The Lost River sucker and the Shortnose sucker reside in the upper Klamath basin. The criteria revisions in the Klamath basin include the lowering of the pH range for Cascade lakes over 5,000 feet to a pH of 6.0 and the lowering of the pH range for the remainder of the freshwaters in the basin from a pH of 7.0 to 6.5. The Lost River and Shortnose Sucker are not found in Cascade Lakes over 5,000 feet, so the applicable criteria in their habitat are pH 6.5 - 9.0.

Exact pH requirements for the adult forms of the Lost River and Shortnose sucker are unknown. The U.S. Bureau of Reclamation (1997) reported that the 96-Hour LC_{50} pH value for larvae and juveniles of the Lost River and Shortnose sucker ranged from 9.76 to 10.1. The Oregon pH water quality criteria for these species are within the range cited by EPA (1986) to adequately protect for the life of freshwater fish and bottom dwelling invertebrates.

Based on the available information, EPA has determined that the Oregon water quality criteria for pH are not likely to adversely affect the Lost River sucker and Shortnose sucker.

D. Columbia spotted frog, Oregon spotted frog

Critical habitat for the Oregon spotted frog is at elevations below about 5,300 feet. This distribution is latitude dependent, with the frog found below 600 meters (1,970 feet) in southern Washington and below 1,500-1,600 meters (4,920 - 5,248 feet) in southern Oregon. The Columbia spotted frog's critical habitat in Oregon is at elevations of approximately 400 feet or higher in the generally drier east-side Cascades and higher plateau inland habitats. No records report either of these frogs, existing in coastal or near coastal areas in western Oregon, the higher Cascade mountains, or the Umpqua drainage basin. The Oregon spotted frog's habitat can exceed elevations greater than 3000 feet, and it is also found in the Klamath basin, so the criteria revisions pertaining to Cascade Lakes and to the Klamath basin would pertain, meaning potential exposure to waters with a pH as low as 6.0 and as high as 9.0. The Columbia spotted frog is found in the eastside basins where the criteria were revised to allow an upper pH of 9.0, therefore it could be exposed to waters with a pH of 6.5 - 9.0.

The upper and lower pH tolerance of the Oregon and Columbia spotted frogs is unknown. Hayes (1998) noted that waters within the identified range of the Oregon spotted frog had pH values between 6.5 and 8.1, and that the majority of the populations were observed in more alkaline waters with pH values ranging from 7.2 to 8.0. It is believed that the observance of the frogs in these alkaline waters was less a result of a water quality preference and more the result of competition for food. Fish are believed to be less tolerant to the alkaline waters thereby providing a more favorable environment for the frogs by reducing the competition for food.

This limited data base does not provide an adequate basis for a thorough analysis. Since the Oregon spotted frog and the Columbia spotted frog are candidate species, no determination is required at this time.

E. Vernal Pool fairy shrimp

The Vernal Pool fairy shrimp is found in the vernal pools that form on hardpan surfaces during the spring in the Agate Desert, in southwestern Oregon. The Agate Desert is located in the Rogue Basin. None of the pH criteria revisions apply to the habitat of the Vernal Pool fairy shrimp.

Therefore, EPA has determined that the revisions to the pH criteria are not likely to affect the Vernal Pool fairy shrimp.

IV. CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, Tribal, local or private actions on endangered or threatened species or critical habitat that are reasonably certain to occur in the action area considered in this biological assessment. Future federal actions or actions on federal lands that are not related to the proposed action are not considered in this section.

Future anticipated non-Federal actions that may occur in or near surface waters in the State of Oregon include timber harvest, grazing, mining, agricultural practices, urban development, municipal and industrial wastewater discharges, road building, sand and gravel operations, introduction of non-native fishes, off-road vehicle use, fishing, hiking, and camping. These non-Federal actions are likely to continue having adverse effects on the endangered and threatened species, and their habitat.

There are also non-Federal actions likely to occur in or near surface waters in the State of Oregon which are likely to have beneficial effects on the endangered and threatened species. These include implementation of riparian improvement measures, best management practices associated with timber harvest, grazing, agricultural activities, urban development, road building and abandonment and recreational activities and other nonpoint source pollution controls.

V. SUMMARY

The following is a summary of EPA's determination of affects of Oregon's water quality standards for DO, temperature, and pH on ESA-listed species.

No Effects Determination

EPA determined that Oregon's standard for Bacteria would not effect ESA-listed species.

Likely to Adversely Affect Determinations

EPA has determined that Oregon's temperature criterion for salmonid rearing (64°) is likely to adversely affect all the ESA-listed salmonid species except Snake River Sockeye and Lahontan Cutthroat Trout. The following listed salmonids will likely be adversely affected: Snake River spring/summer chinook, Southern Oregon and California Coastal spring chinook, Lower Columbia River spring chinook, and Upper Willamette spring chinook salmon; Snake Fall chinook, Southern Oregon and California coastal fall chinook , Lower Columbia River fall chinook salmon; Snake river Basin steelhead, Middle Columbia River steelhead, Lower Columbia River steelhead, and Upper Willamette River steelhead. Also Southern Oregon/Northern California Coast and Oregon Coast coho salmon; Columbia River chum salmon. Umpqua River cutthroat trout.

EPA has determined that Oregon's temperature criterion for bull trout (50°) is likely to adversely affect bull trout.

Not Likely to Adversely Affect Determinations

EPA has determined that Oregon's criterion for Intergravel Dissolved Oxygen (8.0mg/L action level, IGDO shall not fall below 6.0mg/L) is not likely to adversely affect ESA-listed species. However, if the trigger level is not acted on, the 6mg/L IGDO is likely to adversely affect ESA-listed salmonids.

EPA has determined that Oregon's water column Dissolve Oxygen criteria for salmonid spawning (11mg/L or 9.0mg/L if IGDO is 8mg/L) is not likely to adversely to affect ESA-listed salmonids.

EPA has determined that Oregon's Dissolved Oxygen criterion for cold water aquatic life (8.0mg/L) is not likely to adversely affect ESA-listed salmonids.

EPA has determined that Oregon's Dissolved Oxygen criterion for cool water biota (6.5mg/L) is not likely to adversely affect ESA-listed salmonids, Oregon chub, Shortnose and Lost River suckers, Vernal Pool fairy shrimp.

EPA has determined that Oregon's Dissolved Oxygen criterion for warm water biota (5.5mg/L) is not likely to adversely affect Hutton Spring tui chub, Borax Lake chub, Warner sucker, Foskett speckled dace.

EPA has determined that Oregon's Dissolved Oxygen criteria will not likely adversely affect Oregon spotted frog, or Columbia spotted frog.

EPA has determined that Oregon's temperature criterion for salmonid spawning (55°) is not likely to adversely affect ESA-listed salmonids.

EPA has determined that Oregon's temperature criteria for salmonid rearing and spawning is not likely to adversely affect Lahontan cutthroat trout, Oregon chub, Columbia spotted frog, Oregon, and Oregon spotted frog.

EPA has determined that Oregon's three narrative temperature criteria are not likely to adversely affect Hutton Spring tui chub, Borax Lake chub, Warner sucker, Shortnose sucker, Lost River sucker, Foskett speckled dace, Vernal Pool fairy shrimp.

EPA has determined that Oregon's criterion for pH will not likely to adversely affect ESA-listed salmonids, Oregon chub, Hutton Spring tui chub, Borax Lake chub, Warner sucker, Foskett speckled dace, Lost River sucker, Columbia spotted frog, Oregon spotted frog, and Vernal Pool fairy shrimp.

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VII. LIST OF APPENDICES

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APPENDIX A

Endangered, Threatened, Proposed, and Candidate Species Under National Marine Fisheries Service Jurisdiction That Occur in Oregon, Washington and Idaho

Federally Listed Threatened, Endangered, Proposed, Candidate Species and Species of Concern Which May Occur in the Area of the Proposed Water Quality Standards Review, from U.S. Fish & Wildlife Service

APPENDIX B

State of Oregon Revised Water Quality Standards for Dissolved Oxygen, Temperature, and pH as adopted by the Environmental Quality Commission January 11, 1996

OAR 340-41 Basin Index Map and Tables 1 - 19 (Beneficial Uses applicable to each basin)

Appendix B

PROPOSED AMENDMENTS TO OREGON ADMINISTRATIVE RULES

OAR 340-41-[BASIN](2)(a), 340-41-[BASIN](3), 340-41-026 and 340-41-006

NOTE: The underlined portions of text represent proposed additions made to the rules.

The {bracketed} portions of text represent proposed deletions made to the rules. Because the rules differ by basin, the bracketed portions are examples only. The exact reference to be deleted is given in Figure A.

340-41-[Basin](2)(a)

(a) Dissolved oxygen (DO): **The changes adopted by the Commission on January 11, 1996, become effective July 1, 1996. Until that time, the requirements of this rule that were in effect on January 10, 1996, apply:**

~~[(A) Fresh waters: DO concentrations shall not be less than 90 percent of saturation at the seasonal low, or less than 95 percent of saturation in spawning areas during spawning, incubation, hatching, and fry stages of salmonid fishes;~~

~~(B) Marine and estuarine waters (outside of zones of upwelled marine waters naturally deficient in DO): DO concentrations shall not be less than 6 mg/l for estuarine waters, or less than saturation concentrations for marine waters;~~

~~(C) Columbia River: DO concentrations shall not be less than 90 percent of saturation.}~~

(A) For waterbodies identified by the Department as providing salmonid spawning, during the periods from spawning until fry emergence from the gravels, the following criteria apply:

(i) The dissolved oxygen shall not be less than 11 mg/l. However, if the minimum intergravel dissolved oxygen, measured as a spatial median, is 8.0 mg/l or greater, then the DO criteria is 9.0 mg/l;

(ii) Where conditions of barometric pressure, altitude, and temperature preclude attainment of the 11.0mg/L or 9.0 mg/L criteria, dissolved oxygen levels shall not be less than 95 percent of saturation.

(B) For waterbodies identified by the Department as providing salmonid spawning during, the period from spawning until fry emergence from the gravels, the spatial median intergravel dissolved oxygen concentration shall not fall below 6.0 mg/L;

(C) A spatial median of 8.0 mg/L intergravel dissolved oxygen level shall be used to identify areas where the recognized beneficial use of salmonid spawning, egg incubation and fry emergence from the egg and from the gravels may be impaired and therefore require action by the Department. Upon determination that the spatial median intergravel dissolved oxygen concentration is below 8.0 mg/L, the Department may, in accordance with priorities established by the Department for evaluating water quality impaired waterbodies, determine whether to list the waterbody as water quality limited under the Section 303(d) of the Clean Water Act, initiate pollution control strategies as warranted, and where needed cooperate with appropriate designated management agencies to evaluate and implement necessary best management practices for nonpoint source pollution control;

(D) For waterbodies identified by the Department as providing cold-water aquatic life, the dissolved oxygen shall not be less than 8.0 mg/L as an absolute minimum. Where conditions of barometric pressure, altitude, and temperature preclude attainment of the 8.0 mg/L, dissolved oxygen shall not be less than 90 percent of saturation. At the discretion of the Department, when the Department determines that adequate information exists, the dissolved oxygen shall not fall below 8.0 mg/L as a 30-day mean minimum, 6.5 mg/L as a seven-day minimum mean, and shall not fall below 6.0 mg/L as an absolute minimum (Table 20);

(E) For waterbodies identified by the Department as providing cool-water aquatic life, the dissolved oxygen shall not be less than 6.5 mg/L as an absolute minimum. At the discretion of the Department, when the Department determines that adequate information exists, the dissolved oxygen shall not fall below 6.5 mg/L as a 30-day mean minimum, 5.0 mg/L as a seven-day minimum mean, and shall not fall below 4.0 mg/L as an absolute minimum (Table B);

(F) For waterbodies identified by the Department as providing warm-water aquatic life, the dissolved oxygen shall not be less than 5.5 mg/L as an absolute minimum. At the discretion of the Department, when the Department determines that adequate information exists, the dissolved oxygen shall not fall below 5.5 mg/L as a 30-day mean minimum, and shall not fall below 4.0 mg/L as an absolute minimum (Table 20);

(G) For estuarine water, the dissolved oxygen concentrations shall not be less than 6.5 mg/L (for coastal waterbodies);

(H) For marine waters, no measurable reduction in dissolved oxygen concentration shall be allowed.

340-41-[Basin](3)

(3) Where the naturally occurring quality parameters of waters of the [(basin)] are outside the numerical limits of the above assigned water quality standards, the naturally occurring water quality shall be the standard. However, in such cases special restrictions, described in OAR 340-41-026(3)(a)(C)(iii), apply to discharges that affect dissolved oxygen.

TABLE 21
DISSOLVED OXYGEN & INTERGRAVEL DISSOLVED OXYGEN CRITERIA
(Applicable to All Basins)

Class	Concentration and Period[1] (All Units Are mg/L)				Use/Level of Protection
	30D	7D	7mi	Min	
Salmonid Spawning		11.0[2,3]		9.0[3] 8.0[4] | 6.0[5]	Principal use of salmonid spawning and incubation of embryos until emergence from the gravels. Low risk of impairment to cold-water aquatic life, other native fish and invertebrates. The IGDO criteria represents an acute threshold for survival based on field studies.
Cold Water	8.0[6]		6.5	6.0	Principally cold-water aquatic life. Salmon, trout, cold-water invertebrates, and other native cold-water species exist throughout all or most of the year. Juvenile anadromous salmonids may rear throughout the year. No measurable risk level for these communities
Cool Water	6.5		5.0	4.0	Mixed native cool-water aquatic life, such as sculpins, smelt, and lampreys. Waterbodies includes estuaries. Salmonids and other cold-water biota may be present during part or all of the year but do not form a dominant component of the community structure. No measurable risk to cool-water species, slight risk to cold-water species present.
Warm Water	5.5			4.0	Waterbodies whose aquatic life beneficial uses are characterized by introduced, or native, warm-water species.
No Risk	No Change from Background				The only DO criterion that provides no additional risk is "no change from background." Waterbodies accorded this level of protection include marine waters and waters in Wilderness areas.

[1] 30-D = 30-day mean minimum as defined in definitions section.
7-D = Seven -7 day mean minimum as defined in Division 41, Section 006
7mi = Seven -7 day minimum mean as defined in Division 41, Section 006
Min = Absolute minimums for surface samples when applying the averaging period, spatial median of IGDO

[2] When Intergravel DO levels are 8.0 mg/L or greater, DO levels may be as low as 9.0 mg/L, without triggering a violation.

[3] If conditions of barometric pressure, altitude and temperature preclude achievement of the footnoted criteria, then 95 percent saturation applies

[4] Intergravel DO action level, spatial median minimum

[5] Intergravel DO criterion, spatial median minimum

[6] If conditions of barometric pressure, altitude and temperature preclude achievement of 8.0 mg/L, then 90 percent saturation applies

Note

Shaded values present the absolute minimum criteria unless the Department believes adequate data exists to apply the multiple criteria and associated periods

POLICIES AND GUIDELINES GENERALLY APPLICABLE TO ALL BASINS

OAR 340-41-026

(3) The Commission or Department may grant exceptions to sections (2) and (6) of this rule and approvals to section (5) of this rule for major dischargers and other dischargers, respectively. Major dischargers include those industrial and domestic sources that are classified as major sources for permit fee purposes in OAR 340-45-075(2):

(a) In allowing new or increased discharged loads, the Commission or Department shall make the following findings:

(A) The new or increased discharged load would not cause water quality standards to be violated;

(B) The new or increased discharge load would not unacceptably threaten or impair any recognized beneficial uses. In making this determination, the Commission or Department may rely upon the presumption that if the numeric criteria established to protect specific uses are met the beneficial uses they were designed to protect are protected. In making this determination the Commission or Department may also evaluate other state and federal agency data that would provide information on potential impacts to beneficial uses for which the numeric criteria have not been set;

(C) The new or increased discharged load shall not be granted if the receiving stream is classified as being water quality limited under OAR 340-41-006(30)(a), unless:

(i) The pollutant parameters associated with the proposed discharge are unrelated either directly or indirectly to the parameter(s) causing the receiving stream to violate water quality standards and being designated water quality limited; or

(ii) Total maximum daily loads (TMDLs), waste load allocations (WLAs), load allocations (LAs), and the reserve capacity have been established for the water quality limited receiving stream; and compliance plans under which enforcement action can be taken have been established; and there will be sufficient reserve capacity to assimilate the increased load under the established TMDL at the time of discharge; or

(iii) Effective July 1, 1996, in waterbodies designated water-quality limited for dissolved oxygen, when establishing WLAs under a TMDL for waterbodies meeting the conditions defined in this rule, the Department may at its discretion provide an allowance for WLAs calculated to result in no measurable reduction of dissolved oxygen. For this purpose, "no measurable reduction" is defined as no more than 0.10 mg/L for a single source and no more than 0.20 mg/L for all anthropogenic activities that influence the water quality limited segment. The allowance applies for surface water DO criteria and for Intergravel DO if a determination is made that the conditions are natural. The allowance for WLAs would apply only to surface water 30-day and seven-day mean minimums, and the IGDO action level;

[(iii)](vi) Under extraordinary circumstances to solve an existing, immediate, and critical environmental problem....

DEFINITIONS

OAR 340-41-006

(44) "Intergravel Dissolved Oxygen" (IGDO) -- The concentration of oxygen measured in the stream gravel pore water. For the purposes of compliance with criteria, the dissolved oxygen concentration should be measured within a redd or artificial redd, down-gradient of the egg pocket. Measurements should be taken within a limited time period; for example, prior to emergence of fry during the month of March.

(45) " Spatial Median" -- The value which falls in the middle of a data set of multiple IGDO measurements taken within a spawning area. Half the samples should be greater than, and half the samples should be less than the spatial median.

(46) "Daily Mean" (dissolved oxygen) -- The numeric average of an adequate number of data to describe the variation in dissolved oxygen concentration throughout a day, including daily maximums and minimums. For the purpose of calculating the mean, concentrations in excess of 100 percent of saturation are valued at the saturation concentration.

(47) "Monthly (30-day) Mean Minimum" (dissolved oxygen) -- The minimum of the 30 consecutive day floating averages of the calculated daily mean dissolved oxygen concentration.

(48) "Weekly (seven-day) Mean Minimum" (dissolved oxygen) -- The minimum of the seven consecutive day floating average of the calculated daily *mean* dissolved oxygen concentration.

(49) "Weekly (seven-day) Minimum Mean" (dissolved oxygen) -- The minimum of the seven consecutive day floating average of the daily *minimum* concentration. For purposes of application of the criteria, this value will be used as the reference for diurnal minimums.

(50) "Minimum" (dissolved oxygen) -- The minimum recorded concentration including seasonal and diurnal minimums.

(51) "Cold-Water Aquatic Life" -- The aquatic communities that are physiologically restricted to cold water, composed of one or more species sensitive to reduced oxygen levels. Including but not limited to *Salmonidae* and cold-water invertebrates.

(52) "Cool-Water Aquatic Life" -- The aquatic communities that are physiologically restricted to cool waters, composed of one or more species having dissolved oxygen requirements believed similar to the cold-water communities. Including but not limited to *Cottidae*, *Osmeridae*, *Acipenseridae*, and sensitive *Centrarchidae* such as the small-mouth bass.

(53) "Warm-Water Aquatic Life" -- The aquatic communities that are adapted to warm-water conditions and do not contain either cold- or cool-water species.

Figure A. Existing Basin Rules for Dissolved Oxygen:
OAR 340-41-205, 245, 285 325, 365, 445, 485, 525, 565, 605, 645, 685, 725, 765, 805, 845, 885, 925, and 965

CURRENT DISSOLVED OXYGEN STANDARDS									
Dissolved oxygen standard format by basin All basin criteria are preceded by "(a) Dissolved Oxygen (DO):"									
1	2	3	4	5	6	7	8	9	Comment
(A)	(A)	E(i)	B(i)	B				C(i)	[Salmonid producing waters] [All other Waters] [Fresh waters] [(trout)]: DO concentrations shall not be less than 90 percent of saturation at the seasonal low, or less than 95 percent of saturation in spawning areas during spawning, incubation, hatching, and fry stages of salmonid fish.
(B)	(B)								Marine and estuarine waters (outside of the zones of upwelled marine waters naturally deficient in DO) DO concentrations shall not be less than 6 mg/L for estuarine waters, or less than saturation concentrations for marine waters.
(C)		F	A	A	A				Columbia River: DO concentrations shall not be less than 90 percent of saturation.
		e(ii)	B(ii)					C(ii)	Non-salmonid producing waters: The Dissolved oxygen concentration shall not be less than 6.0 mg/L.
		A						A	Multnomah Channel and mainstem Willamette River from mouth to the Willamette Falls [Mainstem Klamath River from Klamath Lake to Keno Dam (river miles 255 to 232.5)], the DO concentration shall not be less than 5.0 mg/L.
		B						B	Mainstem Willamette River from the Willamette Falls to Newberg: The dissolved oxygen concentration shall not be less than 6.0 mg/L.
		C							Mainstem Willamette River from Newburg to Salem, River mile 85: [Mainstem Klamath River from Keno Dam to the Oregon-California Border (river miles 232.5 to 208.5): The DO concentration shall not be less than 7.0 mg/L.
		D							Mainstem Willamette River from Salem to confluence of Coast to Middle Forks (river mile 187), the DO concentrates shall not be less than 90 percentof saturation.
					B	a	A		All Other [Name] [Except Goose lake] and tributaries; DO concentrations shall not be less than 75 percent of saturation at the seasonal low, or less than 95 percent of saturation in spawning areas during spawning, incubation, hatching, and fry stages of salmonid fish.
							B		Goose Lake: DO concentrations shall not be less than 7.0 mg/L.

(1) North Coast; (2) Mid Coast, Umpqua, South Coast, Rogue; (3) Willamette; (4) Hood; (5) Deschutes and Sandy; (6) John Day, Umatilla; (7) Walla Walla, Grande Ronde, Powder, Malheur, Owyhee, Malheur Lake; (8) Goose & Summer Lakes; (9) Klamath

PROPOSED AMENDMENTS TO OREGON ADMINISTRATIVE RULES

OAR 340-41-[Basin](2)(b), OAR 340-41-685(2)(o) and OAR 340-41-026

NOTE: The underlined portions of text represent proposed additions made to the rules.

The [bracketed] portions of text represent proposed deletions made to the rules. Because the rules differ by basin, the bracketed portions are examples only. The exact reference to be deleted is given in Figure B.

(b) Temperature: The changes adopted by the Commission on January 11, 1996, become effective July 1, 1996. Until that time, the requirements of this rule that were in effect on January 10, 1996, apply. The method for measuring the numeric temperature criteria specified in this rule is defined in OAR 340-41-006(54):

[(A) Columbia River: No measurable increases shall be allowed outside of the assigned mixing zone, as measured relative to a control point immediately upstream from a discharge when stream temperatures are 68° F. or greater; or more than 0.5° F. increase due to a single source discharge when receiving water temperatures are 67.5° F. or less; or more than 2° F. increase due to all sources combined when stream temperatures are 66° F. or less, except for specifically limited duration activities which may be authorized by DEQ under such conditions as DEQ and the Department of Fish and Wildlife may prescribe and which are necessary to accommodate legitimate uses or activities where temperatures in excess of this standard are unavoidable and all practical preventive techniques have been applied to minimize temperature rises. The Director shall hold a public hearing when a request for an exception to the temperature standard for a planned activity or discharge will in all probability adversely affect the beneficial uses;

~~(B) All other freshwater streams and tributaries thereto: No measurable increases shall be allowed outside of the assigned mixing zone, as measured relative to a control point immediately upstream from a discharge when stream temperatures are 58° F. or greater; or more than 0.5° F. increase due to a single source discharge when receiving water temperatures are 57.5° F. or less; or more than 2° F. increase due to all sources combined when stream temperatures are 56° F. or less, except for specifically limited duration activities which may be authorized by DEQ under such conditions as DEQ and the Department of Fish and Wildlife may prescribe and which are necessary to accommodate legitimate uses or activities where temperatures in excess of this standard are unavoidable and all practical preventive techniques have been applied to minimize temperature rises. The Director shall hold a public hearing when a request for an exception to the temperature standard for a planned activity or discharge will in all probability adversely affect the beneficial uses;~~

~~(C) Marine and estuarine waters: No significant increase above natural background temperatures shall be allowed, and water temperatures shall not be altered to a degree which creates or can reasonably be expected to create an adverse effect on fish or other aquatic life.]~~

(A) To accomplish the goals identified in OAR 340-41-120(11), unless specifically allowed under a Department-approved surface water temperature management plan as required under OAR 340-41-026(3)(a)(D), no measurable surface water temperature increase resulting from anthropogenic activities is allowed:

(i) In a basin for which salmonid fish rearing is a designated beneficial use, and in which surface water temperatures exceed 64.0°F (17.8°C);

(ii) In the Columbia River or its associated sloughs and channels from the mouth to river mile 309 when surface water temperatures exceed 68.0°F (20.0°C);

(iii) In the Willamette River or its associated sloughs and channels from the mouth to river mile 50 when surface water temperatures exceed 68.0°F (20.0°C);

(iv) In waters and periods of the year determined by the Department to support native salmonid spawning, egg incubation, and fry emergence from the egg and from the gravels in a basin which exceeds 55.0°F (12.8°C);

(v) In waters determined by the Department to support or to be necessary to maintain the viability of native Oregon bull trout, when surface water temperatures exceed 50.0°F (10.0°C);

(vi) In waters determined by the Department to be ecologically significant cold-water refugia;

(vii) In stream segments containing federally listed Threatened and Endangered species if the increase would impair the biological integrity of the Threatened and Endangered population;

(viii) In Oregon waters when the dissolved oxygen (DO) levels are within 0.5 mg/L or 10 percent saturation of the water column or intergravel DO criterion for a given stream reach or subbasin;

(ix) In natural lakes.

(B) An exceedance of the numeric criteria identified in subparagraph (A)(i) through (v) of this subsection will not be deemed a temperature standard violation if it occurs when the air temperature during the warmest seven-day period of the year exceeds the 90th percentile of the seven-day average daily maximum air temperature calculated in a yearly series over the historic record. However, during such periods, the anthropogenic sources must still continue to comply with their surface water temperature management plans developed under OAR 340-41-026(3)(a)(D);

(C) Any source may petition the Commission for an exception to subparagraph (A)(i) through (ix) of this subsection for discharge above the identified criteria if:

(i) The source provides the necessary scientific information to describe how the designated beneficial uses would not be adversely impacted; or

(ii) A source is implementing all reasonable management practices or measures; its activity will not significantly affect the beneficial uses; and the environmental cost of treating the parameter to the level necessary to assure full protection would outweigh the risk to the resource.

(D) Marine and estuarine waters: No significant increase above natural background temperatures shall be allowed, and water temperatures shall not be altered to a degree which creates or can reasonably be expected to create an adverse effect on fish or other aquatic life.

POLICIES AND GUIDELINES GENERALLY APPLICABLE TO ALL BASINS

OAR 340-41-026

(3) The Commission or Department may grant exceptions to sections (2) and (6) of this rule and approvals to section (5) of this rule for major dischargers and other dischargers, respectively. Major dischargers include those industrial and domestic sources that are classified as major sources for permit fee purposes in OAR 340-45-075(2):

(a) In allowing new or increased discharged loads, the Commission or Department shall make the following findings:

(A) The new or increased discharged load would not cause water quality standards to be violated;

(B) The new or increased discharge load would not unacceptably threaten or impair any recognized beneficial uses. In making this determination, the Commission or Department may rely upon the presumption that if the numeric criteria established to protect specific uses are met the beneficial uses they were designed to protect are protected. In making this determination the Commission or Department may also evaluate other state and federal agency data that would provide information on potential impacts to beneficial uses for which the numeric criteria have not been set;

(C) The new or increased discharged load shall not be granted if the receiving stream is classified as being water quality limited under OAR 340-41-006(30)(a), unless:

(i) The pollutant parameters associated with the proposed discharge are unrelated either directly or indirectly to the parameter(s) causing the receiving stream to violate water quality standards and being designated water quality limited; or

(ii) Total maximum daily loads (TMDLs), waste load allocations (WLAs), load allocations (LAs), and the reserve capacity have been established for the water quality limited receiving stream; and compliance plans under which enforcement action can be taken have been established, and there will be sufficient reserve capacity to assimilate the increased load under the established TMDL at the time of discharge; or

(iii) Effective July 1, 1996, in waterbodies designated water-quality limited for dissolved oxygen, when establishing WLAs under a TMDL for waterbodies meeting the conditions defined in this rule, the Department may at its discretion provide an allowance for WLAs calculated to result in no measurable reduction of dissolved oxygen. For this purpose, "no measurable reduction" is defined as no more than 0.10 mg/L for a single source and no more than 0.20 mg/L for all anthropogenic activities that influence the water quality limited segment. The allowance applies for surface water DO criteria and for Intergravel DO if a determination is made that the conditions are natural. The allowance for WLAs would apply only to surface water 30-day and seven-day means, and the IGDO action level;

~~[(iii)]~~(iv) Under extraordinary circumstances to solve an existing, immediate, and critical environmental problem that the Commission or Department may consider a waste load increase for an existing source on a receiving stream designated water quality limited under OAR 340-41-006(30)(a) during the period between the establishment of TMDLs, WLAs, and LAs and their achievement based on the following conditions:

(I) That TMDLs, WLAs, and LAs have been set; and

(II) That a compliance plan under which enforcement actions can be taken has been established and is being implemented on schedule; and

(III) That an evaluation of the requested increased load shows that this increment of load will not have an unacceptable temporary or permanent adverse effect on beneficial uses; and

(IV) That any waste load increase granted under subparagraph (iv of this paragraph is temporary and does not extend beyond the TMDL compliance deadline established for the waterbody. If this action will result in a permanent load increase, the action has to comply with subparagraphs (i) or (ii) of this paragraph

(D) Effective July 1, 1996, in any waterbody identified by the Department as exceeding the relevant numeric temperature criteria specified for each individual water quality management basin identified in OAR 340-41-205, OAR-340-41-245, OAR-340-41-285, OAR-340-41-325, OAR-340-41-365, OAR-340-41-445, OAR-340-41-485, OAR-340-41-525, OAR-340-41-565, OAR-340-41-605, OAR-340-41-645, OAR-340-41-685, OAR-340-41-725, OAR-340-41-765, OAR-340-41-805, OAR-340-41-845, OAR-340-41-885, OAR-340-41-925, OAR-340-41-965, and designated as water quality limited under Section 303(d) of the Clean Water Act, the following requirements shall apply to appropriate watersheds or stream segments in accordance with priorities established by the Department. The Department may determine that a plan is not necessary for a particular stream segment or segments within a water-quality limited basin based on the contribution of the segment(s) to the temperature problem:

(i) Anthropogenic sources are required to develop and implement a surface water temperature management plan which describes the best management practices, measures, and/or control technologies which will be used to reverse the warming trend of the basin, watershed, or stream segment identified as water quality limited for temperature;

(ii) Sources shall continue to maintain and improve, if necessary, the surface water temperature management plan in order to maintain the cooling trend until the numeric criterion is achieved or until the Department, in consultation with the Designated Management Agencies (DMAs), has determined that all feasible steps have been taken to meet the criterion and that the designated beneficial uses are not being adversely impacted. In this latter situation, the temperature achieved after all feasible steps have been taken will be the temperature criterion for the surface waters covered by the applicable management plan. The determination that all feasible steps have been taken will be based on, but not limited to, a site-specific balance of the following criteria: protection of beneficial uses, appropriateness to local conditions; use of best treatment technologies or management practices or measures, and cost of compliance.

(iii) Once the numeric criterion is achieved or the Department has determined that all feasible steps have been taken, sources shall continue to implement the practices or measures described in the surface water temperature management plan in order to continually achieve the temperature criterion;

(iv) For point sources, the surface water temperature management plan will be part of their National Pollutant Discharge Elimination System Permit (NPDES);

(v) For nonpoint sources, the surface water temperature management plan will be developed by designated management agencies (DMAs) which will identify the appropriate BMPs or measures;

(vi) A source (including but not limited to permitted point sources, individual landowners and land managers) in compliance with the Department or DMA (as appropriate) approved surface water temperature management plan shall not be deemed to be causing or contributing to a violation of the numeric criterion if the surface water temperature exceeds the criterion;

(vii) In waters the Department determines to be critical for bull trout recovery, the goal of a bull trout surface water temperature management plan is to specifically protect those habitat ranges necessary to maintain the viability of existing stocks by restoring stream and riparian conditions or allowing them to revert to conditions attaining the coolest surface water temperatures possible under natural background conditions;

(E) Waters of the state exceeding the temperature criteria will be identified in the Clean Water Act (CWA), Section 303(d) list developed by the Department according to the schedule required by the Clean Water Act. This list will be prioritized in consultation with the DMAs to identify the order in which those waters will be addressed by the Department and the DMAs;

(F) In basins determined by the Department to be exceeding the numeric temperature criteria, and which are required to develop surface water temperature management plans, new or increased discharge loads from point sources which require an NPDES permit under Section 402 of the Clean Water Act or hydro-power projects which require certification under Section 401 of the Clean Water Act are allowed a 1.0°F total cumulative increase in surface water temperatures as the surface water temperature management plan is being developed and implemented for the water quality limited basin if:

(i) In the best professional judgment of the Department, the new or increased discharge load, even with the resulting 1.0°F cumulative increase, will not conflict with or impair the ability of a surface water temperature management plan to achieve the numeric temperature criteria; and

(ii) A new or expanding source must demonstrate that it fits within the 1.0°F increase and that its activities will not result in a measurable impact on beneficial uses. This latter showing must be made by demonstrating to the Department that the temperature change due to its activities will be less than or equal to 0.25°F under a conservative approach or by demonstrating the same to the EQC with appropriate modeling.

(G) Any source may petition the Department for an exception to paragraph (F) of this subsection, provided:

(i) The discharge will result in less than 1.0°F increase at the edge of the mixing zone, and subparagraph (ii) or (iii) of this paragraph applies;

(ii) The source provides the necessary scientific information to describe how the designated beneficial uses would not be adversely impacted; or

(iii) The source demonstrates that: it is implementing all reasonable management practices; its activity will not significantly affect the beneficial uses; and the environmental cost of treating the parameter to the level necessary to assure full protection would outweigh the risk to the resource.

(H) Any source or DMA may petition the Commission for an exception to paragraph (F) of this subsection, provided:

(i) The source or DMA provides the necessary scientific information to describe how the designated beneficial uses would not be adversely impacted; or

(ii) The source or DMA demonstrates that: it is implementing all reasonable management practices; its activity will not significantly affect the beneficial uses; and the environmental cost of treating the parameter to the level necessary to assure full protection would outweigh the risk to the resource.

[~~(D)~~](I) The activity, expansion, or growth necessitating a new or increased discharge load is....

IMPLEMENTATION PROGRAM APPLICABLE TO ALL BASINS

OAR 340-41-120

(10) Agricultural water quality management plans to reduce agricultural nonpoint source pollution shall be developed and implemented by the Oregon Department of Agriculture (ODA) through a cooperative agreement with the Department of Environmental Quality (DEQ) to implement applicable provisions of ORS 568.900-933 and ORS 561.191. If DEQ has reason to believe that agricultural discharges or activities are contributing to water quality problems resulting in water quality standards violations, DEQ shall hold a consultation with the ODA. If water quality impacts are likely from agricultural sources, and DEQ determines that a water quality management plan is necessary, the Director of DEQ shall write a letter to the Director of the ODA requesting that such a management plan be prepared and implemented to reduce pollutant loads and achieve the water quality criteria.

(11) EQC policy on surface water temperature (as regulated in the basin standards found in OAR 340-41-205; OAR-340-41-245, OAR-340-41-285, OAR-340-41-325, OAR-340-41-365, OAR-340-41-445, OAR-340-41-485, OAR-340-41-525, OAR-340-41-565, OAR-340-41-605, OAR-340-41-645, OAR-340-41-685, OAR-340-41-725, OAR-340-41-765, OAR-340-41-805, OAR-340-41-845, OAR-340-41-885, OAR-340-41-925, OAR-340-41-965):

(a) It is the policy of the Environmental Quality Commission (EQC) to protect aquatic ecosystems from adverse surface water warming caused by anthropogenic activities. The intent of the EQC is to minimize the risk to cold-water aquatic ecosystems from anthropogenic warming of surface waters, to encourage the restoration of critical aquatic habitat, to reverse surface water warming trends, to cool the waters of the State, and to control extremes in temperature fluctuations due to anthropogenic activities:

(A) The first element of this policy is to encourage the proactive development and implementation of best management practices or other measures and available temperature control technologies for nonpoint and point source activities to prevent thermal pollution of surface waters;

(B) The second element of this policy is to require the development and implementation of surface water temperature management plans for those basins exceeding the numeric temperature criteria identified in the basin standards. The surface water temperature management plans will identify the best management practices (BMPs) or measures and approaches to be taken by nonpoint sources, and technologies to be implemented by point sources to limit or eliminate adverse anthropogenic warming of surface waters.

(b) Surface water temperatures in general are warming throughout the State. These water temperatures are influenced by natural physical factors including, but not limited to solar radiation, stream-side shade, ambient air temperatures, heated water discharges, cold-water discharges, channel morphology, and stream flow. Surface water temperatures may also be affected by anthropogenic activities that discharge heated water, widen streams, or reduce stream shading, flows, and depth. These anthropogenic activities, as well as others, increase water temperatures. Anthropogenic activities may also result in the discharge of cold water that decreases water temperatures and affects biological cycles of aquatic species;

(c) The temperature criteria in the basin standards establish numeric and narrative criteria to protect designated beneficial uses and to initiate actions to control anthropogenic sources that adversely increase or decrease stream temperatures. Natural surface water temperatures at times exceed the numeric criteria due to naturally high ambient air temperatures, naturally heated discharges, naturally low stream flows or other natural conditions. These exceedances are not water quality standards violations when the natural conditions themselves cause water temperatures to exceed the numeric criteria. In these situations, the natural surface water temperatures become the numeric criteria. In surface waters where both natural and anthropogenic factors cause exceedances of the numeric criteria, each anthropogenic source will be responsible for controlling, through implementation of a management plan, only that portion of the temperature increase caused by that anthropogenic source;

(d) The purpose of the numeric criteria in the basin standards is to protect designated beneficial uses; this includes specific life cycle stages during the time periods they are present in a surface water of the state. Surface water temperature measurements taken to determine compliance with the identified criteria will be taken using a sampling protocol appropriate to indicate impact to the beneficial use. The EQC, in establishing these criteria, recognizes that new information is constantly being developed on water temperatures and how water temperatures affect different beneficial uses. Therefore, continued reevaluation of temperature information is needed to refine and revise numeric criteria in the basin standards over time. The EQC also recognizes that the development and implementation of control technologies and best management practices or measures to reduce anthropogenic warming is evolving and the achievement of the numeric criteria will be an iterative process;

(e) Surface water temperature management plans will be required according to OAR 340-41-026 (3)(a)(D) when the relevant numeric temperature criteria are exceeded and the waterbody is designated as water-quality limited under Section 303(d) of the Clean Water Act. The plans will identify those steps, measures, technologies, and/or practices to be implemented by those sources determined by the Department to be contributing to the problem. The plan may be for an entire basin, a single watershed, a segment of a stream, single or multiple nonpoint source categories, single or multiple point sources or any combination of these, as deemed appropriate by the Department, to address the identified temperature problem:

(A) In the case of state and private forest lands, the practices identified in rules adopted pursuant to the State Forest Practices Act (FPA) will constitute the surface water temperature management plan for the activities covered by the act. Consequently, in those basins, watersheds or stream segments exceeding the relevant temperature criterion, and for those activities covered by the Forest Practices Act, the forestry component of the temperature management plan will be the practices required under the FPA. If the mandated practices need to be improved in specific basins, watersheds or stream segments to fully protect identified beneficial uses, the Departments of Forestry and Environmental Quality will follow the process described in ORS 527.765 to establish, implement, and improve practices in order to reduce thermal loads to achieve and maintain the surface water temperature criteria. Federal forest management agencies are required by the federal Clean Water Act to meet or exceed the substantive requirements of the state forestry nonpoint source program. The Department currently has Memoranda of Understanding with the U.S. Forest Service and Bureau of Land Management to implement this aspect of the Clean Water Act. These memoranda will be used to identify the temperature management plan requirements for federal forest lands;

(B) The temperature management plan for agricultural nonpoint sources shall be developed and implemented in the manner described in section (10) of this rule;

(C) The Department will be responsible for determining the appropriate surface water temperature management plan for individual and general NPDES permitted sources. The requirement for a surface water temperature management plan and the content of the plan will be appropriate to the contribution the permitted source makes to the temperature problem, the technologies and practices available to reduce thermal loads, and the potential for trading or mitigating thermal loads;

(D) In urban areas, the Department will work with appropriate state, county, municipal, and special district agencies to develop surface water temperature management plans that reduce thermal loads in basins, watersheds, or stream segments associated with the temperature violations so that the surface water temperature criteria are achieved.

(f) The EQC encourages the release of stored water from reservoirs to cool surface water in order to achieve the identified numeric criteria in the basin standards as long as there is no significant adverse impact to downstream designated beneficial uses from the cooler water temperatures. If the Department determines that a significant adverse impact is resulting from the cold-water release, the Department shall, at its discretion, require the development of a management plan to address the adverse impact created by the cold-water release.

(g) Maintaining low stream temperatures to the maximum extent practicable in basins where surface water temperatures are below the specific criteria identified in this rule shall be accomplished by implementing technology based permits, best management practices or other measures. Any measurable increase in surface water temperature resulting from anthropogenic activities in these basins shall be in accordance with the antidegradation policy contained in OAR 340-41-026.

PROPOSED AMENDMENTS TO OREGON ADMINISTRATIVE RULES

OAR 340-41-006

NOTE: The underlined portions of text represent proposed additions made to the rules.

The ~~[bracketed]~~ portions of text represent proposed deletions made to the rules. Because the rules differ by basin, the bracketed portions are examples only. The exact reference to be deleted is given in Figure B.

(54) "Numeric Temperature Criteria" are measured as the seven-day moving average of the daily maximum temperatures. If there is insufficient data to establish a seven-day average of maximum temperatures, the numeric criteria shall be applied as an instantaneous maximum. The measurements shall be made using a sampling protocol appropriate to indicate impact to the beneficial uses;

(55) "Measurable Temperature Increase" means an increase in stream temperature of more than 0.25°F;

(56) "Anthropogenic", when used to describe "sources" or "warming", means that which results from human activity;

(57) "Ecologically Significant Cold-Water Refuge" exists when all or a portion of a waterbody supports stenotypic cold-water species (flora or fauna) not otherwise widely supported within the subbasin, and either:

(a) Maintains cold-water temperatures throughout the year relative to other segments in the subbasin, providing summertime cold-water holding or rearing habitat that is limited in supply, or;

(b) Supplies cold water to a receiving stream or downstream reach that supports cold-water biota.

FIGURE B. RULE SECTIONS TO BE DELETED BY BASIN
Temperature

Basin	Section and Subsection: (340-41-Basin)
North Coast - Lower Columbia	205(2)(b)[(A),(B),(C)]
Mid Coast	245(2)(b)[(A),(B)]
South Coast	325(2)(b)[(A),(B)]
Umpqua	285(2)(b)[(A),(B)]
Rogue	365(2)(b)[(A),(B)]
Willamette	445(2)(b)[(A),(B),(C),(D)]
Sandy	485(2)(b)[(A),(B)]
Hood	525(2)(b)[(A),(B)]
Deschutes	565(2)(b)[(A),(B)]
John Day	605(2)[(b)]
Umatilla	645(2)[(b)]
Walla Walla	685(2)[(o)]
Grande Ronde	725(2)[(b)]
Powder	765(2)(b)[(A),(B)]
Malheur	805(2)[(b)]
Owyhee	845(2)[(b)]
Malheur Lake	885(2)[(b)]
Goose & Summer Lakes	925(2)[(b)]
Klamath	965(2)(b)[(A),(B)]

<u>NOTE:</u> The Columbia River criteria ((A)(ii)) in the proposed standard apply only to the following basins: North Coast 205, Sandy 485, Hood 525, Deschutes 565, John Day 605, Umatilla 645 and Willamette 445. The Willamette River criteria ((A)(iii)) in the proposed standard apply only to the Willamette Basin 445.

PROPOSED AMENDMENTS TO OREGON ADMINISTRATIVE RULES

OAR 340-41-[Basin](2)(d) and Walla Walla 340-41-685(2)(c)

NOTE: The underlined portions of text represent proposed additions made to the rules.

The ~~[bracketed]~~ portions of text represent proposed deletions made to the rules.

(pH) Hydrogen Ion Concentration

Basin	Rule
North Coast - Lower Columbia 340-41-202(2)(d)	(d) pH (hydrogen ion concentration): pH values shall not fall outside the following ranges: (A) Marine waters; 7.0 to 8.5; (B) Estuarine and fresh waters: 6.5 to 8.5. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria;
Mid Coast 340-41-242(2)(d)	(d) pH (hydrogen ion concentration): pH values shall not fall outside the following ranges: (A) Marine waters; 7.0 to 8.5; (B) Estuarine and fresh waters: 6.5 to 8.5. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria;

Basin	Rule
Umpqua 340-41-285(2)(d)	(d) pH (hydrogen ion concentration): (A) Fresh waters (except Cascade lakes) and estuarine waters: pH values shall not fall outside the range of 6.5 to 8.5[;]. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria; (B) Marine waters: pH values shall not fall outside the range of 7.0 to 8.5[.]; (C) Cascade lakes above 3,000 feet altitude: pH values shall not fall outside the range of 6.0 to 8.5.
South Coast 340-41-325(2)(d)	(d) pH (hydrogen ion concentration): pH values shall not fall outside the following ranges: (A) Estuarine and fresh waters: 6.5 to 8.5. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria; (B) Marine waters; 7.0 to 8.5;
Rogue 340-41-365(2)(d)	(d) pH (hydrogen ion concentration): pH values shall not fall outside the following ranges: (A) Marine waters: 7.0 - 8.5; (B) Estuarine and fresh waters (except Cascade lakes): 6.5 - 8.5. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria; (C) Cascade lakes above 3,000 feet altitude: pH values shall not fall outside the range of 6.0 to 8.5.

Basin	Rule
Willamette 340-41-445(2)(d)	(d) pH (hydrogen ion concentration): pH values shall not fall outside the [~~following~~] ranges[~~:~~] identified in paragraphs (A), (B), and (C) of this subsection. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria:; (A) Columbia River: 7.0 - 8.5; (B) All other basin waters (except Cascade lakes): 6.5 - 8.5[~~.~~]; (C) Cascade lakes above 3,000 feet altitude: pH values shall not fall outside the range of 6.0 to 8.5.
Sandy 340-41-485(2)(d)	(d) pH (hydrogen ion concentration): pH values shall not fall outside the ranges identified in paragraphs (A), (B), and (C) of this subsection. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria: (A) [~~Main Stem~~] Mainstem Columbia River (river miles 120 to 147): pH values shall not fall outside the range of 7.0 to 8.5; (B) All other Basin waters (except Cascade lakes): pH values shall not fall outside the range of 6.5 to 8.5[~~.~~]; (C) Cascade lakes above 3,000 feet altitude: pH values shall not fall outside the range of 6.0 to 8.5.

Basin	Rule
Hood 340-41-525(2)(d)	(d) pH (hydrogen ion concentration): pH values shall not fall outside the ranges identified in paragraphs (A), (B), and (C) of this subsection. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria: (A) [Main Stem] Mainstem Columbia River (river miles 147 to 203): pH values shall not fall outside the range of 7.0 to 8.5; (B) Other Hood River Basin streams (except Cascade lakes): pH values shall not fall outside the range of 6.5 to 8.5[.]; (C) Cascade lakes above 3,000 feet altitude: pH values shall not fall outside the range of 6.0 to 8.5.
Deschutes 340-41-565(2)(d)	(d) pH (hydrogen ion concentration): pH values shall not fall outside the [following] ranges[:] identified in paragraphs (A), (B), and (C) of this subsection. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria: (A) Columbia River (river miles 203 to 218): 7.0 - 8.5; (B) All other Basin streams (except Cascade lakes): 6.5 - 8.5[.]; (C) Cascade lakes above 3,000 feet altitude: pH values shall not fall outside the range of 6.0 to 8.5.

Basin	Rule
Klamath 340-41-965(2)(d)	(d) pH (hydrogen ion concentration): pH values shall not fall outside the [range of 7.0 to 9.0;] ranges identified in paragraphs (A) and (B) of this subsection. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria: (A) Fresh waters except Cascade lakes: pH values shall not fall outside the range of 6.5 – 9.0. When greater than 25 percent of ambient measurements taken between June and September are greater than pH 8.7, and as resources are available according to priorities set by the Department, the Department shall determine whether the values higher than 8.7 are anthropogenic or natural in origin; (B) Cascade lakes above 5,000 feet altitude: pH values shall not fall outside the range of 6.0 to 8.5.
John Day 340-41-605(2)(d)	(d) pH (hydrogen ion concentration): pH values shall not fall outside the [following] ranges[:] identified in paragraphs (A) and (B) of this subsection. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria: (A) Columbia River (river miles 218 to 247): 7.0 – 8.5; (B) All other Basin streams: 6.5 – [8.5] 9.0. When greater than 25 percent of ambient measurements taken between June and September are greater than pH 8.7, and as resources are available according to priorities set by the Department, the Department shall determine whether the values higher than 8.7 are anthropogenic or natural in origin.

Basin		Rule
Umatilla 340-41-645(2)(d)	(d)	pH (hydrogen ion concentration): pH values shall not fall outside the [following] ranges[:] identified in paragraphs (A) and (B) of this subsection. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria: (A) Columbia River (river miles 247 to 309): 7.0 - 8.5; (B) All other Basin streams: 6.5 - [8.5;]9.0. When greater than 25 percent of ambient measurements taken between June and September are greater than pH 8.7, and as resources are available according to priorities set by the Department, the Department shall determine whether the values higher than 8.7 are anthropogenic or natural in origin.
Walla Walla 340-41-685(2)(c)	(c)	pH (hydrogen ion concentration): pH values shall not fall outside the range of 6.5 to [8.5;] 9.0. When greater than 25 percent of ambient measurements taken between June and September are greater than pH 8.7, and as resources are available according to priorities set by the Department, the Department shall determine whether the values higher than 8.7 are anthropogenic or natural in origin. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria;

Basin	Rule
Grande Ronde 340-41-725(2)(d)	(d) pH (hydrogen ion concentration): pH values shall not fall outside the [following] ranges[:] identified in paragraphs (A) and (B) of this subsection. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria: (A) [Main Stem] Mainstem Snake River (river miles 176 to 260): 7.0 - 9.0; (B) All other Basin streams: 6.5 - [8.5] 9.0. When greater than 25 percent of ambient measurements taken between June and September are greater than pH 8.7, and as resources are available according to priorities set by the Department, the Department shall determine whether the values higher than 8.7 are anthropogenic or natural in origin.
Powder 340-41-765(2)(d)	(d) pH (hydrogen ion concentration): pH values shall not fall outside the [following] ranges[:] identified in paragraphs (A) and (B) of this subsection. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria: (A) [Main Stem] Mainstem Snake River (river miles 260 to 335): 7.0 - 9.0; (B) All other Basin streams: 6.5 - [8.5] 9.0. When greater than 25 percent of ambient measurements taken between June and September are greater than pH 8.7, and as resources are available according to priorities set by the Department, the Department shall determine whether the values higher than 8.7 are anthropogenic or natural in origin.

Basin	Rule
Malheur River 340-41-805(2)(d)	(d) pH (hydrogen ion concentration): pH values shall not fall outside the range of 7.0 to 9.0[;]. When greater than 25 percent of ambient measurements taken between June and September are greater than pH 8.7, and as resources are available according to priorities set by the Department, the Department shall determine whether the values higher than 8.7 are anthropogenic or natural in origin. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria;
Owyhee 340-41-845(2)(d)	(d) pH (hydrogen ion concentration): pH values shall not fall outside the range of 7.0 to 9.0[;]. When greater than 25 percent of ambient measurements taken between June and September are greater than pH 8.7, and as resources are available according to priorities set by the Department, the Department shall determine whether the values higher than 8.7 are anthropogenic or natural in origin. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria;
Malheur Lake 340-41-885(2)(d)	(d) pH (hydrogen ion concentration): pH values shall not fall outside the range of 7.0 to 9.0[;]. When greater than 25 percent of ambient measurements taken between June and September are greater than pH 8.7, and as resources are available according to priorities set by the Department, the Department shall determine whether the values higher than 8.7 are anthropogenic or natural in origin. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria;

Basin	Rule
Goose and Summer Lakes 340-41-925(2)(d)	(d) pH (hydrogen ion concentration): (A) Goose Lake: pH values shall not fall outside the range of 7.5 to 9.5; (B) All other basin waters: pH values shall not fall outside the range of 7.0 to 9.0. When greater than 25 percent of ambient measurements taken between June and September are greater than pH 8.7, and as resources are available according to priorities set by the Department, the Department shall determine whether the values higher than 8.7 are anthropogenic or natural in origin. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria.

PROPOSED AMENDMENTS TO OREGON ADMINISTRATIVE RULES

OAR 340-41-[Basin](2)(e)

NOTE: The underlined portions of text represent proposed additions made to the rules.

The [bracketed] portions of text represent proposed deletions made to the rules. Because the rules differ by basin, the bracketed portions are example only. The exact reference to be deleted is given in Figure C.

(e) Bacteria Standards:

(A) [Effective from July 1, 1995 and through December 31, 1995.] Numeric Criteria: [O]organisms of the coliform group [where] commonly associated with fecal sources (MPN or equivalent membrane filtration using a representative number of samples) shall not exceed the criteria described in subparagraphs (i) and (ii) of this paragraph:

[(i) Freshwaters: A log mean of 200 fecal coliform per 100 milliliters based on a minimum of five samples in a 30-day period with no more than ten percent of the samples in the 30-day period exceeding 400 per 100 ml;]

(i) Freshwaters and Estuarine Waters Other than Shellfish Growing Waters:

(I) A 30-day log mean of 126 *E. coli* organisms per 100 ml, based on a minimum of five (5) samples.

(II) No single sample shall exceed 406 *E. coli* organisms per 100 ml;

(ii) Marine [w]Waters and [e]Estuarine [s]Shellfish [g]Growing [w]Waters: A fecal coliform median concentration of 14 organisms per 100 milliliters, with not more than ten percent of the samples exceeding 43 organisms per 100 ml[;].

[(iii) Estuarine waters other than shellfish growing waters: A log mean of 200 fecal coliform per 100 milliliters based on a minimum of five samples in a 30-day period with no more than ten percent of the samples in the 30-day period exceeding 400 per 100 ml.]

~~[(B) Effective January 1, 1996. Bacteria of the coliform group associated with fecal sources and bacteria of the enterococci group (MPN or equivalent membrane filtration using a representative number of samples) shall not exceed the criteria values described in subparagraphs (2)(e)(B)(i) through (iii) of this rule. However, the Department may designate site specific bacteria criteria on a case-by-case basis to protect beneficial uses. Site specific values shall be described in and included as part of a water quality management plan:~~

~~(i) Freshwaters: A geometric mean of 33 enterococci per 100 milliliters based on no fewer than five samples, representative of seasonal conditions, collected over a period of at least 30 days. No single sample should exceed 61 enterococci per 100 ml;~~

~~(ii) Marine waters and estuarine shellfish growing waters: A fecal coliform median concentration of 14 organisms per 100 milliliters, with not more than ten percent of the samples exceeding 43 organisms per 100 ml;~~

~~(iii) Estuarine waters other than shellfish growing waters: A geometric mean of 35 enterococci per 100 milliliters based on no fewer than five samples, representative of seasonal conditions, collected over a period of at least 30 days. No single sample should exceed 104 enterococci per 100 ml.]~~

(B) Raw Sewage Prohibition: No sewage shall be discharged into or in any other manner be allowed to enter the waters of the State unless such sewage has been treated in a manner approved by the Department or otherwise allowed by these rules;

(C) Animal Waste: Runoff contaminated with domesticated animal wastes shall be minimized and treated to the maximum extent practicable before it is allowed to enter waters of the State;

(D) Effluent Limitations and Water Quality Limited Waterbodies: Effluent limitations to implement the criteria in this rule are found in OAR 340-41-120(12) - (16). Implementation of the criteria in this rule in water quality limited waterbodies is described in OAR 340-41-026(3)(a)(I) and OAR 340-41-120 (17)

POLICIES AND GUIDELINES GENERALLY APPLICABLE TO ALL BASINS

OAR 340-41-026

(3)(a)

(H) Any source may petition the Commission for an exception to paragraph (F) of this subsection, provided:

(i) The source provides the necessary scientific information to describe how the designated beneficial uses would not be adversely impacted; or

(ii) The source demonstrates that: it is implementing all reasonable management practices; its activity will not significantly affect the beneficial uses; and the environmental cost of treating the parameter to the level necessary to assure full protection would outweigh the risk to the beneficial uses.

(I) In waterbodies designated by the Department as water-quality limited for bacteria, and in accordance with priorities established by the Department, development and implementation of a bacteria management plan shall be required of those sources that the Department determines to be contributing to the problem. The Department may determine that a plan is not necessary for a particular stream segment or segments within a water-quality limited basin based on the contribution of the segment(s) to the problem. The bacteria management plans will identify the technologies, BMPs and/or measures and approaches to be implemented by point and nonpoint sources to limit bacterial contamination. For point sources, their National Pollutant Discharge Elimination System permit is their bacteria management plan. For nonpoint sources, the bacteria management plan will be developed by designated management agencies (DMAs) which will identify the appropriate BMPs or measures and approaches.

~~[(D)]~~ (J) The activity, expansion, or growth necessitating a new or increased discharge load is....

IMPLEMENTATION PROGRAM APPLICABLE TO ALL BASINS

OAR 340-41-120

(12) Effluent Limitations for Bacteria: Except as allowed in subsection (c) of this section, upon NPDES permit renewal or issuance, or upon request for a permit modification by the permittee at an earlier date, effluent discharges to freshwaters and estuarine waters other than shellfish growing waters shall not exceed a monthly log mean of 126 *E. coli* organisms per 100 ml based on a minimum of five (5) samples. No single sample shall exceed 406 *E. coli* organisms per 100 ml. If a single sample exceeds 406 *E. coli* per 100 ml, then five consecutive re-samples shall be taken at four-hour intervals beginning as soon as practicable (preferably within 28 hours) after the original sample was taken. If the log mean of the five re-samples is less than or equal to 126, a violation shall not occur. The following conditions apply:

(a) If the Department finds that re-sampling within the timeframe outlined in this section would pose an undue hardship on a treatment facility, a more convenient schedule may be negotiated in the permit, provided that the permittee demonstrates that the sampling delay will result in no increase in the risk to water contact recreation in waters affected by the discharge;

(b) The in-stream criterion for chlorine listed in **Table 20** shall be met at all times outside the assigned mixing zone;

(c) For sewage treatment plants that are authorized to use reclaimed water pursuant to Oregon Administrative Rule (OAR) 340, Division 55, and which also use a storage pond as a means to dechlorinate their effluent prior to discharge to public waters, effluent limitations for bacteria shall, upon request by the permittee, be based upon appropriate total coliform limits as required by OAR 340, Division 55;

(I) For Level II limitations, if two consecutive samples exceed 240 total coliform per 100 ml or for Level III and Level IV limitations, if a single sample exceeds 23 total coliform per 100 ml, then five consecutive re-samples shall be taken at four hour intervals beginning as soon as practicable (preferably within 28 hours) after the original sample(s) were taken;

(II) And, if in the case of Level II effluent, the log mean of the five re-samples is less than or equal to 23 total coliform per 100 ml or, in the case of Level III and IV effluent, if the log mean of the five re-samples is less than or equal to 2.2 total coliform per 100 ml, a violation shall not be triggered.

(13) Sewer Overflows in Winter: Domestic waste collection and treatment facilities are prohibited from discharging raw sewage to waters of the State during the period of November 1 through May 21, except during a storm event greater than the one-in-five year, 24-hour duration storm. However, the following exceptions apply:

(a) The Commission may on a case-by-case basis approve a bacteria control management plan to be prepared by the permittee, for a basin or specified geographic area which describes hydrologic conditions under which the numeric bacteria criteria would be waived. These plans will identify the specific hydrologic conditions, identify the public notification and education processes that will be followed to inform the public about an event and the plan, describe the water quality assessment conducted to determine bacteria sources and loads associated with the specified hydrologic conditions, and describe the bacteria control program that is being implemented in the basin or specified geographic area for the identified sources;

(b) Facilities with separate sanitary and storm sewers existing on January 10, 1996, and which currently experience sanitary sewer overflows due to inflow and infiltration problems, shall submit an acceptable plan to the Department at the first permit renewal, which describes actions that will be taken to assure compliance with the discharge prohibition by January 1, 2010. Where discharges occur to a receiving stream with sensitive beneficial uses, the Department may negotiate a more aggressive schedule for discharge elimination;

(c) On a case-by-case basis, the beginning of winter may be defined as October 15 if the permittee so requests and demonstrates to the Department's satisfaction that the risk to beneficial uses, including water contact recreation, will not be increased due to the date change.

(14) Sewer Overflows in Summer: Domestic waste collection and treatment facilities are prohibited from discharging raw sewage to waters of the State during the period of May 22 through October 31, except during a storm event greater than the one-in-ten-year, 24-hour duration storm. The following exceptions apply:

(a) For facilities with combined sanitary and storm sewers, the Commission may on a case-by-case basis approve a bacteria control management plan such as that described in subsection (13)(a) of this rule;

(b) On a case-by-case basis, the beginning of summer may be defined as June 1 if the permittee so requests and demonstrates to the Department's satisfaction that the risk to beneficial uses, including water contact recreation, will not be increased due to the date change;

(c) For discharge sources whose permit identifies the beginning of summer as any date from May 22 through May 31: If the permittee demonstrates to the Department's satisfaction that an exceedance occurred between May 21 and June 1 because of a sewer overflow, and that no increase in risk to beneficial uses, including water contact recreation, occurred because of the exceedance, no violation shall be triggered if the storm associated with the overflow was greater than the one-in-five-year, 24-hour duration storm.

(15) Storm Sewers Systems Subject to Municipal NPDES Storm Water Permits: Best management practices shall be implemented for permitted storm sewers to control bacteria to the maximum extent practicable. In addition, a collection-system evaluation shall be performed prior to permit issuance or renewal so that illicit and cross connections are identified. Such connections shall be removed upon identification. A collection system evaluation is not required where the Department determines that illicit and cross connections are unlikely to exist.

(16) Storm Sewers Systems Not Subject to Municipal NPDES Storm Water Permits: A collection system evaluation shall be performed of non-permitted storm sewers by January 1, 2005, unless the Department determines that an evaluation is not necessary because illicit and cross connections are unlikely to exist. Illicit and cross-connections shall be removed upon identification.

(17) Water Quality Limited for Bacteria: In those waterbodies, or segments of waterbodies identified by the Department as exceeding the relevant numeric criteria for bacteria in the basin standards and designated as water-quality limited under section 303(d) of the Clean Water Act, the requirements specified in OAR 340-41-026(3)(a)(I) and in section (10) of this rule shall apply.

FIGURE C. RULE SECTIONS TO BE DELETED BY BASIN
Bacteria

Basin	**Section and Subsection: (340-41-Basin)**
North Coast - Lower Columbia	205(2)(e)(A)(i)
Mid Coast	245(2)(e)(A)(i)
Umpqua	285(2)(e)(A)(i)
South Coast	325(2)(e)(A)(i)
Rogue	365(2)(e)(A)(i)
Willamette	445(2)(e)(A)
Sandy	485(2)(e)(A)
Hood	525(2)(e)(A)
Deschutes	565(2)(e)(A)
John Day	605(2)(e)(A)
Umatilla	645(2)(e)(A)
Walla Walla	685(2)(d)(A)
Grande Ronde	725(2)(e)(A)
Powder	765(2)(e)(A)
Malheur	805(2)(e)(A)
Owyhee	845(2)(e)(A)
Malheur Lake	885(2)(e)(A)
Goose & Summer Lakes	925(2)(e)(A)
Klamath	965(2)(e)(A)

NOTE: The portions of the proposed bacteria standard ((A)(ii). and part of (A)(i)) specific to marine or estuarine waters apply only to basins in which such waters occur (the North Coast 205, Mid-Coast 245, South Coast 325, Umpqua 285 and Rogue 365)

PROPOSED AMENDMENTS TO OREGON ADMINISTRATIVE RULES OAR 340-40-090

NOTE: The underlined portions of text represent proposed additions made to the rules.

The [bracketed] portions of text represent proposed deletions made to the rules.

340-40-090

[The levels]Interim standards are contained in Tables 4A, 5, and 6 of this Division [are the interim standards] for maximum measurable levels (MMLs) of contaminants in groundwater to be used in the designation of a groundwater management area. Permanent standards for MMLs are found in Table 4B. The[se] permanent or interim levels shall be used in all actions conducted by the Department where the use of maximum measurable levels for contaminants in groundwater is required.

TABLE 4A
(OAR 340-40-090)

Interim Standards for Maximum Measurable Levels of Contaminants in Groundwater:[1,2,3]

Inorganic Contaminants	Interim Standard (mg/L)
Arsenic	0.05
Barium	1.0
Cadmium	0.010
Chromium	0.05
Fluoride	4.0
Lead	0.05
Mercury	0.002
[~~Nitrate-N~~	~~10~~]
Selenium	0.01
Silver	0.05

1 All reference levels are for total (unfiltered) concentrations unless otherwise specified by the Department.

2 The source of all standards listed is 40 CFR Part 141.

3 MMLs are used to trigger designation of a groundwater management area when concentrations are detected on an areawide basis which exceed 70 percent of the nitrate MML or 50 percent of other MMLs.

TABLE 4B
(OAR 340-40-090)

Permanent Standards for Maximum Measurable Levels of Contaminants in Groundwater:[1,2,3]

Inorganic Contaminants	Standard (mg/L)
Nitrate-N (Nitrate expressed as Nitrogen)	10

1 All reference levels are for total (unfiltered) concentrations unless otherwise specified by the Department.

2 The source of all standards listed is 40 CFR Part 141.

3 MMLs are used to trigger designation of a groundwater management area when concentrations are detected on an areawide basis which exceed 70 percent of the nitrate MML or 50 percent of other MMLs.

TABLE 5
(OAR 340-40-090)

Interim Standards for Maximum Measurable Levels of Contaminants in Groundwater (Continued):[1,2,3]

Organic Contaminants	Interim Standard (mg/L)
Benzene	0.005
Carbon Tetrachloride	0.005
p-Dichlorobenzene	0.075
1,2-Dichloroethane	0.005
~~[1,1,]~~1,1-Dichloroethylene	0.007
~~[1,1,1]~~1,1,1-Trichloroethane	0.20
Trichloroethylene	0.005
Total Trihalomethanes (the sum of concentrations bromodichloromethane, dibromochloromethane, tribromomethane (bromoform), and trichloromethane (chloroform))	0.10
Vinyl Chloride	0.002
2,4-D	0.10
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.10
Toxaphene	0.005
2,4,5-TP Silvex	0.01

1 All reference levels are for total (unfiltered) concentrations unless otherwise specified by the Department.

2 The source of all standards listed is 40 CFR Part 141.

3 MMLs are used to trigger designation of a groundwater management area when concentrations are detected on an areawide basis which exceed 70 percent of the nitrate MML or 50 percent of other MMLs.

TABLE 6
(OAR 340-40-090)

Interim Standards for Maximum
Measurable Levels of Contaminants in Groundwater:[1,3]

Radioactive Substances, Microbiological and Turbidity

Contaminant	Interim Standard
Turbidity	1 T U
Coliform Bacteria	< 1/100 ml
Radioactive Substances	
Gross Alpha[2]	15 pCi/1
Combined Radium 226 and 228	5 pCi/1
Gross Beta	50 pCi/1
I - 131	5 pCi/1
Sr - 90	8 pCi/1
Tritium	20,000 pCi/1

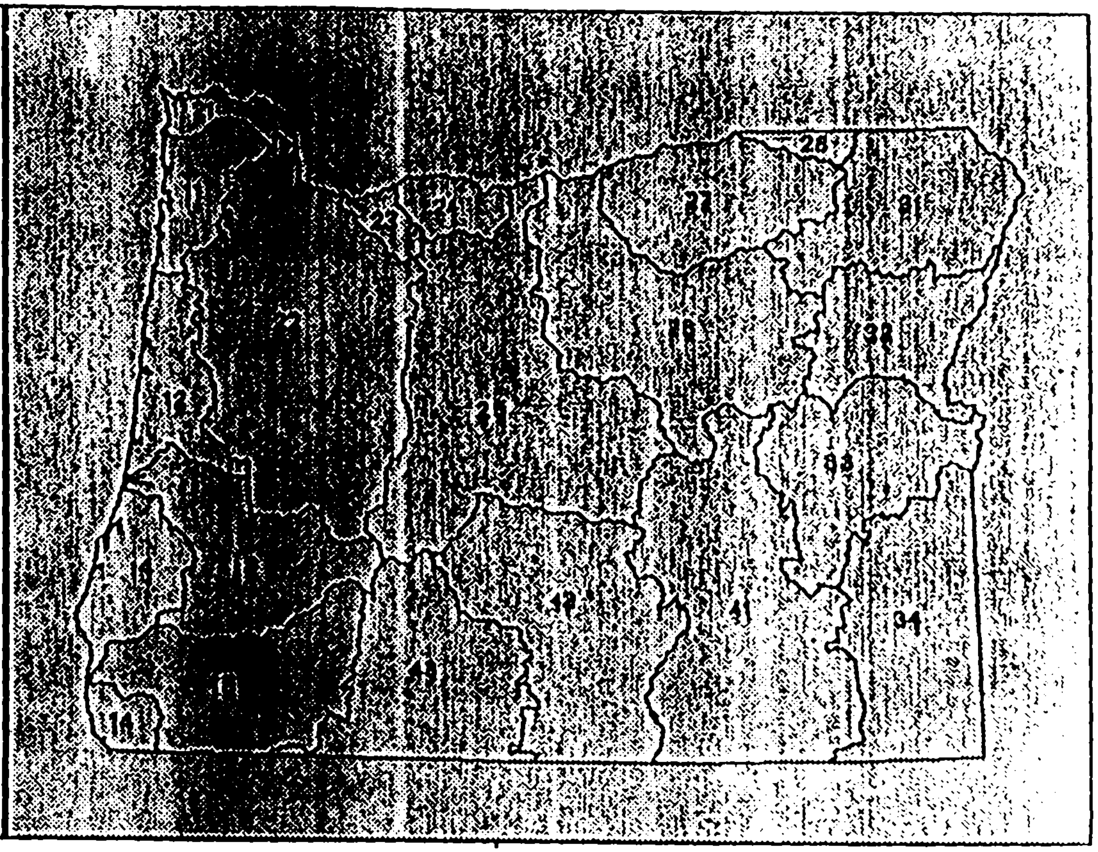
1 The source of all standards listed is 40 CFR Part 141.
2 Including Radium 226 but excluding Radon and Uranium.
3 MMLs are used to trigger designation of a groundwater management area when concentrations are detected on an areawide basis which exceed 70 percent of the nitrate MML or 50 percent of other MMLs.

FIGURE 1

BASIN INDEX MAP

Basin No.	Basin	Rule Number
11-21	North Coast — Lower Columbia	340-41-202
12	Mid Coast	340-41-242
13	Umpqua	340-41-282
14	South Coast	340-41-322
15	Rogue	340-41-362
22	Willamette	340-41-442
23	Sandy	340-41-482
24	Hood	340-41-522
25	Deschutes	340-41-562
26	John Day	340-41-602
27	Umatilla	340-41-642
28	Walla Walla	340-41-682
31	Grande Ronde	340-41-722
32	Powder	340-41-762
33	Malheur River	340-41-802
34	Owyhee	340-41-842
41	Malheur Lake	340-41-882
42	Goose & Summer Lakes	340-41-922
43	Klamath	340-41-962

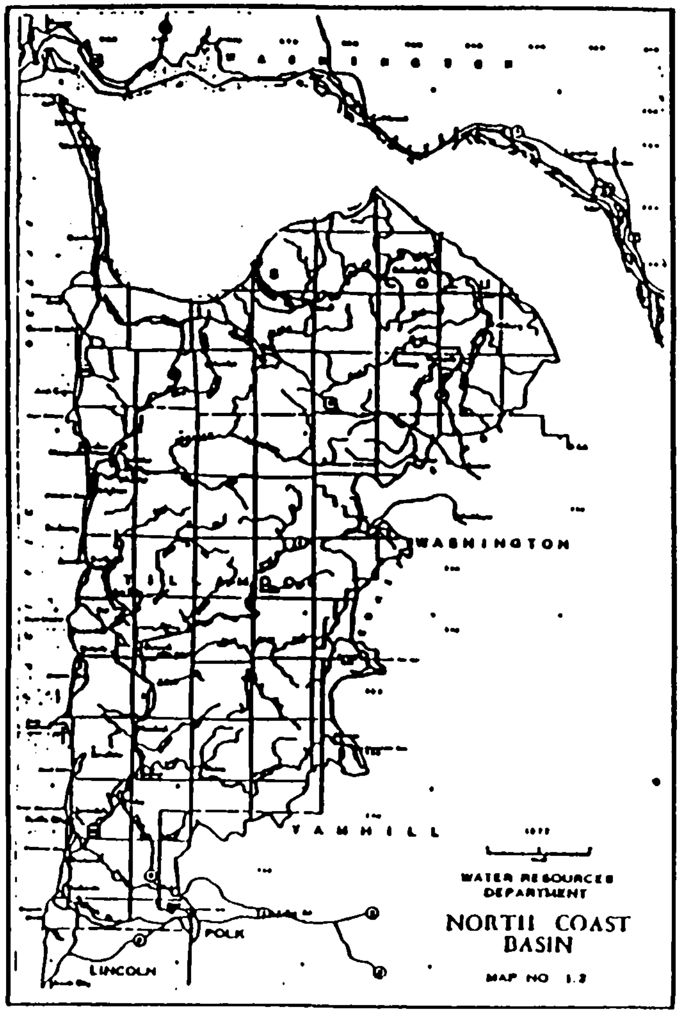
SA\Table\W115267.5



OREGON DRAINAGE BASINS

NORTH COAST — LOWER COLUMBIA BASIN
(340-41-202)

(Note: Basin Boundaries are as shown in figure below.)



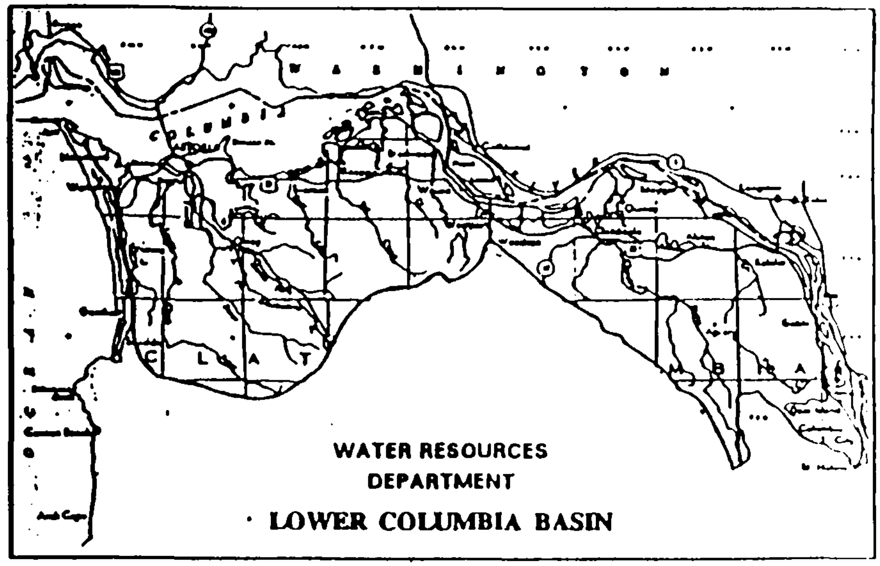


TABLE 1

NORTH COAST — LOWER COLUMBIA BASIN
(340-41-202)

Beneficial Uses	Estuaries and Adjacent Marine Waters	Columbia River Mouth to RM 86	All Other Streams & Tributaries Thereto
Public Domestic Water Supply[1]		X	X
Private Domestic Water Supply[1]		X	X
Industrial Water Supply	X	X	X
Irrigation		X	X
Livestock Watering		X	X
Anadromous Fish Passage	X	X	X
Salmonid Fish Rearing	X	X	X
Salmonid Fish Spawning	X	X	X
Resident Fish & Aquatic Life	X	X	X
Wildlife & Hunting	X	X	X
Fishing	X	X	X
Boating	X	X	X
Water Contact Recreation	X	X	X
Aesthetic Quality	X	X	X
Hydro Power			
Commercial Navigation & Transportation	X	X	

[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards.

SA\Table\WH5288.5

FIGURE 3

MID COAST BASIN
(340-41-242)

(Note: Basin Boundaries are as shown in figure below.)

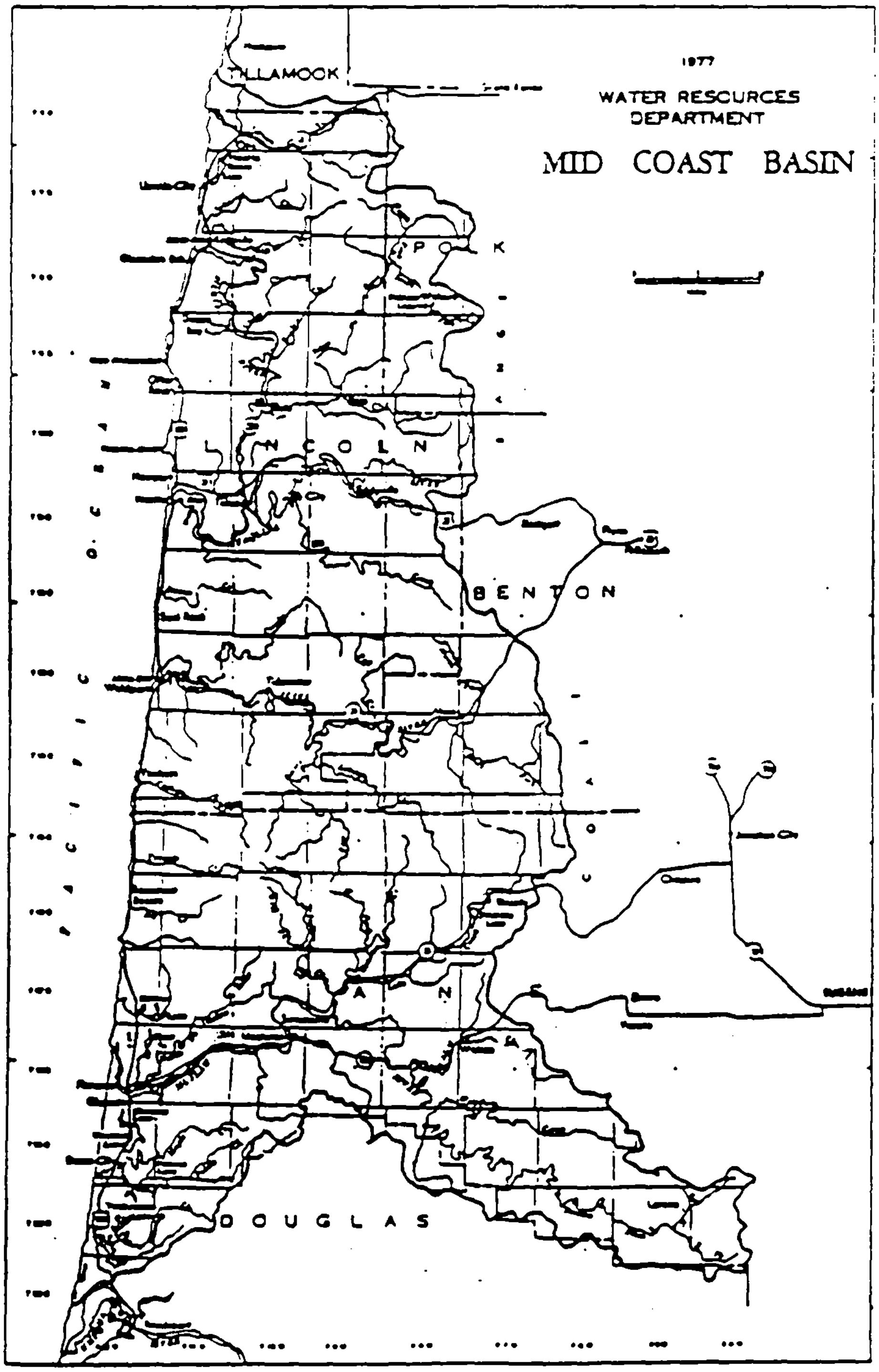


TABLE 2

MID COAST BASIN
(340-41-242)

Beneficial Uses	Estuaries & Adjacent Marine Waters	Fresh Waters
Public Domestic Water Supply[1]		X
Private Domestic Water Supply[1]		X
Industrial Water Supply	X	X
Irrigation		X
Livestock Watering		X
Anadromous Fish Passage	X	X
Salmonid Fish Rearing	X	X
Salmonid Fish Spawning	X	X
Resident Fish & Aquatic Life	X	X
Wildlife & Hunting	X	X
Fishing	X	X
Boating	X	X
Water Contact Recreation	X	X
Aesthetic Quality	X	X
Hydro Power		X
Commercial Navigation & Transportation	X	

[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards.

SA\Table\WH5289.5

FIGURE 4

UMPQUA BASIN
(340-41-282)

(Note: Basin Boundaries are as shown in figure below.)

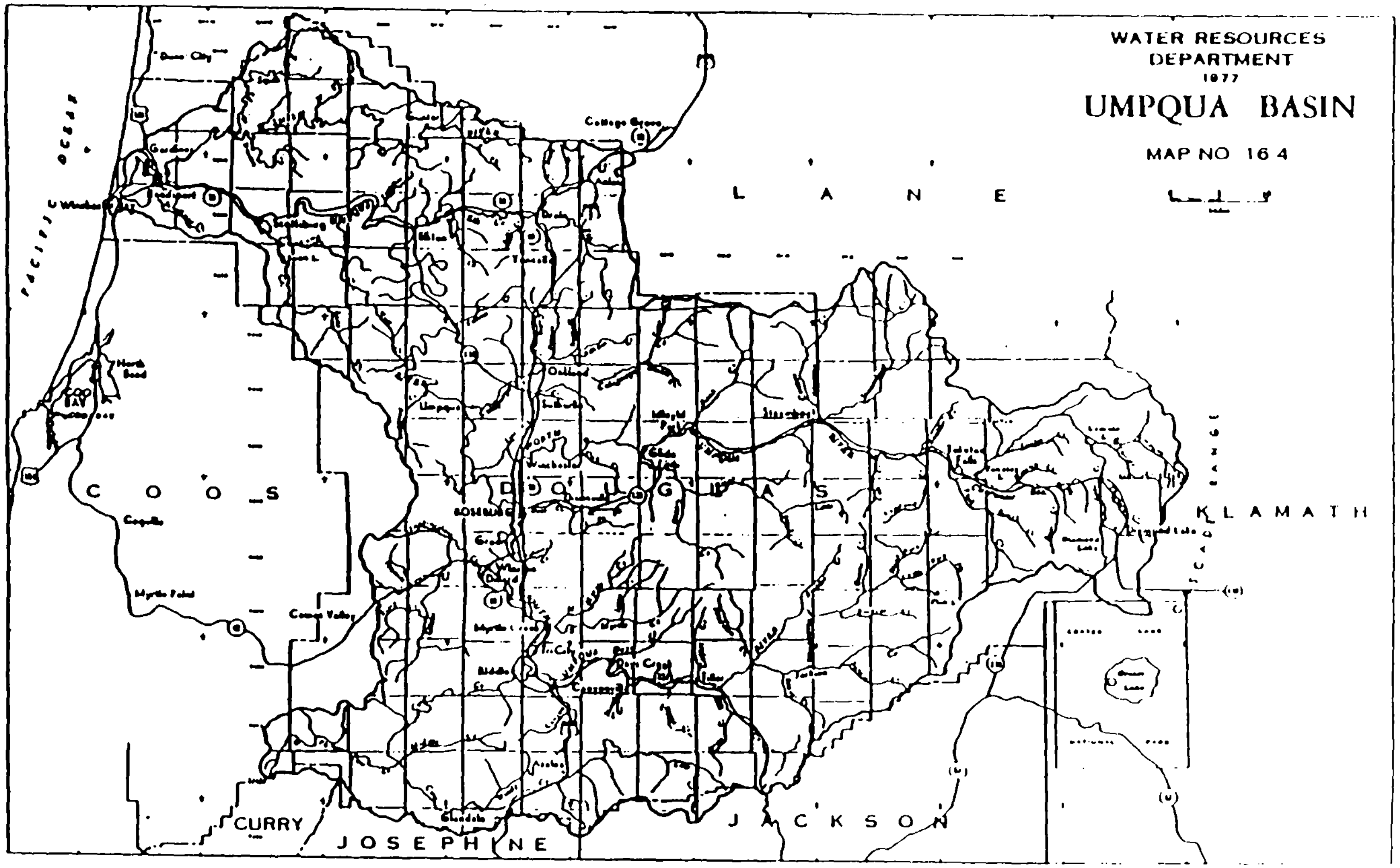


TABLE 3

UMPQUA BASIN
(340-41-282)

Beneficial Uses	Umpqua R. Estuary to Head of Tidewater and Adjacent Marine Waters	Umpqua R. Main Stem from Head of Tidewater to Confluence of N. & S. Umpqua Rivers	North Umpqua River Main Stem	South Umpqua River Main Stem	All Other Tributaries to Umpqua, North & South Umpque Rivers
Public Domestic Water Supply[1]		X	X	X	X
Private Domestic Water Supply[1]		X	X	X	X
Industrial Water Supply	X	X	X	X	X
Irrigation		X	X	X	X
Livestock Watering		X	X	X	X
Anadromous Fish Passage	X	X	X	X	X
Salmonid Fish Rearing	X	X	X	X	X
Salmonid Fish Spawning		X	X	X	X
Resident Fish & Aquatic Life	X	X	X	X	X
Wildlife & Hunting	X	X	X	X	X
Fishing	X	X	X	X	X
Boating	X	X	X	X	X
Water Contact Recreation	X	X	X	X	X
Aesthetic Quality	X	X	X	X	X
Hydro Power			X	X	X
Commercial Navigation & Transportation	X				

[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards.

SA\Table\WH5290.5

FIGURE 5

SOUTH COAST BASIN
(340-41-322)

(Note: Basin Boundaries are as shown in figure below.)

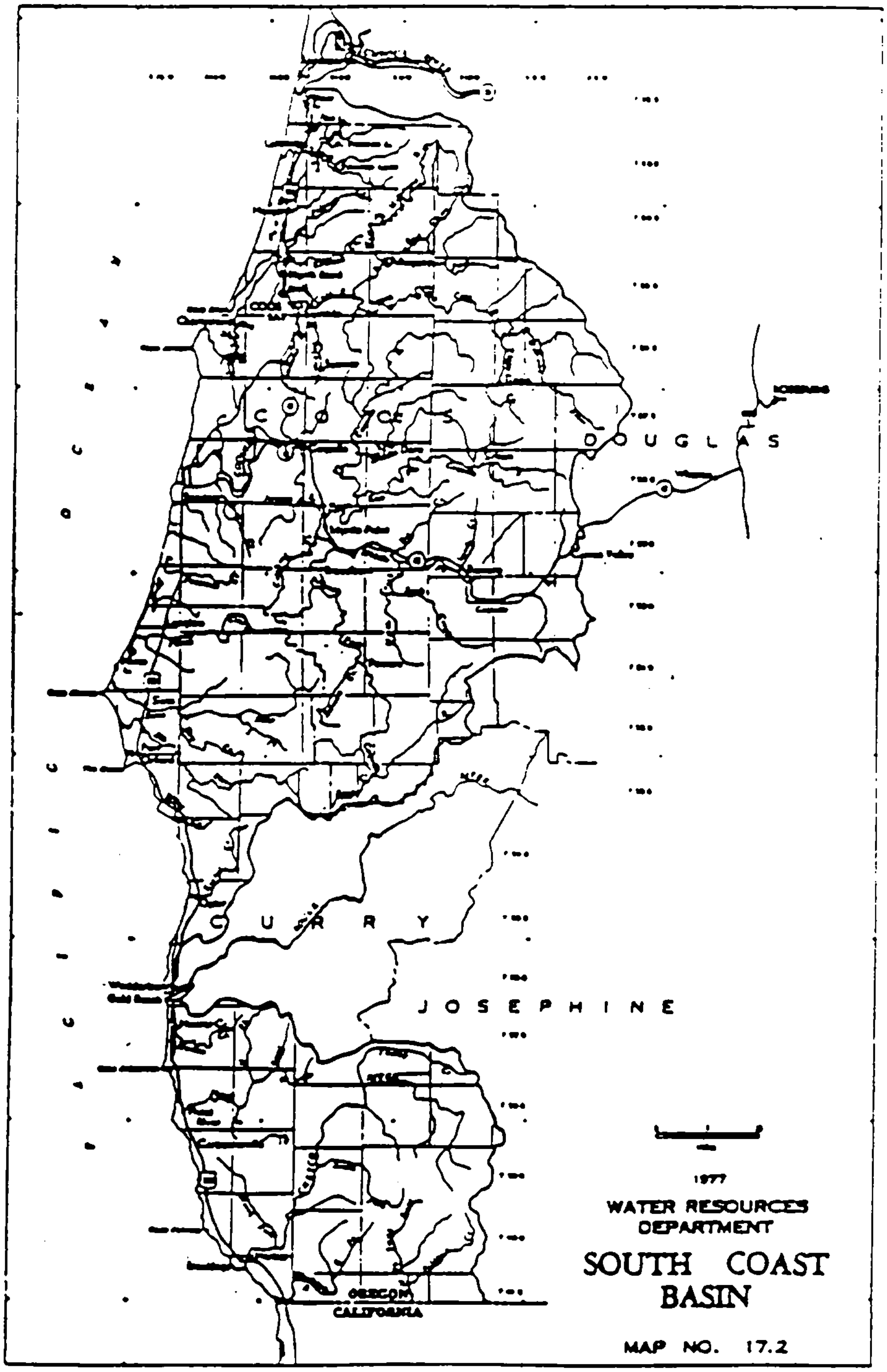


TABLE 4

SOUTH COAST BASIN
(340-41-322)

Beneficial Uses	Estuaries and Adjacent Marine Waters	All Streams & Tributaries Thereto
Public Domestic Water Supply[1]		X
Private Domestic Water Supply[1]		X
Industrial Water Supply	X	X
Irrigation		X
Livestock Watering		X
Anadromous Fish Passage	X	X
Salmonid Fish Rearing	X	X
Salmonid Fish Spawning	X	X
Resident Fish & Aquatic Life	X	X
Wildlife & Hunting	X	X
Fishing	X	X
Boating	X	X
Water Contact Recreation	X	X
Aesthetic Quality	X	X
Hydro Power		X
Commercial Navigation & Transportation	X	

[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards.

SA\Table\WH5291.5

FIGURE 6

ROGUE BASIN
(340-41-362)

(Note: Basin Boundaries are as shown in figure below.)

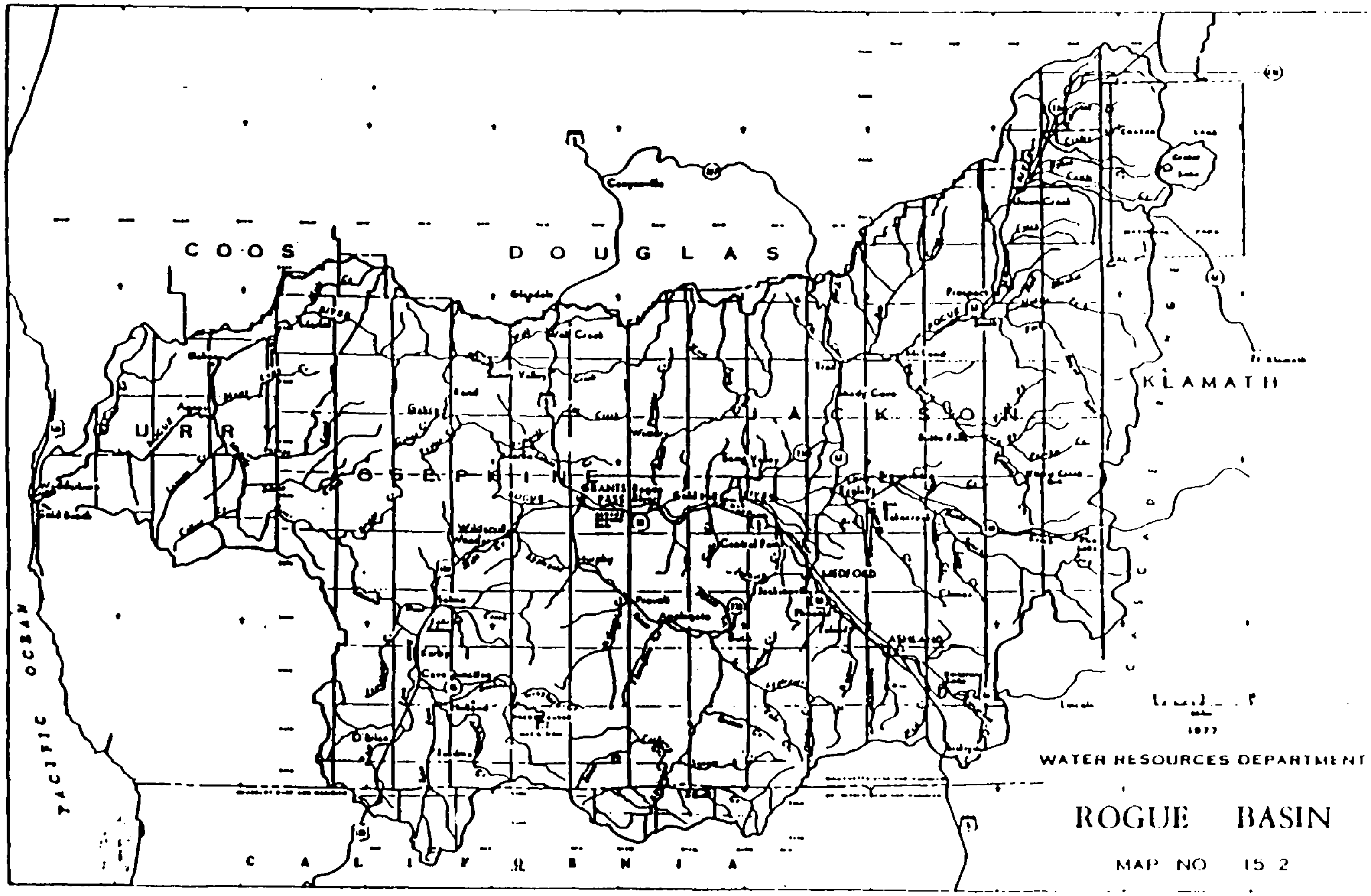


TABLE 5

ROGUE BASIN
(340-41-362)

Beneficial Uses	Rogue River Estuary and Adjacent Marine Waters	Rogue River Main Stem from Estuary to Lost Creek Dam	Rogue River Main Stem above Lost Dam & Tributaries	Bear Creek Main Stem	All Other Tributaries to Rogue River & Bear Creek
Public Domestic Water Supply[1]		X	X	*	X
Private Domestic Water Supply[1]		X	X		X
Industrial Water Supply	X	X	X	X	X
Irrigation		X	X	X	X
Livestock Watering		X	X	X	X
Anadromous Fish Passage	X	X	X	X	X
Salmonid Fish Rearing	X	X	X	X	X
Salmonid Fish Spawning		X	X	X	X
Resident Fish & Aquatic Life	X	X	X	X	X
Wildlife & Hunting	X	X	X	X	X
Fishing	X	X	X	X	X
Boating	X	X	X	X	X
Water Contact Recreation	X	X	X	X	X
Aesthetic Quality	X	X	X	X	X
Hydro Power			X		X
Commercial Navigation & Transportation	X	X			

* Designation for this use is presently under study.
[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards.

SA\Table\WH5292.5

FIGURE 7

WILLAMETTE BASIN
(340-41-442)

(Note: Basin Boundaries are as shown in figure below.)

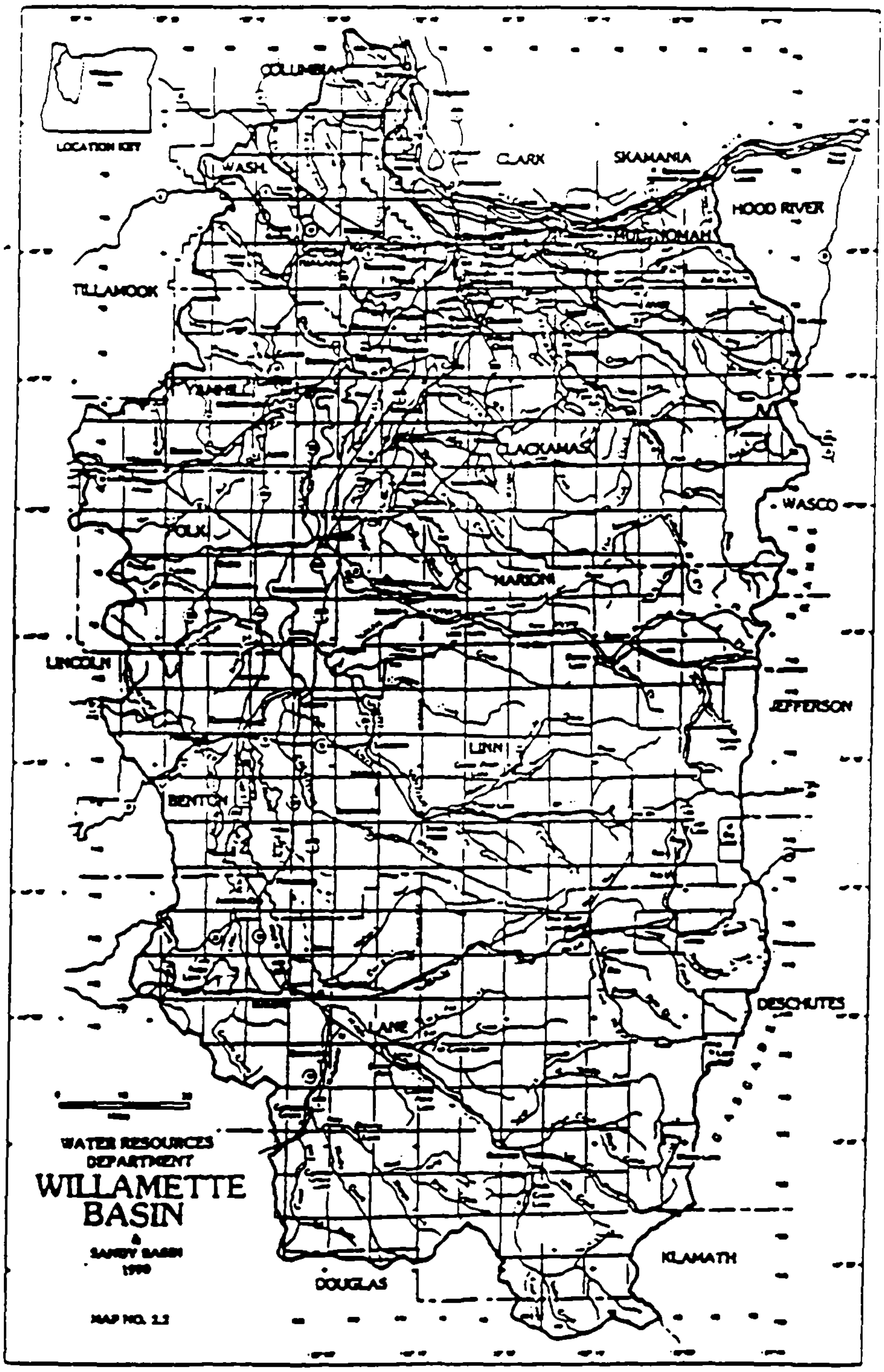


TABLE 6

WILLAMETTE BASIN
(340-41-442)

Beneficial Uses	Willamette River Tributaries						Main Stem Willamette River				
	Clackamas River	Molalla River	Santiam River	McKenzie River	Tualatin River	All Other Streams & Tributaries	Mouth to Willamette Falls, Including Multnomah Channel	Willamette Falls to Newberg	Newberg to Salem	Salem to Coast Fork	Main Stem Columbia River (RM 86 to 120)
Public Domestic Water Supply[1]	X	X	X	X	X	X	X	X	X	X	X
Private Domestic Water Supply[1]	X	X	X	X	X	X	X	X	X	X	X
Industrial Water Supply	X	X	X	X	X	X	X	X	X	X	X
Irrigation	X	X	X	X	X	X	X	X	X	X	X
Livestock Watering	X	X	X	X	X	X	X	X	X	X	X
Anadromous Fish Passage	X	X	X	X	X	X	X	X	X	X	X
Salmonid Fish Rearing	X	X	X	X	X	X	X	X	X	X	X
Salmonid Fish Spawning	X	X	X	X	X	X			X	X	X
Resident Fish & Aquatic Life	X	X	X	X	X	X	X	X	X	X	X
Wildlife & Hunting	X	X	X	X	X	X	X	X	X	X	X
Fishing	X	X	X	X	X	X	X	X	X	X	X
Boating	X	X	X	X	X	X	X	X	X	X	X
Water Contact Recreation	X	X	X	X	X	X	X	X[2]	X	X	X
Aesthetic Quality	X	X	X	X	X	X	X	X	X	X	X
Hydro Power	X	X	X	X	X	X	X	X			X
Commercial Navigation & Transportation							X	X	X		X

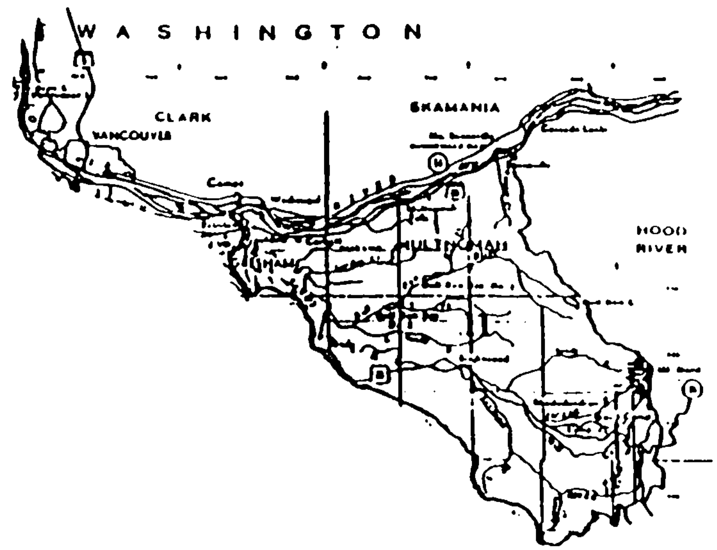
[1] With adequate pretreatment and natural quality that meets drinking water standards.
[2] Not to conflict with commercial activities in Portland Harbor.

SA\Table\WH5293.5

FIGURE 8

SANDY BASIN
(340-41-482)

(Note: Basin Boundaries are as shown in figure below.)



WATER RESOURCES DEPARTMENT

SANDY BASIN

TABLE 7

SANDY BASIN
(340-41-482)

Beneficial Uses	Streams Forming Waterfalls Near Columbia River Highway	Sandy River	Bull Run River and All Tributaries	All Other Tributaries to Sandy River	Columbia River (RM 120 to 147)
Public Domestic Water Supply[1]		X	X	X	X
Private Domestic Water Supply[1]		X		X	X
Industrial Water Supply		X		X	X
Irrigation		X		X	X
Livestock Watering		X		X	X
Anadromous Fish Passage		X	X	X	X
Salmonid Fish Rearing	X	X	X	X	X
Salmonid Fish Spawning	X	X	X		
Resident Fish & Aquatic Life	X	X	X	X	X
Wildlife & Hunting	X	X		X	X
Fishing	X	X		X	X
Boating		X		X	X
Water Contact Recreation	X	X		X	X
Aesthetic Quality	X	X	X	X	X
Hydro Power		X	X	X	X
Commercial Navigation & Transportation					X

[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards.

SA\Table\WH5294.5

FIGURE 9

HOOD BASIN
(340-41-522)

(Note: Basin Boundaries are as shown in figure below.)

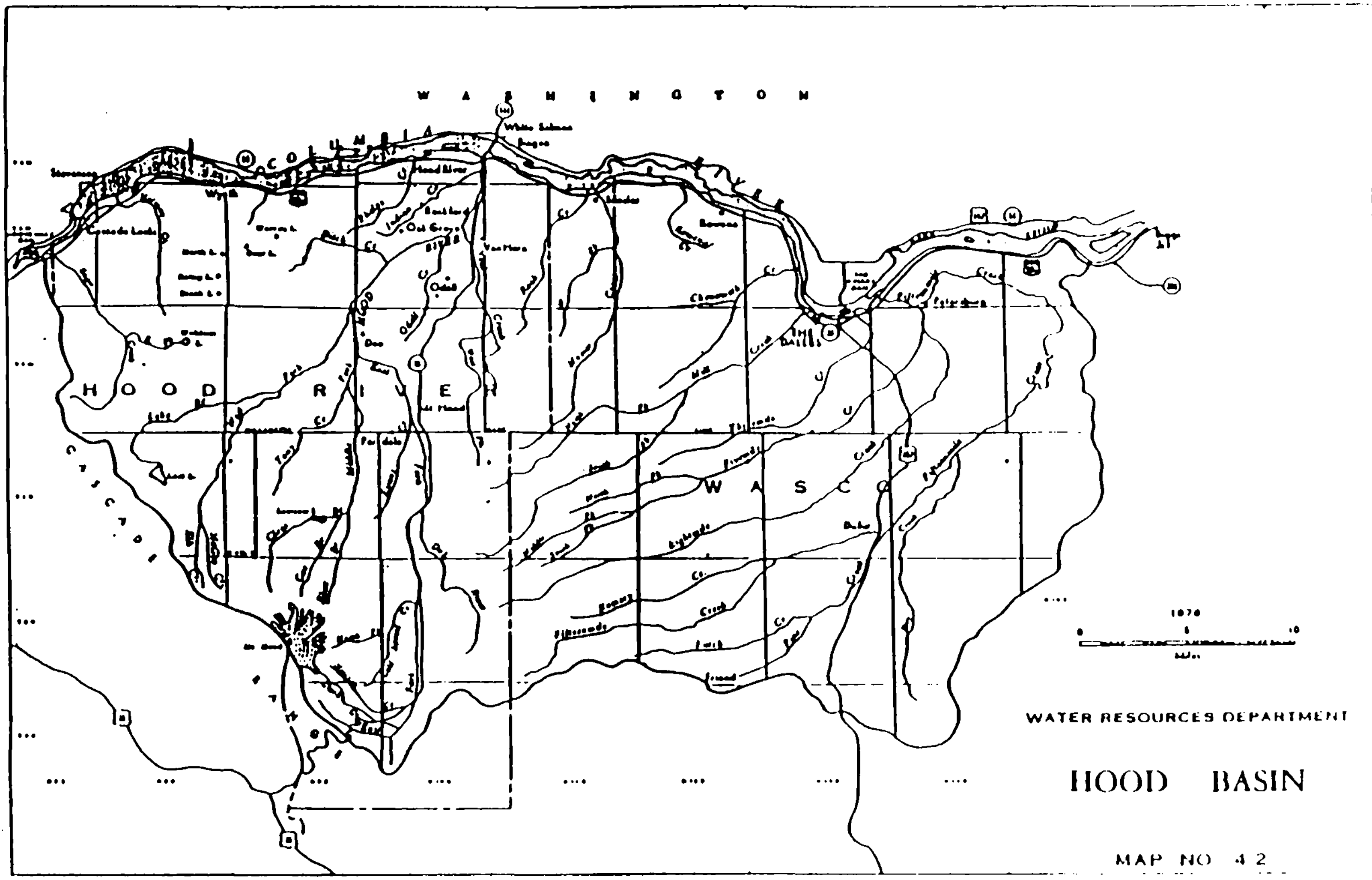


TABLE 8

HOOD BASIN
(340-41-522)

Beneficial Uses	Columbia River (RM 147 to 203)	Other Hood River Basin Streams
Public Domestic Water Supply[1]	X	X
Private Domestic Water Supply[1]	X	X
Industrial Water Supply	X	X
Irrigation	X	X
Livestock Watering	X	X
Anadromous Fish Passage	X	X
Anadromous Fish (Shad & Sturgeon) Spawning & Rearing	X	
Salmonid Fish Rearing	X	X
Salmonid Fish Spawning		X
Resident Fish & Aquatic Life	X	X
Wildlife & Hunting	X	X
Fishing	X	X
Boating	X	X
Water Contact Recreation	X	X
Aesthetic Quality	X	X
Hydro Power	X	X
Commercial Navigation & Transportation	X	

[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards.

SA\Table\WH5295.5

FIGURE 10

DESCHUTES BASIN
(340-41-562)

(Note: Basin Boundaries are as shown in figure below.)

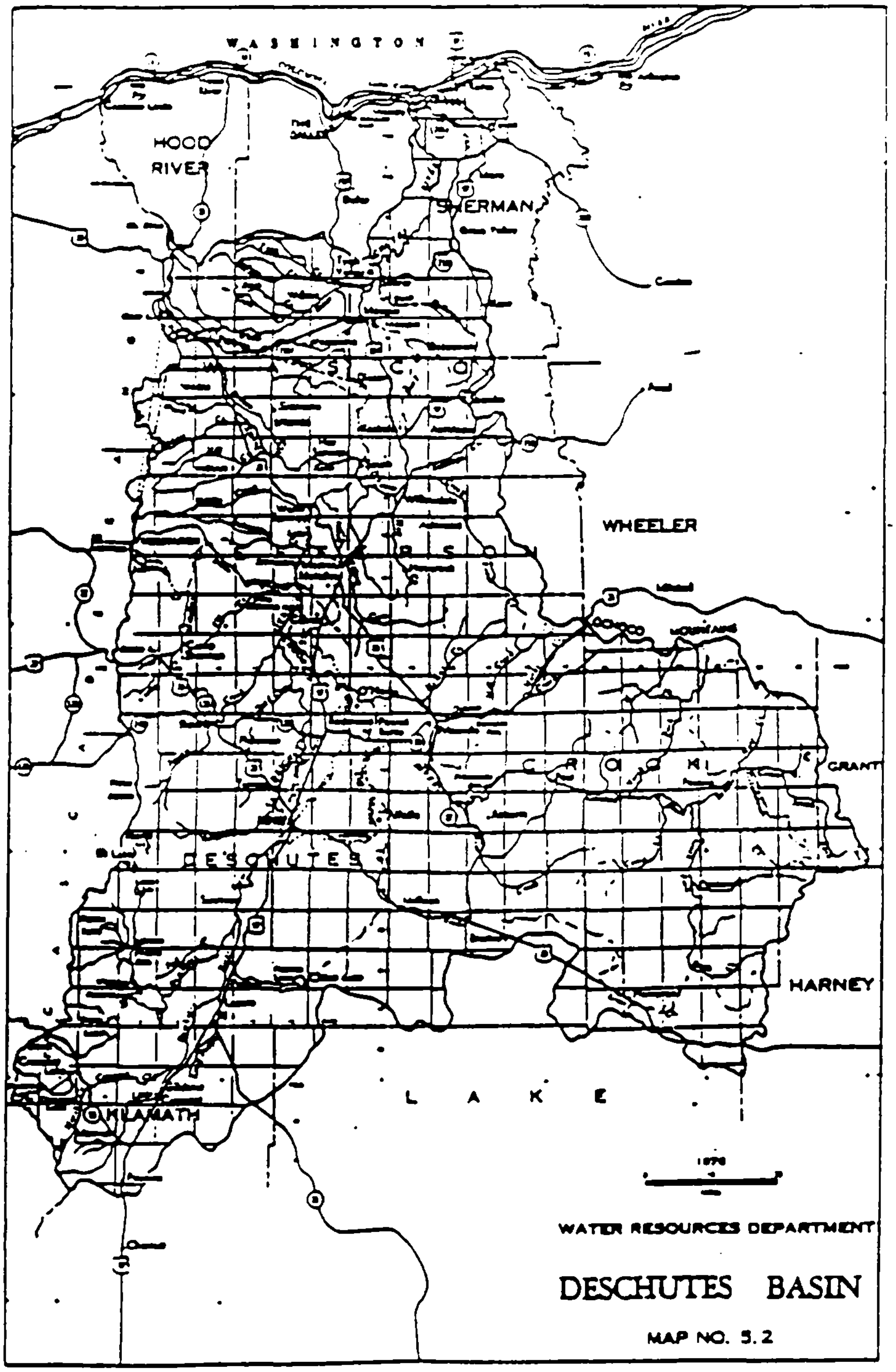


TABLE 9

DESCHUTES BASIN
(340-41-562)

Beneficial Uses	Columbia River (RM 203 to 218)	Deschutes River Main Stem from Mouth to Pelton Regulating Dam	Deschutes River Main Stem from Pelton Regulating Dam to Bend Diversion Dam and for the Crooked River Main Stem	Deschutes River Main Stem above Bend Diversion Dam & for the Metolius River Main Stem	All Other Basin Streams
Public Domestic Water Supply[1]	X	X	X	X	X
Private Domestic Water Supply[1]	X	X	X	X	X
Industrial Water Supply	X	X	X	X	X
Irrigation	X	X	X	X	X
Livestock Watering	X	X	X	X	X
Anadromous Fish Passage	X	X	X	X	X
Salmonid Fish Rearing	X	X	X	X	X
Salmonid Fish Spawning		X	X	X	X
Resident Fish & Aquatic Life	X	X	X	X	X
Wildlife & Hunting	X	X	X	X	X
Fishing	X	X	X	X	X
Boating	X	X	X	X	X
Water Contact Recreation	X	X	X	X	X
Aesthetic Quality	X	X	X	X	X
Hydro Power	X		X		
Commercial Navigation & Transportation	X				

[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards.

SA\Table\WH5296.5

FIGURE 11

JOHN DAY BASIN
(340-41-602)

(Note: Basin Boundaries are as shown in figure below.)

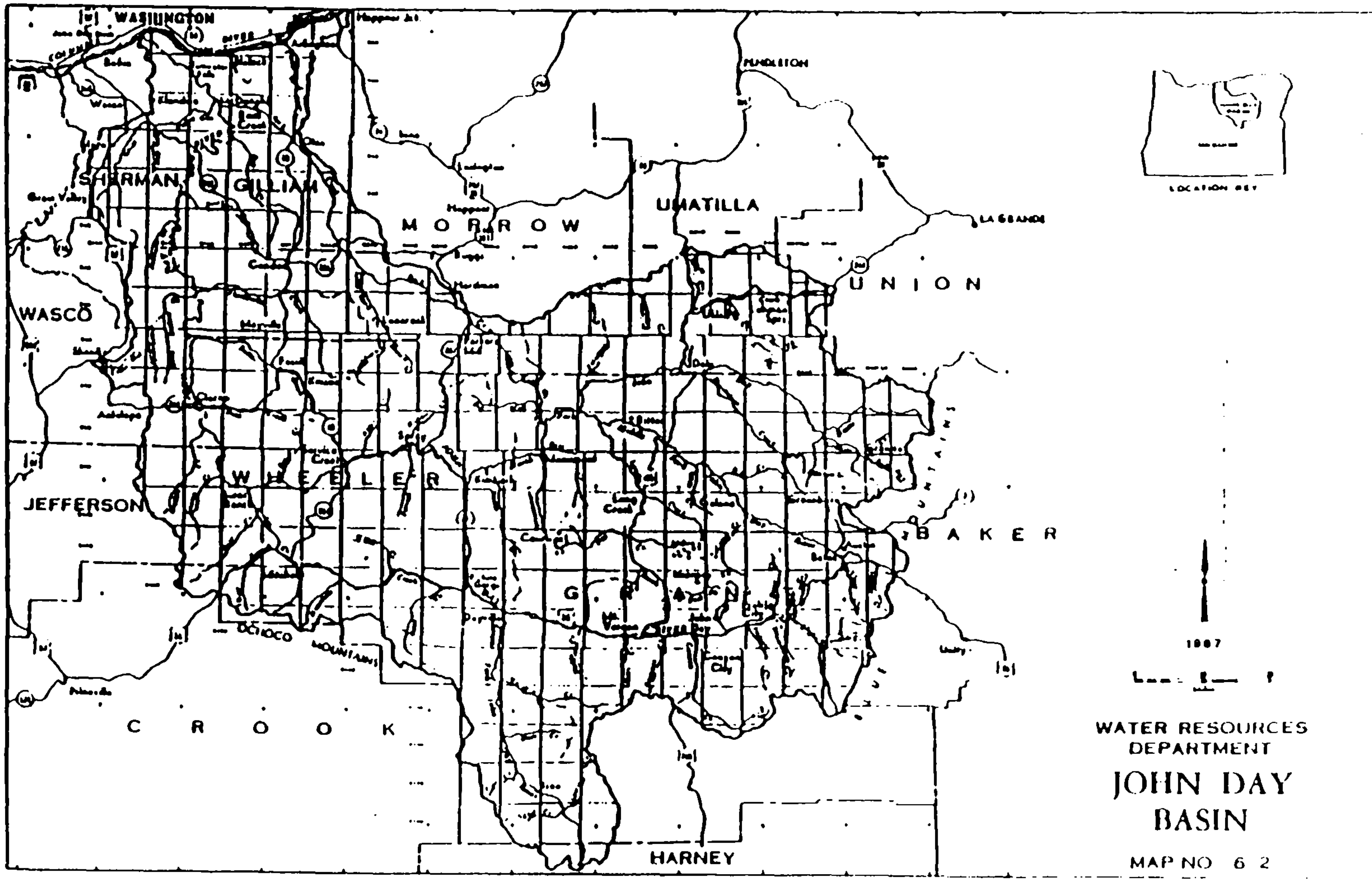


TABLE 10

JOHN DAY BASIN
(340-41-602)

Beneficial Uses	Columbia River (RM 218 to 247)	John Day River & All Tributaries
Public Domestic Water Supply[1]	X	X
Private Domestic Water Supply[1]	X	X
Industrial Water Supply	X	X
Irrigation	X	X
Livestock Watering	X	X
Anadromous Fish Passage	X	X
Salmonid Fish Rearing	X	X
Salmonid Fish Spawning	X	X
Resident Fish & Aquatic Life	X	X
Wildlife & Hunting	X	X
Fishing	X	X
Boating	X	X
Water Contact Recreation	X	X
Aesthetic Quality	X	X
Hydro Power	X	
Commercial Navigation & Transportation	X	

[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards

SA\Table\WH5297.5

FIGURE 12

UMATILLA BASIN
(340-41-642)

(Note: Basin Boundaries are as shown in figure below.)

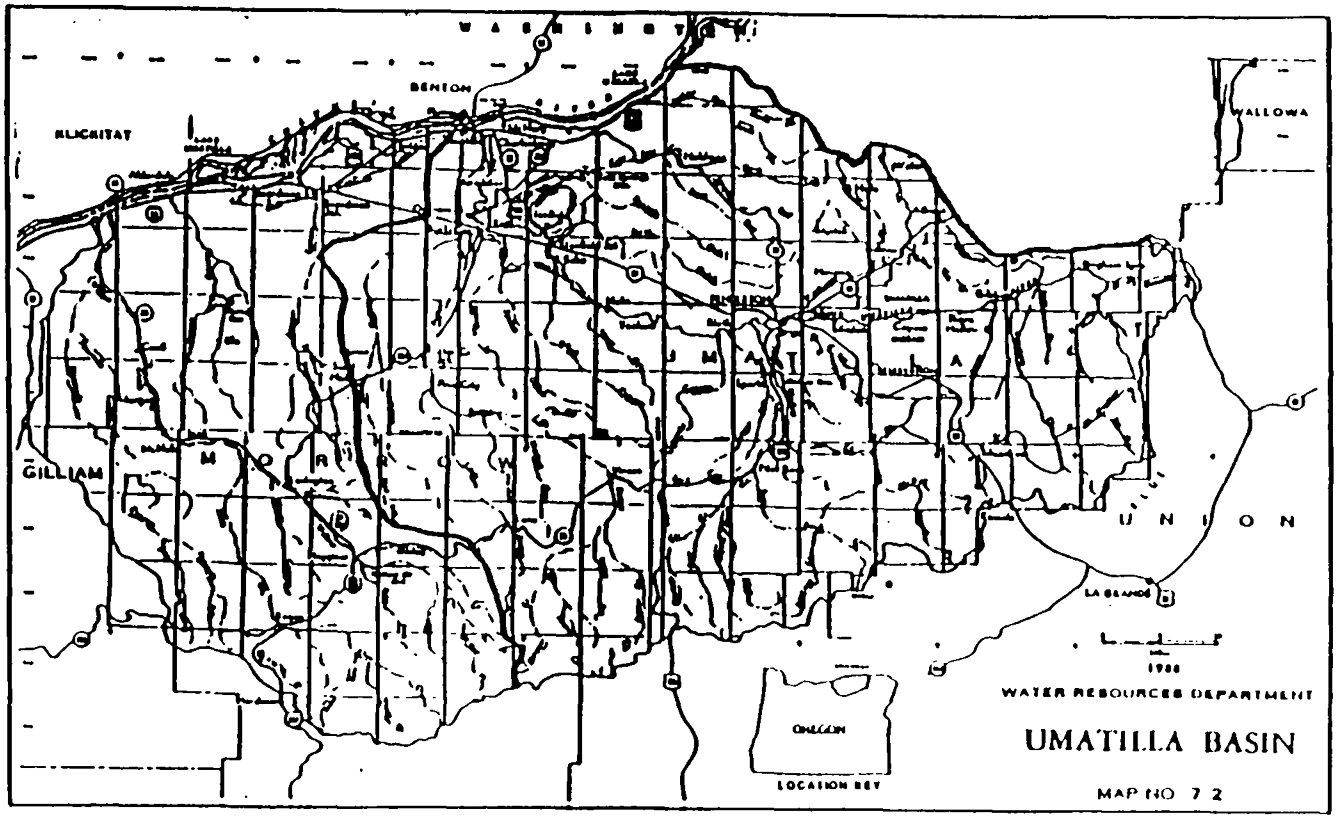


TABLE 11

UMATILLA BASIN
(340-41-642)

Beneficial Uses	Umatilla Subbasin	Willow Creek Subbasin	Main Stem Columbia River (RM 247 to 309)
Public Domestic Water Supply[1]	X	X	X
Private Domestic Water Supply[1]	X	X	X
Industrial Water Supply	X	X	X
Irrigation	X	X	X
Livestock Watering	X	X	X
Anadromous Fish Passage	X		X
Salmonid Fish Rearing (Trout)	X	X	X
Salmonid Fish Spawning (Trout)	X	X	X
Resident Fish & Aquatic Life	X	X	X
Wildlife & Hunting	X	X	X
Fishing	X	X	X
Boating	X	X (at mouth)	X
Water Contact Recreation	X	X	X
Aesthetic Quality	X	X	X
Hydro Power	X	X	X
Commercial Navigation & Transportation			X

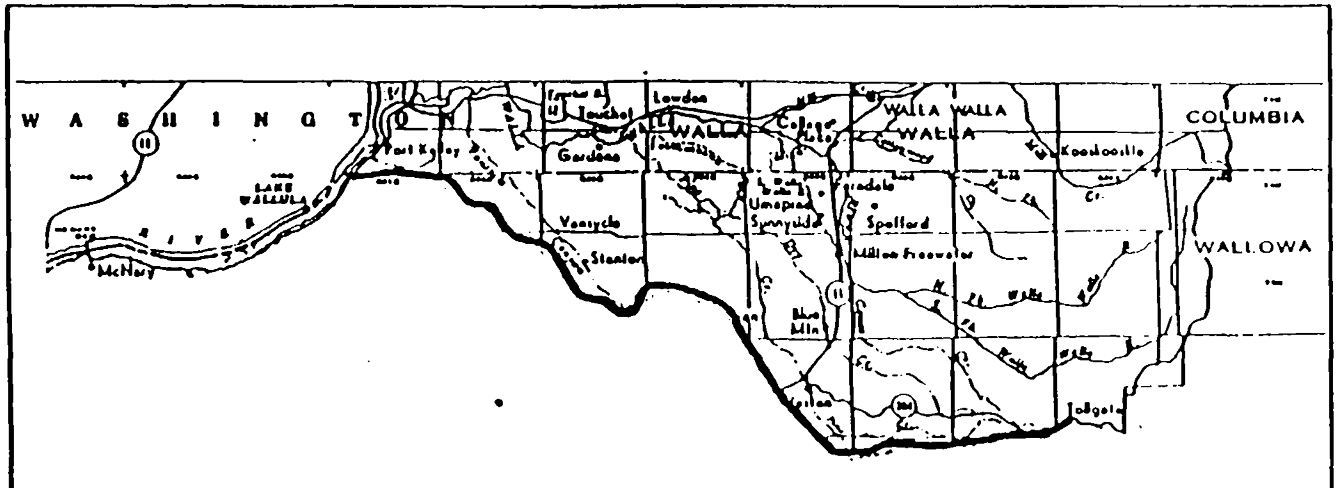
[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards.

SA\Table\WH5298.5

FIGURE 13

WALLA WALLA BASIN
(340-41-682)

(Note: Basin Boundaries are as shown in figure below.)



WATER RESOURCES DEPARTMENT

WALLA WALLA BASIN

TABLE 12

WALLA WALLA BASIN
(340-41-682)

Beneficial Uses	Walla Walla River Main Stem from Confluence of North and South Forks to State Line	All Other Basin Streams
Public Domestic Water Supply[1]	X	X
Private Domestic Water Supply[1]	X	X
Industrial Water Supply	X	
Irrigation	X	X
Livestock Watering	X	X
Anadromous Fish Passage	X	X
Salmonid Fish Rearing	X	X
Salmonid Fish Spawning	X	X
Resident Fish & Aquatic Life	X	X
Wildlife & Hunting	X	X
Fishing	X	X
Boating	X	X
Water Contact Recreation	X	X
Aesthetic Quality	X	X
Hydro Power		X

[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards

SA\Table\WH5299.5

FIGURE 14

GRANDE RONDE BASIN
(340-41-722)

(Note: Basin Boundaries are as shown in figure below.)

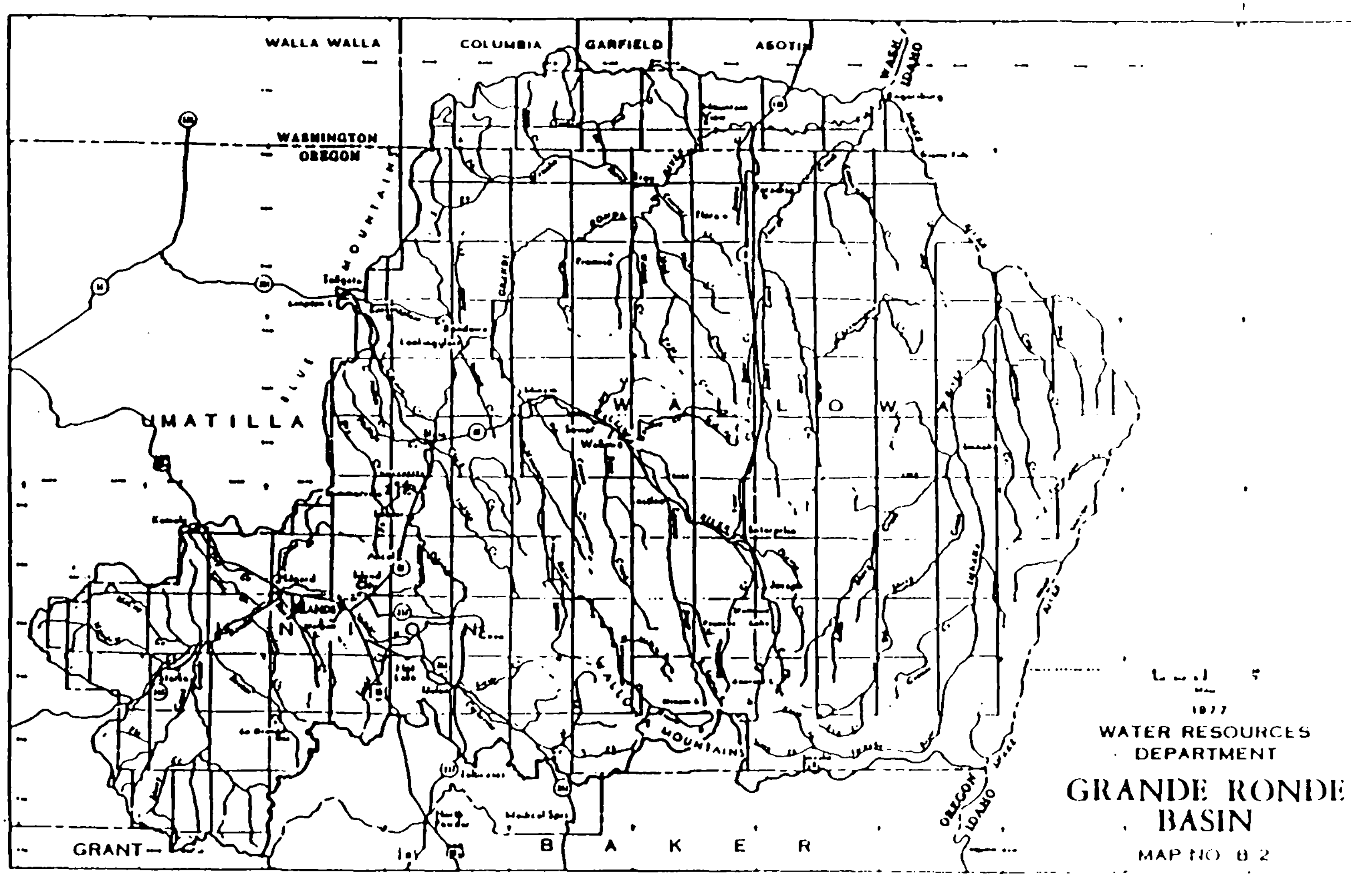


TABLE 13

GRANDE RONDE BASIN
(340-41-722)

Beneficial Uses	Main Stem Snake River (RM 176 to 260)	Main Stem Grande Ronde River (RM 39 to 165)	All Other Basin Waters
Public Domestic Water Supply[1]	X	X	X
Private Domestic Water Supply[1]	X	X	X
Industrial Water Supply	X	X	X
Irrigation	X	X	X
Livestock Watering	X	X	X
Anadromous Fish Passage	X	X	X
Salmonid Fish Rearing	X	X	X
Salmonid Fish Spawning	X	X	X
Resident Fish & Aquatic Life	X	X	X
Wildlife & Hunting	X	X	X
Fishing	X	X	X
Boating	X	X	X
Water Contact Recreation	X	X	X
Aesthetic Quality	X	X	X
Commercial Navigation & Transportation	X		

[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards.

SA\Table\WH5300.5

FIGURE 15

POWDER BASIN
(340-41-762)

(Note: Basin Boundaries are as shown in figure below.)

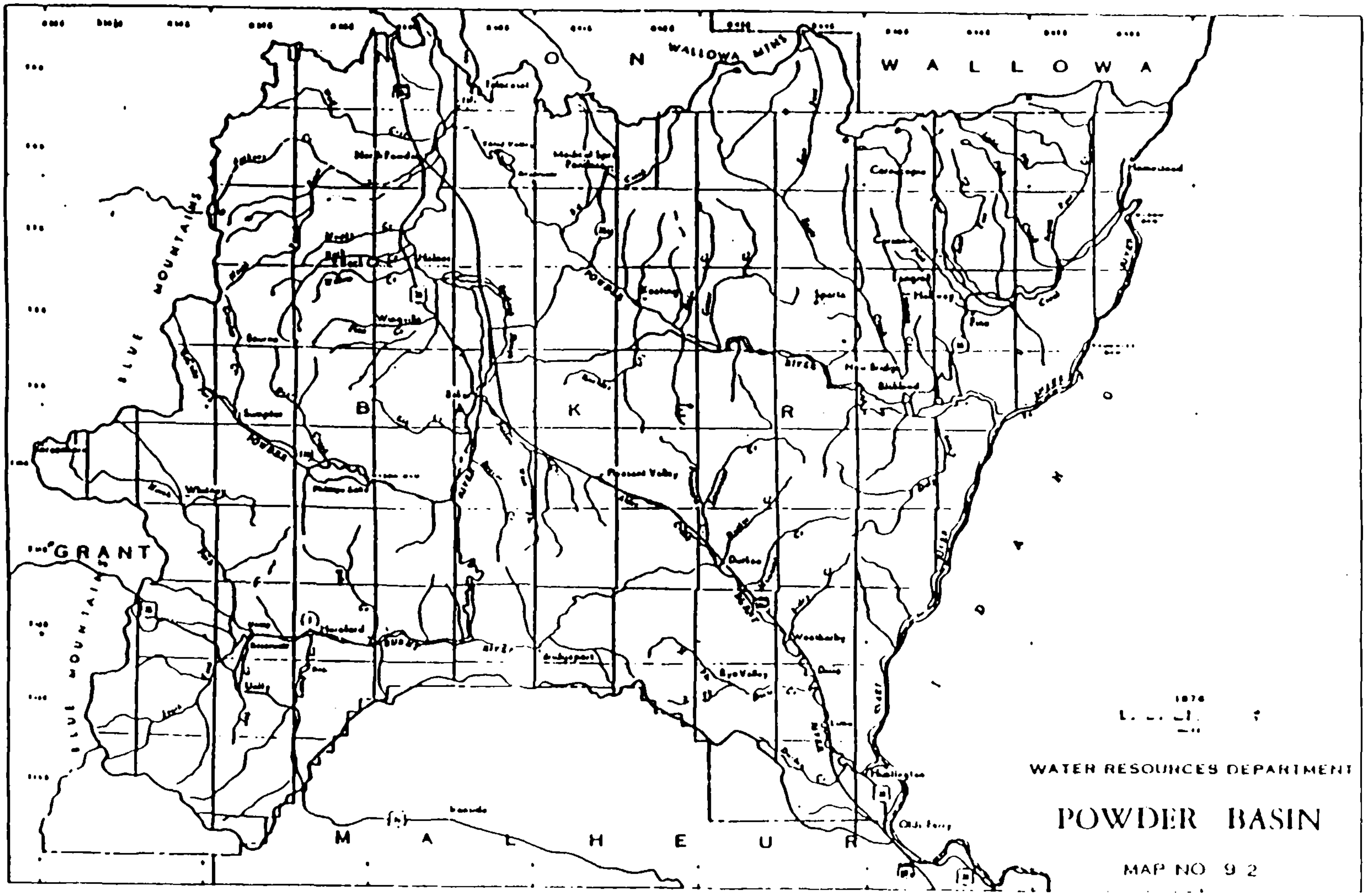


TABLE 14

POWDER BASIN
(340-41-762)

Beneficial Uses	Main Stem Snake River (RM 260 to 335)	All Other Basin Waters
Public Domestic Water Supply[1]	X	X
Private Domestic Water Supply[1]	X	X
Industrial Water Supply	X	X
Irrigation	X	X
Livestock Watering	X	X
Salmonid Fish Rearing	X	X
Salmonid Fish Spawning	X	X
Resident Fish & Aquatic Life	X	X
Wildlife & Hunting	X	X
Fishing	X	X
Boating	X	X
Water Contact Recreation	X	X
Aesthetic Quality	X	X
Hydro Power	X	

[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards.

SA\Table\WH5301.5

FIGURE 16

MALHEUR RIVER BASIN
(340-41-802)

(Note: Basin Boundaries are as shown in figure below.)

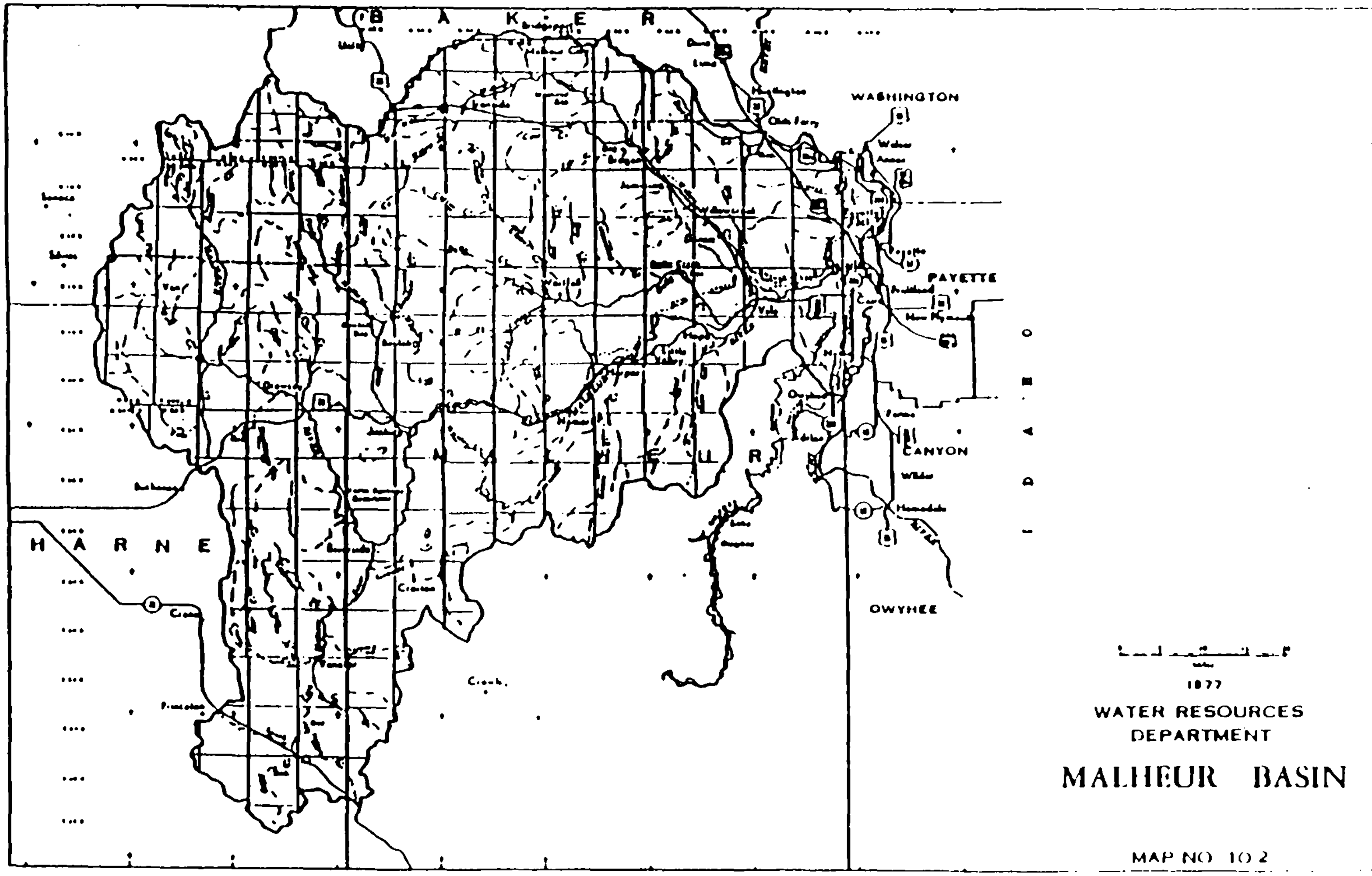


TABLE 15

MALHEUR RIVER BASIN
(340-41-802)

Beneficial Uses	Snake River Main Stem (RM 335 to 395)	Malheur River (Namorf to Mouth) Willow Creek (Brogan to Mouth) Bully Creek (Reservoir to Mouth)	Willow Creek (Malheur Reservoir to Brogan) Malheur R. (Beulah Dam & Warm Springs Dam to Namorf)	Reservoirs Malheur Bully Creek Beulah Warm Springs	Malheur River & Tributaries Upstream from Reservoirs
Public Domestic Water Supply[1]	X	X	X	X	X
Private Domestic Water Supply[1]	X	X	X	X	X
Industrial Water Supply	X	X	X	X	X
Irrigation	X	X	X	X	X
Livestock Watering	X	X	X	X	X
Salmonid Fish Rearing (trout)	X		X	X	X
Salmonid Fish Spawning (trout)	X		X		X
Resident Fish (Warm Water) & Aquatic Life	X	X	X	X	X
Wildlife & Hunting	X	X	X	X	X
Fishing	X	X	X	X	X
Boating	X	X	X	X	X
Water Contact Recreation	X	X	X	X	X
Aesthetic Quality	X	X	X	X	X

[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards.

SA\Table\WH5302.5

FIGURE 17

OWYHEE BASIN
(340-41-842)

(Note: Basin Boundaries are as shown in figure below.)

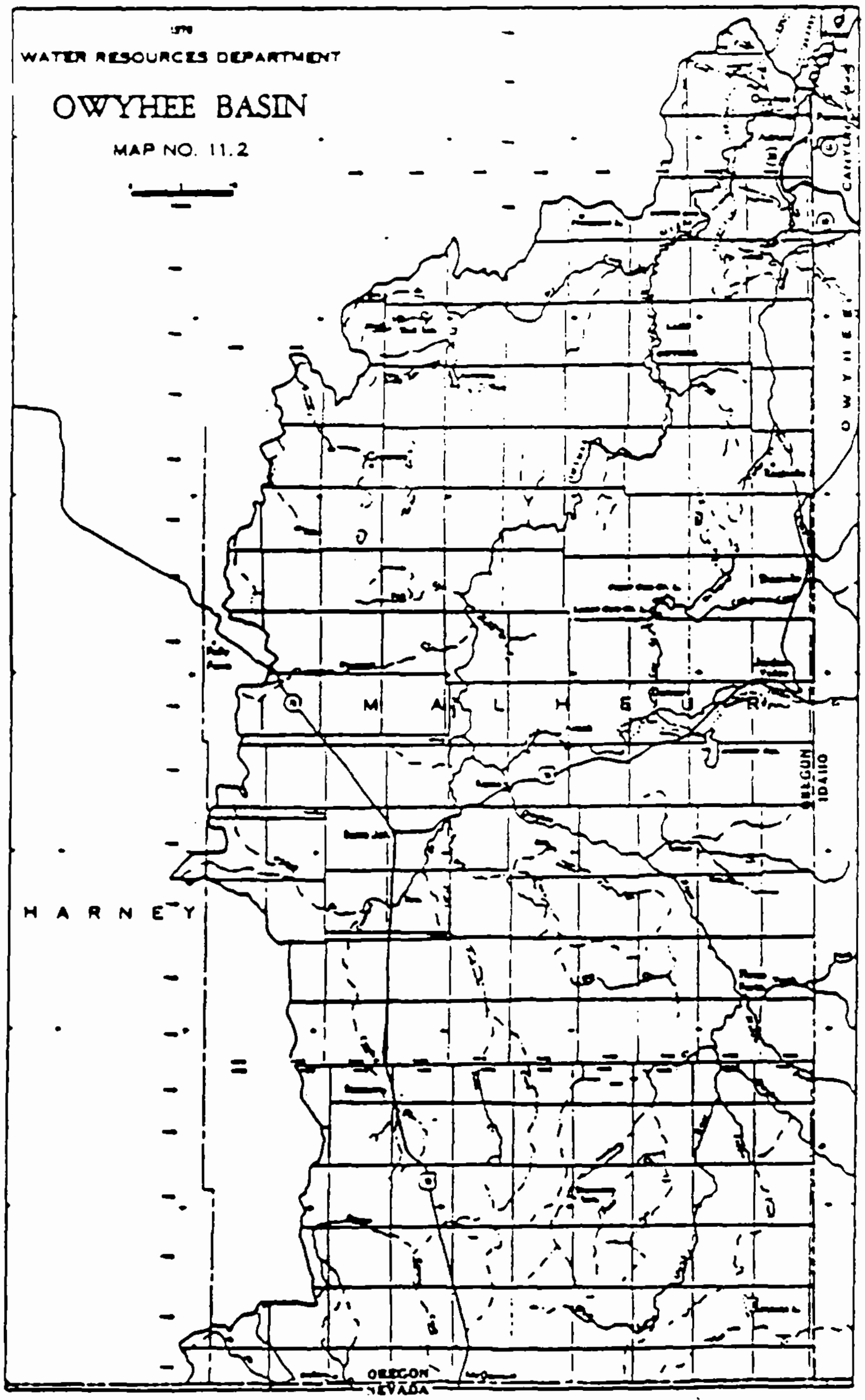


TABLE 16

OWYHEE BASIN
(340-41-842)

Beneficial Uses	Snake River (RM 295 — 409)	Owyhee River (RM 0 — 18)	Owyhee River (RM 18 — Dam)	Reservoirs Antelope Cow Creek Owyhee	Owyhee River & Tributaries Upstream from Owyhee Reservoir	Designated Scenic Waterway[2]
Public Domestic Water Supply[1]	X	X	X	X	X	X
Private Domestic Water Supply[1]	X	X	X	X	X	X
Industrial Water Supply	X	X	X	X	X	
Irrigation	X	X	X	X	X	
Livestock Watering	X	X	X	X	X	X
Salmonid Fish Rearing (Trout)	X		X	X	X	X
Salmonid Fish Spawning (Trout)	X		X		X	X
Resident Fish (Warm Water) & Aquatic Life	X	X	X	X	X	X
Wildlife & Hunting	X	X	X	X	X	X
Fishing	X	X	X	X	X	X
Boating	X	X	X	X	X	X
Water Contact Recreation	X	X	X	X	X	X
Aesthetic Quality	X	X	X	X	X	X

[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards.

[2] The mainstem of the South Fork of the Owyhee River from the Oregon — Idaho River border to Three Forks (the confluence of the North, Middle and South Forks Owyhee River) and the mainstem Owyhee River from Crooked Creek (river mile 22) to the mouth of Birch Creek (river mile 76) is designated by statute as a Scenic Waterway.

SA\Table\WH5303.5

FIGURE 18

MALHEUR LAKE BASIN
(340-41-882)

(Note: Basin Boundaries are as shown in figure below.)

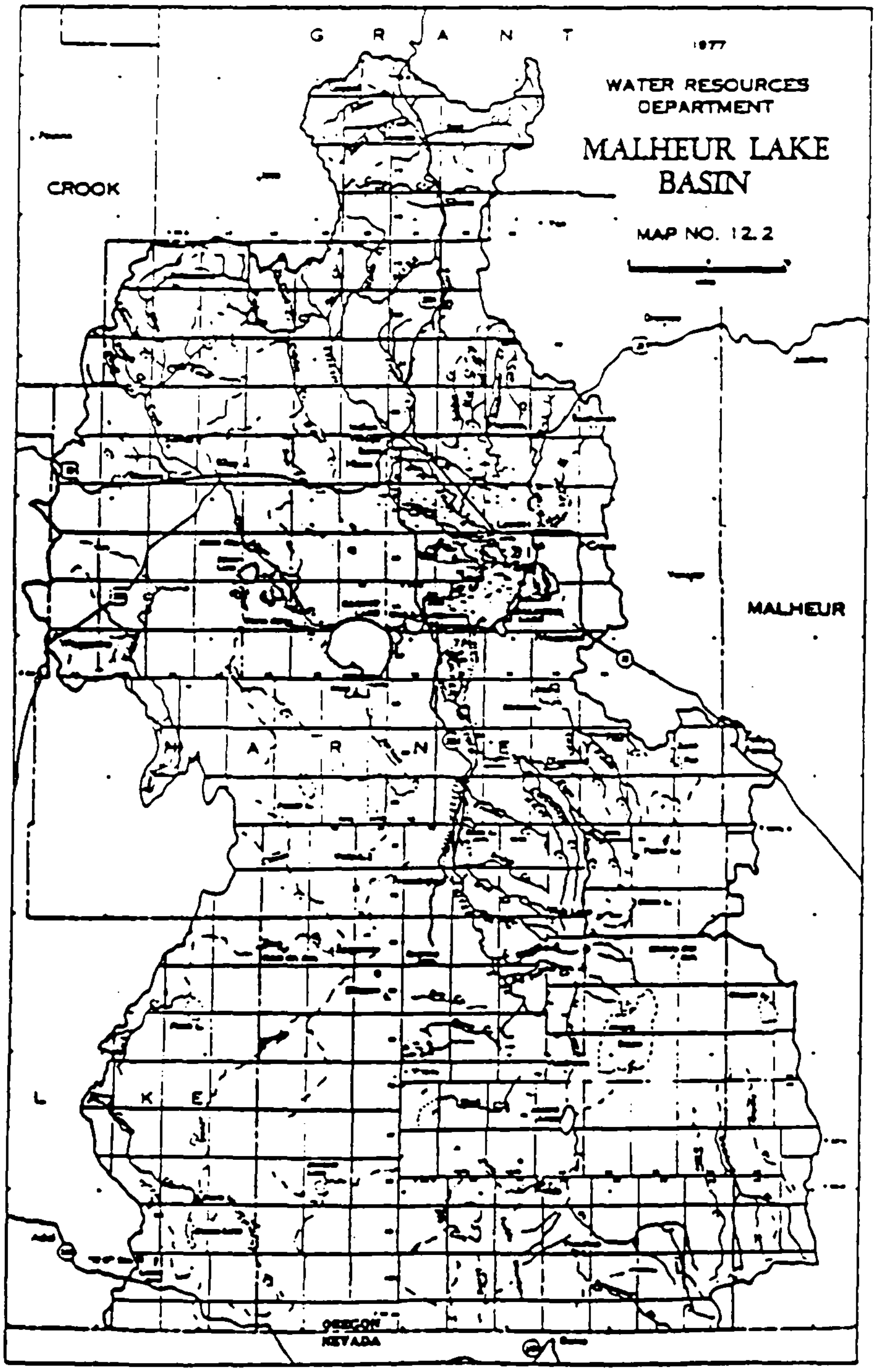


TABLE 17

MALHEUR LAKE BASIN
(340-41-882)

Beneficial Uses	Natural Lakes	All Rivers & Tributaries
Public Domestic Water Supply[1]		X
Private Domestic Water Supply[1]		X
Industrial Water Supply		X
Irrigation	X	X
Livestock Watering	X	X
Salmonid Fish Rearing (Trout)		X
Salmonid Fish Spawning (Trout)		X
Resident Fish & Aquatic Life	X	X
Wildlife & Hunting	X	X
Fishing	X	X
Boating	X	X
Water Contact Recreation	X	X
Aesthetic Quality	X	X

[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards.

SA\Table\WH5304.5

FIGURE 19

GOOSE & SUMMER LAKES BASIN
(340-41-922)

(Note: Basin Boundaries are as shown in figure below.)

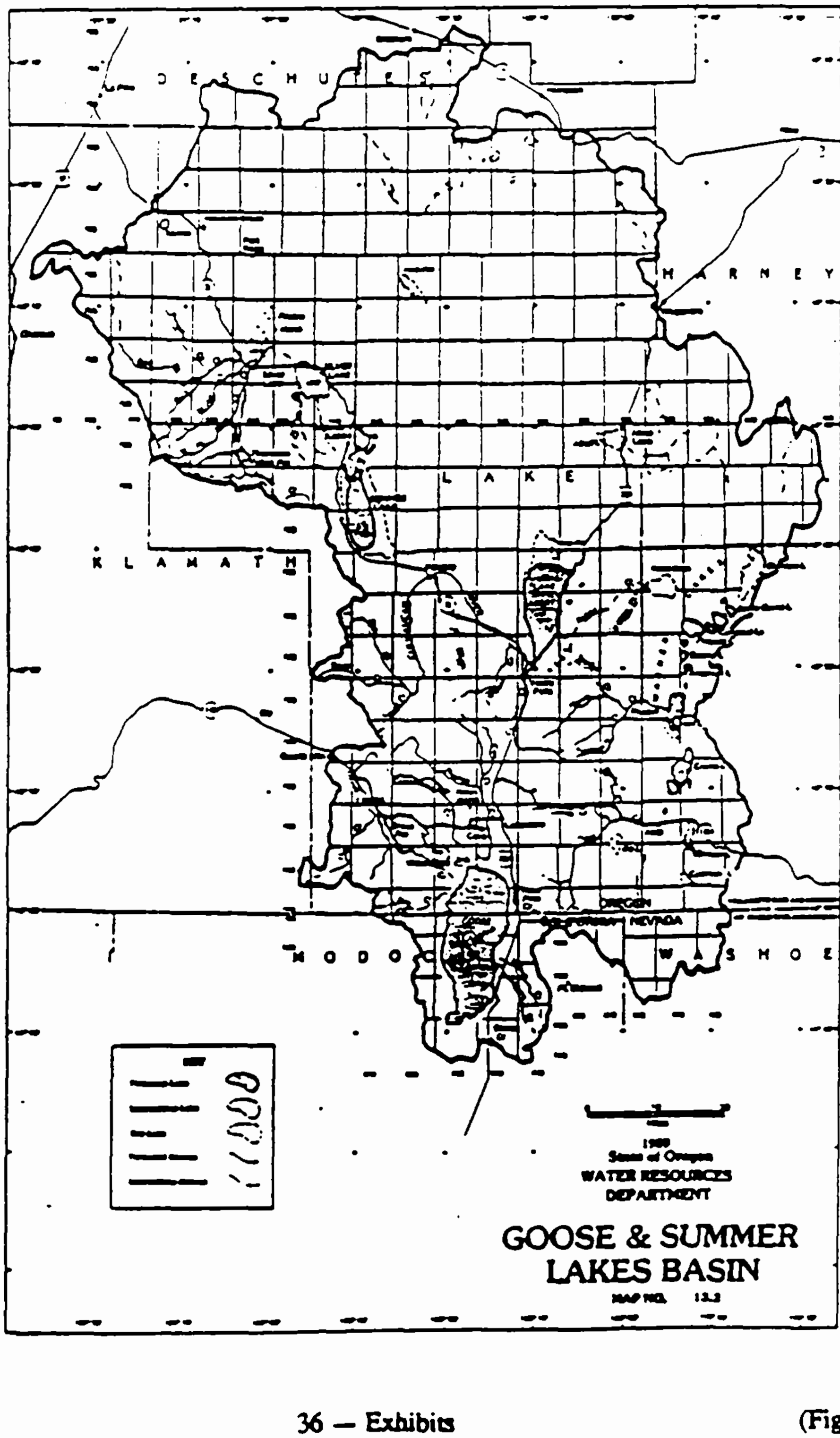


TABLE 18

GOOSE AND SUMMER LAKES BASIN
(340-41-922)

Beneficial Uses	Goose Lake	Fresh Water Lakes & Reservoirs	Highly Alkaline & Saline Lakes	Freshwater Streams
Public Domestic Water Supply[1]		X		X
Private Domestic Water Supply[1]		X		X
Industrial Water Supply		X	X	X
Irrigation		X		X
Livestock Watering	X	X		X
Salmonid Fish Rearing (Trout)	X	X		X
Salmonid Fish Spawning (Trout)		X		X
Resident Fish & Aquatic Life	X	X	X	X
Wildlife & Hunting	X	X	X	X
Fishing	X	X	X	X
Boating	X	X	X	X
Water Contact Recreation	X	X	X	X
Aesthetic Quality	X	X	X	X

[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards.

SA\Table\WH5305.5

FIGURE 20

KLAMATH BASIN
(340-41-962)

(Note: Basin Boundaries are as shown in figure below.)

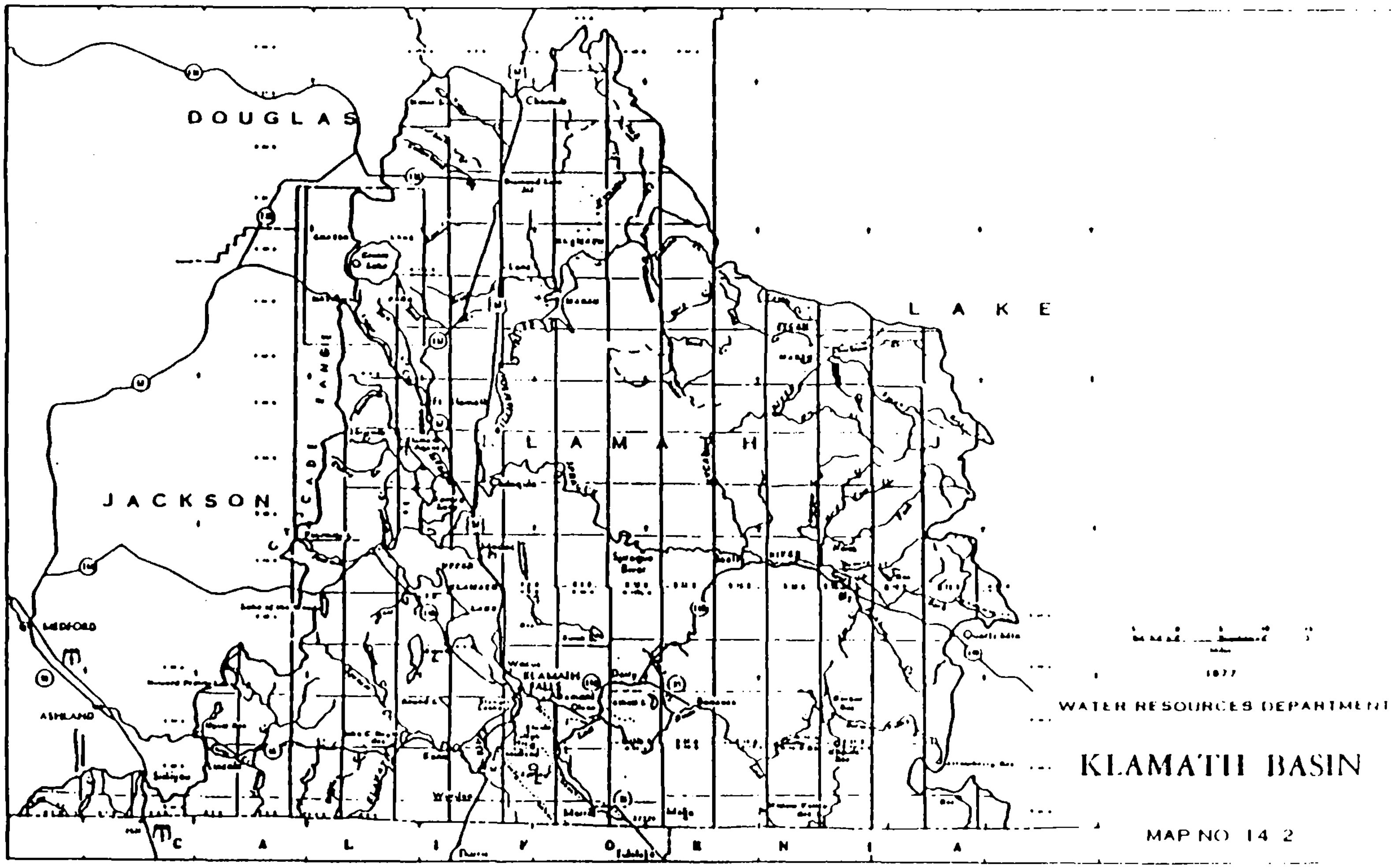


TABLE 19

KLAMATH BASIN
(340-41-962)

Beneficial Uses	Klamath River from Klamath Lake to Keno Dam (RM 255 to 232.5)	Lost River (RM 5 to 65) & Lost River Diversion Channel	All Other Basin Waters
Public Domestic Water Supply[1]	X	X	X
Private Domestic Water Supply[1]	X	X	X
Industrial Water Supply	X	X	X
Irrigation	X	X	X
Livestock Watering	X	X	X
Salmonid Fish Rearing[2]			X
Salmonid Fish Spawning[2]			X
Resident Fish & Aquatic Life	X	X	X
Wildlife & Hunting	X	X	X
Fishing	X	X	X
Boating	X	X	X
Water Contact Recreation	X	X	X
Aesthetic Quality	X	X	X
Hydro Power	X		
Commercial Navigation & Transportation	X		

[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards.
[2] Where natural conditions are suitable for salmonid fish use.

SA\Table\WH5306.5

APPENDIX C

Policy letter from Michael T. Llewelyn, Oregon Department of Environmental Quality, dated June 22, 1998 to Philip Millam, EPA Region 10, clarifying Oregon's water quality standards revision.

Appendix C

Oregon

June 22, 1998

DEPARTMENT OF ENVIRONMENTAL QUALITY

JUL - 6 1998

Philip Millam
Director, Office of Water, OW-134
U.S. Environmental Protection Agency, Region X
1200 Sixth Avenue
Seattle, Washington 98101

Dear ~~Phil:~~ Phil

This letter is to provide policy clarification of the Oregon water quality standards revisions that were submitted for Environmental Protection Agency's (EPA) approval on July 10, 1996. Specifically, this letter addresses how the Department of Environmental Quality (DEQ) is interpreting certain language contained in the Oregon Water Quality Standards (OAR 340-41) and responds to questions that EPA has raised in its review of the standards.

The regulatory clarifications included herein will be incorporated into the water quality standards, to the extent possible, during the next triennial review. As there are quite a number of issues that are candidates for review in the next triennial review, we will need to carefully prioritize these issues working with EPA and the next Policy Advisory Committee.

The following comments are organized in the following manner: beneficial use issues, numeric criteria issues and implementation issues.

BENEFICIAL USE ISSUES:

Bull Trout Waters: The language in the rule (OAR 340-41- basin (2)(b)(A)) reads: "*...no measurable surface water temperature increase resulting from anthropogenic activities is allowed: ... (v) In waters determined by the Department to support or to be necessary to maintain the viability of native Oregon bull trout, when surface water temperatures exceed 50.0° F (12.8° C)*". [Please note that the specific citation for the temperature criteria for Bull Trout may vary slightly in its numbering depending on the basin, this example and subsequent citations are from the standards for the Willamette Basin (OAR 340-41-445)]

The Department has consulted with the Oregon Department of Fish and Wildlife (ODFW) to make a determination of the current distribution of Bull Trout. Maps have been developed by ODFW as part of an effort to develop plans to protect and restore Bull Trout populations. These maps can be found in the following publication: "Status of Oregon's Bull Trout" (Oregon Department of Fish and Wildlife. October 1997. Buchanan, David, M. Hanson and R. Hooton. Portland, OR) which is available from ODFW or viewed in the "StreamNet" website (www.streamnet.org). A map showing the most recent Bull Trout distribution (export file dated June 1997) has been sent separately to EPA and a digital version can be provided to EPA.

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The Department will use the 1997 Bull Trout distribution maps contained in the 1997 ODFW publication to clarify the phrase "waters determined by the Department to support or to be necessary to maintain the viability of native Oregon Bull Trout." The temperature criteria of 50°F applies to the stream reaches which indicate that "Spawning, Rearing, or Resident Adult Bull Trout" populations are present. These waters are shown by a solid green line on the maps that are referenced.

The mapping and planning effort is an on-going effort by ODFW. Any changes made to the mapped distribution will represent a change in the standard which would be submitted to EPA for approval. The Bull Trout portion of the standards will be revised to incorporate a reference to the 1997 ODFW publication or identify any other means for determining waters that support or are necessary to support Bull Trout in the next triennial standards review.

Waters supporting spawning, egg incubation and fry emergence: The language in the rule reads:

Temperature (OAR 340-41- basin (2)(b)(A)): "*...no measurable surface water temperature increase resulting from anthropogenic activities is allowed: ... (iv) In waters and periods of the year determined by the Department to support native salmonid spawning, egg incubation, and fry emergence from the egg and from the gravels in a basin which exceeds 55°F (12.8°C)*".

Dissolved Oxygen (OAR 340-41- basin (2)(a)(A)): "*For waterbodies identified by the Department as providing salmonid spawning, during the periods from spawning until fry emergence from the gravels, following criteria apply...*"

The Beneficial Use Tables (Tables 1-19 in the Oregon water quality standards) indicate the recognized beneficial uses to generally be protected **in the basin**. In some basins (e.g. Table 15, Malheur River Basin), the information in the Tables has been refined for particular water bodies. In general, salmonid spawning and rearing are shown on the tables to be found in all basins. In order to make the spawning determinations, information on location and timing in a specific waterbody is further developed through consultation with ODFW as spawning does not occur at all times of the year or in all locations in the basin. In addition, timing often varies from year to year depending on seasonal factors such as flow. ODFW, in cooperation with other federal and tribal fishery agencies has begun to map out this information on a species by species basis (StreamNet Project) but this work is still several years from completion.

DEQ is submitting the attached table that identifies when the spawning criteria listed under the dissolved oxygen and temperature standards will be applied to a basin. This table provides the generally accepted time frame during which spawning occurs. However, spawning periods for Spring Chinook and Winter Steelhead vary with elevation (e.g. Spring Chinook tend to spawn earlier and fry emergence occurs later in the Spring for Winter Steelhead in streams at higher elevations). Therefore, to address differences in actual spawning periods, the Department will consult directly with the ODFW to determine if waterbody specific adjustments (which would be changes to the standards) are necessary

Furthermore, the Department will apply the antidegradation policy in specific actions, e.g. permits, 401 certification and 303(d) listing, to protect spawning that occurs outside the identified time frames or utilize the narrative temperature criteria that applies to threatened or endangered species.

Application of the warm-water Dissolved Oxygen Criteria (OAR 340-41- basin (2)(a)(F)):
The language in the rule reads: *"For waterbodies identified by the Department as providing warm-water aquatic life, the dissolved oxygen shall not be less than 5.5 mg/l as an absolute minimum..."*

Warm-water criteria is applied in waters where Salmonid Fish Rearing and Salmonid Fish Spawning are not a listed beneficial use in Tables 1 - 19 with the exception of Table 19 (Klamath Basin) in which the cool water dissolved oxygen criteria will be applied (see Klamath TMDL supporting documentation, (Hammon 1998)). Specifically, the warm water criteria would be applied to:

Table 15: Malheur River (Namorf to Mouth), Willow Creek (Brogan to Mouth), Bully Creek (Reservoir to Mouth);
Table 16: Owyhee River (RM 0-18);
Table 17: Malheur Lake Basin - Natural Lakes;
Table 18: Goose and Summer Lakes Basin - High Alkaline & Saline Lakes.

Application of the cool-water Dissolved Oxygen Criteria (OAR 340-41- basin (2)(a)(E)):
The language in the rule reads: *"For waterbodies identified by the Department as providing cool-water aquatic life, the dissolved oxygen shall not be less than 6.5 mg/l as an absolute minimum..."*

Cool-water aquatic life is a sub-category of cold-water aquatic life and is defined under OAR 340-41-006 (52) as *"the aquatic communities that are physiologically restricted to cool waters, composed of one or more species having dissolved oxygen requirements believed similar to the cold-water communities. Including but not limited to Cottidae, Osmeridae, Acipenseridae, and sensitive Centrachidae such as the small-mouth bass."* This criteria will be applied on an ecoregional basis[1] (see attached map) as follows:

West Side:

Cold Water: Coast Range Ecoregion - all, Sierra Nevada Ecoregion -all, Cascade-all, Willamette Valley - generally typical including Willamette River above Corvallis, Santiam (including the North and South), Clackamas, McKenzie, Mid Fork and Coast Fork mainstems.

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[1] The original Ecoregions described in "Ecorgions of the Pacific Northwest" (James Omernik and A. Gallant 1986 EPA/600/3-86/033) were used. This work is currently being updated but is not complete for Oregon. The terms most typical and generally typical are defined as follows. The most typical portions of ecoregions are generally those areas that share all of the characteristics that are predominant in each ecoregion. The remaining portions, generally typical of each ecoregion, share most but not all of these same characteristics. These areas are defined on maps included in the publication referenced above and have been sent separately to EPA.

Cool Water: Willamette Valley Ecoregion - most typical.

East Side (with the exception of waters listed under warm water criteria in Tables 15-19):
Cold Water: Eastern Cascades Slopes and Foothills - most typical, Blue Mountain - most typical.
Cool Water: Remainder of Eastern Oregon Ecoregions.

NUMERIC CRITERIA ISSUES:

Temperature criteria for waters without a specific numeric criterion: The temperature criteria of 64°F will be applied to all water bodies that support salmonid fish rearing as identified in Tables 1 - 19. This would include all waters except those listed as warm water above. Currently, there is no numeric criteria for those waters listed as warm water. This was an inadvertent oversight for the rivers described under 2 and 3 below which will be corrected by setting site specific criteria during the next triennial review. In the mean time, these waters will be protected as follows:

1. There is a criteria that covers natural lakes and would cover lakes in the Malheur Lake Basin (Table 17) and Goose and Summer Lakes Basin (Table 18). This criteria (OAR 340-41-922 (2)(b)(A)) reads: *"...no measurable surface water temperature increase resulting from anthropogenic activities is allowed: ... (vii) In natural lakes".*

2. The waters shown in the Klamath Basin (Table 19) are currently listed in Oregon's 1994/96 303(d) list for temperature based on exceedence of the criterion that is linked to dissolved oxygen. This criterion (OAR 340-41-965 (2)(b)(A)) reads: *"...no measurable surface water temperature increase resulting form anthropogenic activities is allowed: ... (vi) In Oregon waters when the dissolved oxygen (DO) levels are within 0.5 mg/l or 10 percent saturation of the water column or intergravel DO criterion for a given stream reach or subbasin."* An additional narrative criterion would apply to these waters as they contain a federally listed Threatened and Endangered species - Lost River Sucker and Shortnose Sucker, both of which are listed as endangered (USFWS, 7/88, 53FR27130). This criterion (OAR 340-41-965 (2)(b)(A)) states: *"no measurable surface water temperature increase resulting form anthropogenic activities is allowed: ... (v) In stream segments containing federally listed Threatened and Endangered species if the increase would impair the biological integrity of the Threatened and Endangered population."* A Site Specific Criteria is currently being developed as part of a TMDL for these waters and a new criteria for temperature will be established. This criterion will be adopted by the EQC and submitted to EPA for approval prior the completion of a TMDL. This work should be accomplished during our next triennial standards review (1998 - 2000). The TMDL schedule is currently being negotiated with EPA.

3. Warm water streams in the lower Malheur and Owyhee (Table 15 and 16) would be addressed in a similar manner using temperature criterion that relates to dissolved oxygen. These waters were not listed on the current 303(d) list as the waters were not within 0.5 mg/l or 10 percent saturation of the water column DO criterion. These waters

are included in beneficial use survey work that the Department is undertaking in the Snake River Basin/High Desert Ecoregion. This work, which will include the development of numeric temperature criteria for these waters, will be accomplished during our next triennial standards review (1998-2000).

Willamette and Columbia River Temperature Criteria: The language in the rule (OAR 340-41-445 (2)(b)(A)) reads: *"...no measurable surface water temperature increase resulting from anthropogenic activities is allowed: ... (ii) In the Columbia River or its associated sloughs and channels from the mouth to river mile 309 when surface water temperatures exceed 68.0°F (20.0°C); (iii) In the Willamette River or its associated sloughs and channels from the mouth to river mile 50 when surface water temperatures exceed 68.0°F (20.0°C)."*

For the Columbia River, this is not a change to the previous standard (OAR 340-41-445 (2) (b) (D). The Columbia River forms the boundary between the states of Oregon and Washington and this criterion is consistent with the current temperature standard for the State of Washington.

For the Willamette River, this value represents a decrease from the previous temperature criteria of 70°F and makes it consistent with the Columbia River numeric criteria. The technical committee had recommended the 68°F criteria for these large, lower river segments recognizing that temperatures were expected to be higher in these segments as factors such as the naturally wide channels would minimize the ability to shade these rivers and reduce the thermal loading.

Both of these rivers are water quality limited for temperature and the temperature criteria can be revisited as part of the effort to develop Total Maximum Daily Loads. The Department is currently working with EPA to develop a temperature assessment for the Columbia River and is participating in a Willamette Basin Reservoir Study with the Corp of Engineers and other state agencies. The timing of specific TMDLs is currently being negotiated with EPA.

64° F Temperature Criteria: EPA has expressed concern that the 64°F criterion may not be fully protective. The Final Issue Paper on Temperature indicates that "the incidence of disease from *Chondrococcus columnaris* increases above 60-62° F and cites various sources for this statement (page 2-4 and Appendix D of the Final Issue Paper on Temperature). This is based both on observations from laboratory studies and field studies.

A review of this literature indicates that it is difficult to establish a temperature criteria for waters that experience diurnal temperature changes that would assure no affects due to *C columnaris*. For example, J. Fryer and K. Pilcher ("Effects of Temperature on Diseases of Salmonid Fishes EPA-660/3-73-020 1974) conducted in the laboratory studies using constant temperatures and concluded

"When coho and spring chinook salmon, and rainbow trout are infected with *C. columnans* by water contact, the percentage of fatal infections is high at temperatures of 64°F and above, moderate at 59°F and approaches zero at 49°F and below. A temperature of 54°F is close to the threshold for development of fatal infection of salmonids by *C. columnaris.*"

There is literature that suggests that fish pathogens which affect Oregon's cold-water fishes become more infective and virulent at temperatures ranging from the lower mid-sixties to low seventies (Becker and Fujihara, 1978). Ordal and Pacha (1963) found that mortalities due to *C. columnaris* outbreaks are lessened or cease when temperatures are reduced below 65°F. Bell (1986) suggested that outbreaks of high virulence strains of *C. columnaris* occur when average water temperatures reach 15.5°C and the low virulence strains become apparent with average water temperatures over 20°C.

A good discussion of field studies is given in the report "Columbia River Thermal Effects Study" (EPA, 1971).

"Natural outbreaks of columnaris disease in adult salmon have been linked to high water temperatures in the Fraser River, British Columbia. ...The pathological effects of the disease became evident when water temperatures along the migration route, and in spawning areas, exceeded 60°F. Prespawning mortality reached 90 percent in some tributaries. Columnaris is the infected sockeye spawners was controlled when temperatures fell below 57-58°F and mortalities were reduced. "

"Data collected on antibody levels in the Columbia River fish "...suggest peak yearly effective infection of at least 70 percent to 80 percent of most adult river fish species" (Fujihara and Hungate, 1970). Occurrence of the disease was generally associated with temperatures above 55°F; the authors further suggest that the incidence of columnaris may be increased by extended periods of warm temperatures than by peak summer temperatures."

"Other factors including the general condition of the fish, nutritional state, size, presence of toxicants, level of antibody protection, exposure to nitrogen supersaturation, level of dissolved oxygen, and perhaps other factors interrelate in the infection of fish by diseases. However, the diseases discussed here are of less importance at temperatures below 60°F; that is, in most instances mortalities due to columaris are minimized or eliminated below that level."

As indicated in the section on "Standard Alternatives and Technical Evaluation" in the Temperature Issue Paper, the technical committee had recommended a temperature range (58 - 64°F) as being protective for salmonid rearing. While 64°F is at the upper end of the range, the key to this recommendation is the temperature unit (page 3-2) that is used in the standard - the seven-day moving average of the daily maximum temperatures. Exceedence of the criteria is based on the average of the daily maximum temperatures that a waterbody experiences over the course of seven consecutive days exceeding 64°F.

Streams experience a natural fluctuation of daily temperatures so streams that were just meeting the temperature standard would be experiencing temperatures over 60°F for only short periods of time during the day and have lower average temperatures. For example, the Department has summarized temperature data collected at 6 sites around the state which are near the 7-day average of the daily maximum of 64°F (see table below). As shown, the daily average temperatures typically range between 55-60°F. Risks should be minimized at these average temperatures.

In conclusion, the criteria does not represent an assured no-effect level. However, because the criteria represent a "maximum" condition, given diurnal variability, conditions will be better that criteria nearly all of the time at most sites.

	7-Day Statistic	Average Daily Temperatures						
		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Grande Ronde Basin								
East Fork Grande Ronde River	64.7	57.8	58.1	57.4	57.1	57.3	58.0	58.1
Beaver Creek (upstream La Grande Res.)	65.2	55.1	56.5	58	58.2	59.7	60.1	59.9
Umpqua Basin								
Jim Creek (mouth)	62.5	58.2	59.5	59.9	60.1	58.6	55.7	56.8
Pass Creek (upper)	64.4	59.0	58.7	58.1	58.5	59.1	59.3	57.7
Tillamook Basin								
Myrtle Creek (mouth)	65.0	57.7	59.1	58.6	57.9	58.0	57.6	56.8
Sam Downs Creek (mouth)	63.9	55.8	55.9	55.5	55.5	55.7	55.6	56.1

Minimum Dissolved Oxygen Criteria for Cool Water and Warm Water Species:

Warm Water: The Oregon warm water criteria for dissolved oxygen is 5.5 mg/l as a 30 day mean and 4.0 mg/l as a minimum. These values meet or exceed the recommended national criteria for warm water criteria for other life stages (5.5 mg/l as a 30 day mean and 3.0 as a 1 day minimum as shown in Table 1 of the dissolved oxygen criteria in *Quality Criteria for Water, 1986* (EPA 440/5-86-001)). These values are slightly below national criteria suggested for protection of early life stages (6.0 mg/l as a 7 day mean and 5.0 as a 1 day minimum as shown in Table 1 of the dissolved oxygen criteria in *Quality Criteria for Water, 1986)*. As shown on Table 2 of the dissolved oxygen criteria in *Quality Criteria for Water, 1986*, this would represent a slight impairment for early life stages.

This criteria would be applied to both native and non-native warm water species. Table 2-3 in the Temperature Issue Paper (page 2-14) contains a list of non-salmonid fish species present in Oregon. Warm water species include Borax Chub, Cyprinids (goldfish, carp, fathead minnows), Centrarchids (Bluegill, Crappie, Large-mouth Bass), and Catfish. The only known warm-water species that is native to Oregon is the Borax Chub which is found near a hot springs. The others have been introduced and now perpetuate themselves in some basins. These species are typically Spring spawners (April - June) during which times dissolved oxygen values are not at the seasonal lows (July - August) and typically have not been found to be a problem. In addition, salmonid spawning criteria, which are more protective, typically apply during these time period.

It should be noted that most of the introduced warm water species now compete with the native cold and cool water species for habitat and food. There are numerous recovery plans being developed for these native species. A level of protection that may have a slight production impairment for non-native warm water species is not necessarily undesirable.

Cool Water: A cool water classification was created to protect cool water species where cold-water biota may be present during part or all of the year but would not form the dominate community structure. The cool water criteria match the national coldwater criteria - other life stages criteria.

Table 2-3 in the Temperature Issue Paper (page 2-14) contains a list of non-salmonid fish species present in Oregon. Cool water species include: Chub; Suckers; Sandroller; Sturgeon; Centrarchids (Small-mouth Bass); Striped Bass; and Walleye. Small mouth bass, striped bass and walleye are introduced species. This category was set up to provide more protection than that afforded by the other life stage criteria for warm water fish and, as discussed in the Gold Book, we provided these cool water species with the cold water species protection suggested in the national criteria (Table 1 of the dissolved oxygen criteria in *Quality Criteria for Water*, 1986). These species are typically Spring spawners (April - June) during which times dissolved oxygen values are not at the seasonal lows (July-August) and typically have not been found to be a problem.

Table 2-2 of the Dissolved Oxygen Issue Paper indicates that salmonids and other cold-water biota may be present during part or all of the year but may not dominate community structure. Any salmonid spawning would still be covered by the salmonid spawning standard. The Oregon standards provide higher protection for salmonid spawning and cold water rearing than that recommended under the national criteria by choosing the "no production impairment" levels suggested in Table 2 of the dissolved oxygen criteria in *Quality Criteria for Water*, 1986.

When adequate information/data exists: The dissolved oxygen standard provides multiple criteria for cold, cool and warm water aquatic life. For example, OAR 340-41-445 (2) (a) (D) reads: *"For waterbodies identified by the Department as providing cold-water aquatic life, the dissolved oxygen shall not be less than 8.0 mg/l as an absolute minimum. Where conditions of barometric pressure, altitude, and temperature preclude attainment of the 8.0 mg/l, dissolved oxygen shall not be less than 90 percent of saturation. At the discretion of the Department, when the Department determines that adequate information exists, the dissolved oxygen shall not fall below 8.0 mg/l as a 30-day mean minimum, 6.5 mg/l as a seven-day minimum mean, and shall not fall below 6.0mg/l as an absolute minimum (Table 21)."*

In this example, the Department would routinely compare dissolved oxygen values against 8.0 mg/l criteria (the higher dissolved oxygen criteria). Most dissolved oxygen data is collected by a grab sample during the day time and would not reflect minimum conditions, that is why we would use a more restrictive criteria. Adequate information to use the other criteria would involve the collection of diurnal data over long enough periods of time (e.g. multiple days or multiple weeks) during critical time periods (e.g. low flow periods, hottest water temperature periods, period of maximum waste discharge). Such data would be collected through continuous monitoring with proper quality assurance. Based on this data collection, sufficient data would be available to calculate means, minimum means and minimum values and to compare to the appropriate criteria. Models that would provide these statistics could also be compared to the appropriate criteria.

In addition, for actions such as permitting and developing TMDLs, additional information on the beneficial uses of the waterbody will be considered such as: species present; listing status of those species; locations, time periods and presence of sensitive early life stages, etc. Based on presence of early life stages or T&E species, the more conservative criteria would be used.

IMPLEMENTATION ISSUES:

Air temperature exemption to the water temperature criteria: OAR 340-41-basin (2)(b)(B) specifies that *"an exceedence of the numeric criteria identified subparagraph (A) ... of this subsection will not be deemed a temperature standard violation if it occurs when the air temperature during the warmest seven-day period of the year exceeds the 90th percentile of the seven-day average daily maximum air temperature calculated in a yearly series over the historic record. However, during such periods, the anthropogenic sources must still continue to comply with their surface water temperature management plans developed under OAR 340-41-026(3)(a)(D)."*

This policy identifies criteria to be used in certain limited circumstances to determine whether a violation of the temperature water quality standard has occurred. This interpretation would be applied for the purposes of enforcement of standards and the 303(d) listing determinations. Our interpretation of how this air temperature exemption would be applied has been sent to you separately. In the 1994/96 303(d) list, no water bodies were excluded from the list for this reason.

Exceptions to the policy that prohibits new or increased discharged load to receiving streams classified as being water quality limited:

OAR 340-41-026 (3) (C) states "the new or increased discharged load shall not be granted if the receiving stream is classified as being water quality limited under OAR 340-41-006(30)(a) unless "

OAR 340-41-026 (3) (a) C (iii) added new language under this policy which defines a condition under which a new or increased discharged load could be allowed to a water quality limited waterbody for dissolved oxygen. The language states: *"(iii) Effective July 1, 1996, in waterbodies designated water-quality limited for dissolved oxygen, when establishing WLAs under a TMDL for waterbodies meeting the conditions defined in this rule, the Department may at its discretion provide an allowance for WLAs calculated to result in no measurable reduction of dissolved oxygen. For this purpose, "no measurable reduction" is defined as no more than 0.10 mg/l for a single source and no more than 0.20 mg/l for all anthropogenic activities that influence the water quality limited segment. The allowance applies for surface water DO criteria and for Intergravel DO if a determination is made that the conditions are natural. The allowance for WLAs would apply only to surface water 30-day and seven-day means, and the IGDO action level."*

This is an implementation policy for OAR 340-41-026 (3) (C) and clarifies that we could allow for an increase in load in a waterbody that is water quality limited for dissolved oxygen as long as it did not result in a measurable reduction of dissolved oxygen as defined above and it was determined that the low DO values were due to a natural condition. A site specific criteria for the waterbody would need to be developed and submitted to EPA for review and approval.

<u>All feasible steps:</u> OAR 340-41-026 (3) (D) indicates that: *"Sources shall continue to maintain and improve, if necessary, the surface water temperature management plan in order to maintain the cooling trend until the numeric criterion is achieved or until the Department, in consultation with the Designated Management Agencies (DMAs), has determined that all feasible steps have been taken to meet the criterion and that the designated beneficial uses are not being adversely impacted. In this latter situation, the temperature achieved after all feasible steps have been taken will be the temperature criterion for the surface waters covered by the applicable management plan. The determination that all feasible steps have been taken will be based on, but not limited to, a site-specific balance of the following criteria: protection of beneficial uses; appropriateness to local conditions; use of best treatment technologies or management practices or measures; and cost of compliance."*

As indicated, if the waters do not come into compliance with the standard after all feasible steps have been taken, the Department would develop a site-specific criteria which would be submitted to EPA for approval pursuant to EPA policy.

<u>1.0° F increase for new or increased discharge loads from point sources or hydro-power projects in temperature water quality limited basins:</u> OAR 340-41-026 (3) (F), (G), (H) state: *"(F) In basins determined by the Department to be exceeding the numeric temperature criteria, and which are required to develop surface water temperature management plans, new or increased discharge loads from point source sources which require an NPDES permit under Section 402 of the Clean Water Act or hydro-power projects which require certification under Section 401 of the Clean Water Act are allowed a 1.0°F total cumulative increase in surface water temperatures as the surface water*

temperature management plan is being developed and implemented for the water quality limited basin if:

- *(i) in the best professional judgment of the Department, the new or increased discharge load, even with the resulting 1.0°F cumulative increase, will not conflict with or impair the ability of the surface water temperature management plan to achieve the numeric temperature criteria; and*
- *(ii) A new or expanding source must demonstrate that it fits within the 1.0°F increase and that its activities will not result in a measurable impact on beneficial uses. This latter showing must be made by demonstrating to the Department that the temperature change due to its activities will be less than or equal to 0.25°F under a conservative approach or by demonstrating the same to the EQC with appropriate modeling.*

(G) Any source may petition the Department for an exception to paragraph (F) of this subsection, provided:

- *(i) The discharge will result in less than 1.0°F increase at the edge of the mixing zone, and subparagraph (ii) or (iii) of this paragraph applies;*
- *(ii) The source provides the necessary scientific information to describe how the designated beneficial uses would not be adversely impacted; or*
- *(iii) The source demonstrates that:*
  - *(I) It is implementing all reasonable management practices;*
  - *(II) Its activity will not significantly affect the beneficial uses; and*
  - *(III) The environmental cost of treating the parameter to the level necessary to assure full protection would outweigh the risk to the resource.*

OAR 340-41-026 (3) (F) and (G) reflect an implementation policy for OAR 340-41-026 (3) (C). They clarify under what conditions the Department could allow for an increase in load to a waterbody that is water quality limited for temperature as long as the load did not result in a measurable increase in temperature (less than or equal to 0.25°F) or a cumulative increase of 1.0°F under (F) but a source could petition for up to the cumulative increase of 1.0°F under (G). The cumulative increase typically addresses the situation where there may be multiple new or increased discharges. A TMDL would still be developed to bring the waterbody back into compliance with the temperature criteria. The WLA and the permit for the new or increased source would target the appropriate temperature criteria using a conservative approach as shown below (e.g. calculations would be made using 63°F so that the cumulative increase would not be above the standard of 64°F).[1]

OAR 340-41-026 (3) (H) states: "*Any source or DMA may petition the Commission for an exception to paragraph (F) of this subsection, provided:*

- *(i) The source or DMA provides the necessary scientific information to describe how the designated beneficial uses would not be adversely impacted; or*
- *(ii) The source or DMA demonstrates that:*
  - *(I) It is implementing all reasonable management practices;*
  - *(II) Its activity will not significantly affect the beneficial uses; and*
  - *(III) The environmental cost of treating the parameter to the level necessary to assure full protection would outweigh the risk to the resource.* "

This exemption is a variance policy in which a source can petition the Commission to allow the temperature to increase by a specified amount for a limited period of time in order to allow for new or increased point source discharges to water quality limited waters until a TMDL is prepared. The variance would be submitted to EPA for review and approval. These variances would be reviewed again during the development of a TMDL or at permit renewal.

Source Petition for an exception to temperature criteria: OAR 340-41-basin (2)(b)(C) specifies that "*Any source may petition the Commission for an exception to subparagraph (A)...of this subsection for discharge above the identified criteria if: (i) The source provides the necessary scientific information to describe how the designated beneficial uses would not be adversely impacted; or (ii) a source is implementing all reasonable management practices or measures; its activity will not significantly affect the beneficial uses; and the environmental cost of treating the parameter to the level necessary to assure full protection would outweigh the risk to the resource.*"

[1] Examples of various of discharge scenarios using a conservative mass balance analysis. The odd numbered examples show a scenario when the stream meets standards. The subsequent even numbered example shows the scenario when the stream is above standard. Examples 1 - 4 would be addressed under OAR 340-41-026 (3) (F); examples 5 - 8 would be addressed under OAR 340-41-026 (3) (G); and examples 9 - 10 would be addressed under OAR 340-41-026 (3) (H)

Example	Upstream		Effluent		Downstream		Change in Temp
	Flow	Temp	Flow	Temp	Flow	Temp	
1	10	63	0.4	69.5	10.4	63.25	0.25
2	10	73	0.4	69.5	10.4	72.87	-0.13
3	10	63	0.1	88	10.1	63.25	0.25
4	10	73	0.1	88	10.1	73.15	0.15
5	10	63	0.4	79.5	10.4	63.63	0.63
6	10	73	0.4	79.5	10.4	73.25	0.25
7	10	63	0.4	89	10.4	64.00	1.00
8	10	73	0.4	89	10.4	73.62	0.62
9	10	61.5	1	89	11	64.00	2.50
10	10	73	1	89	11	74.45	1.45

This will be, for most cases, a variance policy which allows the temperature to increase by a specified amount for a limited period of time in order to allow for an existing point source to discharge to water quality limited waters until a TMDL is prepared. In the case where that source would be the major cause for the temperature criteria to be exceeded and a TMDL would not be developed for that waterbody to bring it back into compliance, a site specific criteria would be developed and submitted to EPA for approval.

pH Standard exception: OAR 340-41-basin (2) (d) states *"The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if the Department determines that the exceedence would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria."*

This language was intended to address the situation where a hydroproject would be applying for a 401 re-certification and it was found that the action of impounding the waters caused algal growth which caused the reservoir to subsequently exceed the pH standard. This might set up the situation where the only way to re-certify the project would be to destroy the dam which may not be the preferred option. In the cases where this exception would be applied, the Department would develop either a TMDL for nutrients in the upstream watershed, develop a site specific criteria for the waterbody or develop a use attainability analysis to modify the uses for portions of the reservoir.

Final Note: ODFW has a great deal of knowledge regarding location and timing for presence, spawning, etc of fish in Oregon streams. Much of this information is either in the files contained in local field offices or is gained from the judgment of the local biologist. Until recently, it has not been mapped. A mapping effort is underway and is furthest along for Bull Trout and Anadromous fish species. There is a coordinated effort underway entitled "StreamNet" (www.streamnet.org). This work is focused on a species by species mapping which would need to be generalized to match cold, cool, warm-water classification and spawning vs rearing groupings indicated in the standards. Issues such as mapping scales and coverage would still need to be worked out. This effort, to better categorize aquatic life uses, could be addressed in subsequent triennial standards reviews but will need additional funding to complete.

There are quite a number of standards related issues that are candidates for consideration during the next triennial review. DEQ and EPA should get together once DEQ has hired a new standards coordinator to discuss priorities and approaches for conducting the next triennial review process

Please feel to contact Andy Schaedel (503-229-6121) or Lynne Kennedy (503-229-5371) if you have further questions.

Sincerely,

Michael T. Llewelyn
Administrator, Water Quality Division

cc: Water Quality Managers

Basin	Salmonids Present within Basin	Spawning - Fry Emergence	Comments
North Coast	CO CHF CHS CS CT STW	September 15 - May 31	
Mid Coast	CO CHF CHS CS CT STS STW	September 15 - May 31	
South Coast	CO CHF CHS CT STW	October 1 - May 31	
Umpqua	CO CHF CHS CT STS STW	September 15 - May 31	No spawning occurs in Umpqua R. estuary to Head of Tidewater and Adjacent Marine Waters (OAR 340-41-282, Table 3)
Rogue	BT CO CHF CHS CT STS STW	October 1 - May 31	No spawning occurs in Rogue River estuary and Adjacent Marine Waters (OAR 340-41-362, Table 5)
Willamette - Other Ecoregions	BUT CHF CHS CT RB STW	October 1 - May 31	
Willamette - Willamette Valley Ecoregion, most typical	CHF CHS CT RB STW	October 1 - May 31	No spawning in Willamette R from the mouth to Newberg including Multnomah Channel (OAR 340-41-442 Table 6), spawning may not occur naturally in many of these streams
Willamette - Clackamas, Santiam (including N & S Fork), McKenzie Molalla, and Mid Fork Mainstems	BUT CHF CHS CT RB STW	September 15 - June 30	
Sandy	CHF CHS	September 15 - June 30	
Hood - Hood River Drainage	CHF CHS CO STS STW	September 15 - June 30	
Hood - Miles Creek Drainage	STW RB	October 1 - June 30	
Deschutes R and East Side Tributaries	BR BT BUT CHF K RB RT STS	October 1 - June 30	
Deschutes R and West Side Tributaries	BR BT BUT CHF K RB RT STS	September 1 - June 30	
John Day	BUT CHS CT RT STS	October 1 - June 30	spawning is typically in upper portions of the basin
Umatilla/Walla Walla	BUT CHF CHS CO RT STS	October 1 - June 30	spawning is typically in upper portions of the basin
Grande Ronde	BUT CHF CHS RB RT STS	October 1 - June 30	spawning is typically in upper portions of the basin
Powder	BUT RB RT	March 1 - June 30	spawning is typically in upper portions of the basin
Malheur River	BUT RB RT	March 1 - June 30	No spawning occurs in the Malheur River (Namorf to Mouth), Willow Cr (Brogan to Mouth), Bully Creek (Reservoir to Mouth) and in the following reservoirs: Malheur, Bully Creek, Beulah and Warm Springs (OAR 340-41-802, Table 15), spawning in upper basin
Owyhee	RB RT LCT	March 1 - June 30	No spawning occurs in the Owyhee River (RM 0-18) and in the following reservoirs: Antelope, Cow Creek, Owyhee (OAR 340-41-842, Table 16), spawning is typically in upper portions of the basin
Malheur Lake	RB RT LCT	March 1 - June 30	No spawning occurs in the natural lakes in the basin (OAR 340-41-882, Table 17), spawning is typically in upper portions of the basin
Goose and Summer Lakes	BT RT	March 1 - June 30	No spawning occurs in Goose Lake and other highly alkaline and saline lakes (OAR 340-41-922, Table 18), spawning is typically in upper portions of the basin
Klamath	BT RB RT	March 1 - June 30	Spawning occurs where natural conditions are suitable for salmonid fish use and no spawning occurs in the Klamath River from Klamath Lake to Keno Dam (RM 255 to 232.5), Lost River (Rm 5 to 65) and Lost River Diversion Channel (OAR 340-41-962, Table 19)
Columbia River	CHF CHS CHR CO CS CT SS STS STW	October 1 - May 31	No spawning occurs in portions of the Columbia River (OAR 340-41-482 (Table 7), -522 (Table 8), -562 (Table 9))
Snake River	CHF CHS SS STS	October 1 - June 30	

Fish Species Coding

BT=brook trout, BUT=bull trout, CHx=chinook salmon (F=fall R=summer S=spring), CO=coho salmon, CS=chum salmon, CT=cutthroat salmon, K=Kokanee, LCT=Lahontan cutthroat trout, RB=rainbow trout, RT=redband trout, SS=sockeye salmon, STx=steelhead (S=summer, W=winter)

Notes

As a general rule, this table reflects the general time frame for which the numerical spawning criteria listed the temperature and dissolved oxygen standards are generally applicable.
Spawning times may vary for individual species on particular streams within a basin.
ODFW biologists will be consulted for final determinations.

APPENDIX D

Table of Oregon's Water Quality Standards, by basin, for Dissolved Oxygen, Temperature, pH -- Revised standards and old standards, August 28, 1998.

Appendix D

August 28, 1998

Location/Species	Comments from Policy Memo	Temperature	DO	pH
North Coast / Lower Columbia Basin Coho Salmon Fall Chinook Spring Chinook Chum Salmon Cutthroat Salmon Winter Steelhead	Spawning -Fry Emergence: Sept 15 - May 31 Designated Cold Water	Sept 15-May 31 - 55 °F June 1-Sept 14 - 64 °F Columbia River up to rm309: 68°F --- *Freshwaters: no increase above 58°F. For waters 57.5°F, no incr more than .5°F. For waters 56°F, no incr more than 2°F.* *Marine/Estuarine: No incr above background & water temp.; shall not cause adverse effect to fish/aquatic life.* *Col. River: no incr above 68°F; For waters 57.5°F, no incr more than .5°F. For waters 56°F, no incr of more than 2°F.*	Sept 15 - May 31: 11 mg/L - waters 6.0 mg/L - intergravel June 1 - Sept. 14: 8.0 mg/L or w/ data: 8.0 mg/L- 30 day mean 6.5 mg/L- 7 day min. mean 6.0 mg/L- absolute mean --- *Freshwaters: not less than 90% saturation; Salmon spawning areas: 95% saturation* *Estuarine: not less than 6mg/L* *Col. River: not less than 90% saturation* *Marine: not less than saturation*	Marine: 7.0-8.5 Fresh/Esturarine: 6.5-8.5 --- *Fresh waters: 6.5-8.5* *Estuarine: 6.5-8.5* *Marine: 7.0-8.5*
Midcoast Coho Salmon Fall Chinook Spring Chinook Chum Salmon Cutthroat Salmon Winter Steelhead Summer Steelhead	Spawning - Fry Emergence: Sept. 15 - May 31 Designated Cold Water	Sept. 15-May 31 - 55°F June 1-Sept 14 - 64°F --- *Freshwaters: no increase above 64°F. For waters 63.5°F, no incr more than .5°F. For waters 62°F, no incr more than 2°F.* *Marine/Estuarine: No incr above background & water temp.; shall not cause adverse effect to fish/aquatic life.*	Sept 15 - May 31: 11 mg/L - waters 6.0 mg/L - intergravel June 1 - Sept. 14: 8.0 mg/L or w/ data: 8.0 mg/L- 30 day mean 6.5 mg/L- 7 day min. mean 6.0 mg/L- absolute mean --- *Freshwaters: not less than 90% saturation; Salmon spawning areas: 95% saturation* *Estuarine: not less than 6mg/L* *Marine: not less than saturation*	Marine: 7.0-8.5 Fresh/Estuarine: 6.5-8.5 --- *Fresh waters: 6.5-8.5* *Estuarine: 6.5-8.5* *Marine: 7.0-8.5*

Location/Species	Comments from Policy Memo	Temperature	DO	pH
<u>Umpqua</u> Coho Salmon Fall Chinook Spring Chinook Cutthroat Salmon Summer Steelhead Winter Steelhead Oregon Chub	Spawning - Fry Emergence: October 1 -May 31 No spawning occurs in Umpqua River estuary to head of tidewater & adjacent marine waters. Designated Cold Water	Oct 1-May 31: 55°F June 1-Sept. 30: 64°F -- - *<u>Freshwaters</u>: no increase above 58°F. For waters 57.5°F, no incr more than .5°F. For waters 56°F, no incr more than 2°F.* *<u>Marine/Estuarine</u>: No incr above background & water temp.; shall not cause adverse effect to fish/aquatic life.*	October 1- May 31: Waters: 11 mg/L Intergravel: 6.0 mg/L June 1 - Sept. 30: 8.0 mg/L or w/ data: 8.0 mg/L- 30 day mean 6.5 mg/L- 7 day min. mean 6.0 mg/L- absolute mean -- - *<u>Freshwaters</u>: not less than 90% saturation; Salmon spawning areas: 95% saturation* *<u>Estuarine</u>: not less than 6mg/L* *<u>Marine</u>: not less than saturation*	Fresh/Estuarine: 6.5-8.5 Marine: 7.0-8.5 Cascade Lakes >3K: 6.0-8.5 ------------------------------ *<u>Fresh waters</u>: 6.5-8.5* *<u>Estuarine</u>: 6.5-8.5* *<u>Marine</u>: 7.0-8.5*
<u>South Coast</u> Coho Salmon Fall Chinook Spring Chinook Cutthroat Salmon Winter Steelhead	Spawning - Fry Emergence: October 1 -May 31 Designated Cold Water	Oct 1-May 31: 55 °F June 1-Sept. 30: 64 °F -- *<u>Freshwaters</u>: no increase above 64°F. For waters 63.5°F, no incr more than .5°F. For waters 62°F, no incr more than 2°F.* *<u>Marine/Estuarine</u>: No incr above background & water temp.; shall not cause adverse effect to fish/aquatic life.*	October 1- May 31: Waters: 11 mg/L Intergravel: 6.0 mg/L June 1 - Sept. 30: 8.0 mg/L or w/ data: 8.0 mg/L- 30 day mean 6.5 mg/L- 7 day min. mean 6.0 mg/L- absolute mean -- - *<u>Freshwaters</u>: not less than 90% saturation; Salmon spawning areas: 95% saturation* *<u>Estuarine</u>: not less than 6mg/L* *<u>Marine</u>: not less than saturation*	Fresh/Estuarine: 6.5-8.5 Marine: 7.0-8.5 ------------------------------ *<u>Fresh waters</u>: 6.5-8.5* *<u>Estuarine</u>: 6.5-8.5* *<u>Marine</u>: 7.0-8.5*

Location/Species	Comments from Policy Memo	Temperature	DO	pH
Rogue Basin Brook Trout Coho Fall Chinook Spring Chinook Cutthroat Spring Steelhead Winter Steelhead	Spawning to Fry Emergence: October 1 - May 31 No spawning occurs in Rogue River Estuary and adjacent marine waters Designated Cold Water	Oct 1 - May 31: 55°F June 1 - Sept 30: 64°F -- - *Freshwaters: no increase above 58°F. For waters 57.5°F, no incr more than .5°F. For waters 56°F, no incr more than 2°F.* *Marine/Estuarine: No incr above background & water temp.; shall not cause adverse effect to fish/aquatic life.*	Oct 1 - May 31: 11mg/L - waters 6.0 mg/L - intergravel June 1 - Sept. 30: 8.0mg/L - or w/ data: 8.0mg/L 30 day mean 6.5 mg/L 7 day min. mean 6.0 mg/L absolute min. -- - *Freshwaters: not less than 90% saturation; Salmon spawning areas: 95% saturation* *Estuarine: not less than 6mg/L* *Marine: not less than saturation*	Marine: 7.0 - 8.5 Fresh/ Estuarine: 6.5-8.5 Cascade Lakes: > 3000' 6.0 - 8.5 ------------------------------ *Fresh waters: 6.5-8.5* *Estuarine: 6.5-8.5* *Marine: 7.0-8.5*
Willamette: mouth to Newberg, including Multnomah Channel Fall Chinook Spring Chinook Cutthroat Rainbow Trout Winter Steelhead	No spawning from mouth to Newburg, including Multnomah Channel Designated Cool Water	68°F -- *Mult. Channel & mouth to RM 26.6: T<70°F.* *For waters 69.5°F, no incr more than .5°F.* *For Waters 68°F, no more incr more than 2°F.* *Columbia River RM 86-RM 120 T<68°F*	6.5 mg/L absolute min. w/ data: 6.5 mg/L 30 day mean min. 5.0 mg/L 7 day min. mean 4.0 mg/L absolute min. -- *Mult. Channel & mouth to RM 26.6: DO<5mg/L.* *Main stem fr. W. Falls to Newburg, RM 50: DO<6mg/L* *Columbia River RM 86-RM 120: DO<90% sat.*	Columbia River: 7.0-8.5 Other waters: 6.5-8.5 ------------------------------ *Columbia River: 7.0-8.5* *All Others: 6.5-8.5*

Location/Species	Comments from Policy Memo	Temperature	DO	pH
Willamette: Newburg to Corvallis Fall Chinook Spring Chinook Cutthroat Rainbow Trout Winter Steelhead	(Geographic area not specifically identified in Policy Memo or Stds., but represents an area that is a gap between specifically referenced segments. Assumptions: mainstem, part of Valley, spawning salmonids [above Newberg exclusion], cool water designation outside of spawning area (per ecoregion designation in Policy Memo.)	Spawning periods: 55°F Non-spawning periods: 64°F -------------------------------- *Main stem fr. Newburg to RM 187: T<64°F* *For waters 63.5°F, no incr more than .5F* *For waters 62°F, no incr more than 2°F*	Spawning periods: water: 11 mg/L (or 9 mg/l.) intergravel: 6 mg/L Non-spawning periods: 6.5 mg/L absolute min. or w/ data: 6.5 mg/L 30 day mean min. 5.0 mg/L 7 day min. mean 4.0 mg/L absolute min. -------------------------------- *Main stem fr. Newburg to Salem, RM 85: DO<7mg/L*	6.5-8.5 -------------------------------- *Columbia River: 7.0-8.5* *All Others: 6.5-8.5*
Willamette: Corvallis to headwaters & main tributaries Bull Trout Fall Chinook Spring Chinook Cutthroat Winter Steelhead Rainbow Trout	Spawning to Fry Emergence: September 15 - June 30 (ppm) Designated Cold Water	Waters w/ Bull Trout: 50°F Other Waters: Sept 15-June 30: 55 °F July 1-Sept 14: 64 °F	Sept 15 - June 1: 11 mg/L - waters 6.0 mg/L - intergravel July 1 - Sept. 14: 8.0 mg/L or w/ data: 8.0 mg/L- 30 day mean 6.5 mg/L- 7 day min. mean 6.0 mg/L- absolute mean -------------------------------- *Main stem from Salem to RM 187: DO<90% sat.*	6.5-8.5 Cascade Lakes: >3000' 6.0-8.5 -------------------------------- *Columbia River: 7.0-8.5* *All Others: 6.5-8.5*

Location/Species	Comments from Policy Memo	Temperature	DO	pH
Willamette: <u>Other Ecoregion</u> Bull Trout Fall Chinook Spring Chinook Cutthroat Trout Rainbow Trout Winter Steelhead	Spawning to Fry Emergence: October 1- May 31 Designated Cold Water	Waters w/ Bull Trout: 50°F Waters w/out Bull Trout: Oct 1-May 31: 55 °F June 1-Sept. 30: 64 °F -------------------- *All other streams:* *Salmonid waters: <58 F* *Non-salmonid waters: <64°F*	October 1- May 31: Waters: 11 mg/L Intergravel: 6.0 mg/L June 1 - Sept. 30: 8.0 mg/L or w/ data: 8.0 mg/L- 30 day mean 6.5 mg/L- 7 day min. mean 6.0 mg/L- absolute mean -------------------- *All other streams:* *Salmonid waters - DO 90% sat.* *Salmonid spawning - DO 95% sat.* *Non-salmonid waters - DO<6mg/L*	6.5-8.5 Cascade Lakes: >3000' 6.0-8.5 -------------------- *Columbia River: 7.0-8.5* *All Others: 6.5-8.5*
<u>Sandy</u> Fall Chinook Spring Chinook	Spawning - Fry Emergence: September 15 - June 30 Designated Cold Water	Sept. 15-June 30 - 55 °F July 1-Sept 14 - 64 °F <Columbia River: 68°F> -------------------- *<u>Basin waters</u>: no increase above 58°F. For waters 57.5°F, no incr more than .5°F. For waters 56°F, no incr more than 2°F.* *<u>Columbia River</u>: RM120-147 T<68°F.*	Sept 15 - June 30: 11 mg/L - waters 6.0 mg/L - intergravel July 1 - Sept. 14: 8.0 mg/L or w/ data: 8.0 mg/L- 30 day mean 6.5 mg/L- 7 day min. mean 6.0 mg/L- absolute mean -------------------- *<u>Basin Waters</u>: not less than 90% saturation; Salmon spawning areas: 95% saturation* *<u>Columbia River</u>: RM 120-147: 90% saturation*	6.5-8.5 Cascade Lks:>3,000' 6.0-8.5 Col. R: 7.0-8.5 -------------------- *Columbia River: 7.0-8.5* *All Others: 6.5-8.5*

Location/Species	Comments from Policy Memo	Temperature	DO	pH
<u>Hood-Hood River Drainage</u> Fall Chinook Spring Chinook Coho Summer Steelhead Winter Steelhead	Spawning - Fry Emergence: Sept. 15-June 30 Cold Water designation (per policy memo & ecoregion map)	Sept. 15-June 30 - 55 °F July 1-Sept 14 - 64 °F Columbia River: 68°F ------------------------------------ *<u>Basin waters</u>: no increase above 58°F. For waters 57.5°F, no incr more than .5°F. For waters 56°F, no incr more than 2°F.* *<u>Columbia River</u>: RM 147-RM 203 T<68°F.*	Sept 15 - June 30: 11 mg/L - waters 6.0 mg/L - intergravel July 1 - Sept. 14: 8.0 mg/L or w/ data: 8.0 mg/L- 30 day mean 6.5 mg/L- 7 day min. mean 6.0 mg/L- absolute mean ------------------------------------ *<u>Basin Waters</u>: not less than 90% saturction; Salmon spawning areas: 95% saturation* *Non salmonid waters: 6 mg/L* *<u>Columbia River</u>: RM 120-RM 203: 90% sat*	6.5-8.5 Cascade Lks: >3000' 6.0-8.5 Col. R: 7.0-8.5 ------------------------------ *Columbia River: 7.0-8.5* *All Others: 6.5-8.5*
<u>Hood River - Miles Creek Drainage</u> Winter Steelhead Rainbow trout	Spawning - Fry Emergence: Oct. 1-June 30 Cool Water designation (per policy memo & ecoregion map)	Oct 1-June 30: 55 °F Jult 1-Sept. 14: 64°F Columbia River: 68°F ------------------------------------ *<u>Basin waters</u>: no increase above 58°F. For waters 57.5°F, no incr more than .5°F. For waters 56°F, no incr more than 2°F.* *<u>Columbia River</u>: RM 147-RM 203 T<68°F.*	Oct. 1 - June 30: 11 mg/L - waters 6.0 mg/L - intergravel July 1 - Sept. 14: 6.5 mg/L absolute min. or w/ data: 6.5 mg/L- 30 day mean 5.0 mg/L- 7 day min. mean 4.0 mg/L- absolute mean ------------------------------------ *<u>Basin Waters</u>: not less than 90% saturction; Salmon spawning areas: 95% saturation* *Non salmonid waters: 6 mg/L* *<u>Columbia River</u>: RM 120-RM 203: 90% sat*	6.5-8.5 Cascade Lks:>3000' 6.0-8.5 Col. R: 7.0-8.5 ------------------------------ *Columbia River: 7.0-8.5* *All Others: 6.5-8.5*

Location/Species	Comments from Policy Memo	Temperature	DO	pH
<u>Deschutes River & Eastside Tribs.</u> Rainbow Trout Brook Trout Bull Trout Fall Chinook Kokanee Brown Trout Redband Trout Summer Steelhead	Spawning to Fry Emergence: October 1 - June 30 Designated Cold Water and Cool Water (per policy memo and ecoregion map)	Bull Trout Waters: 50°F Other Waters: Oct. 1 - June 30: 55°F July 1 - Sept. 30: 64°F Columbia River: 68°F -------------------------------- *<u>Basin waters</u>: no increase above 58°F. For waters 57.5°F, no incr more than .5°F. For waters 56°F, no incr more than 2°F.* *<u>Columbia River</u>: RM 203-RM 218 T<68°F.*	Salmonid spawning waters: Oct 1 - June 30: 11mg/L -waters 6.0mg/L - intergravel Cold Waters areas: July1 - Sept. 30: 8.0 mg/L or w/data: 8.0mg/L - 30 day mean 6.5 mg/L - 7 day min. mean 6.0mg/L - absolute min. Cool Waters areas: 6.5mg/L absolute min. or w/ data: 6.5mg/L 30 day mean min. 5.0 mg/L 7 day min. mean 4.0mg/L absolute min. -------------------------------- *<u>Basin Waters</u>: not less than 90% saturation; Salmon spawning areas: 95% saturation* *<u>Columbia River</u>: RM 203-RM 218: 90% sat*	6.5 - 8.5 Cascade Lakes: >3000' 6.0-8.5 Columbia River: 7.0-8.5 -------------------------------- *Columbia River: 7.0-8.5* *All Others: 6.5-8.5*

Location/Species	Comments from Policy Memo	Temperature	DO	pH
<u>Deschutes River & Westside Tribs</u> Bull Trout Fall Chinook Summer Steelhead Redband Trout Rainbow Trout Kikanee Brook Trout Brown Trout	Salmonid Spawning to Fry Emergence: Sept. 1 - June 30 Cool Water and Cold Water designations (per policy memo and ecoregion map)	Bull Trout waters: 50°F Other Waters: Sept 1 - June 30: 55°F July 1 - Aug 31: 64°F Columbia River: 68°F --------------------------------- *<u>Basin waters</u>: no increase above 58°F. For waters 57.5°F, no incr more than .5°F. For waters 56°F, no incr more than 2°F.* *<u>Columbia River</u>: RM 203-RM 218 T<68°F.*	Spawning waters: Sept. 1 - June 30: 11mg/L - waters 6.0mg/L - intergravels July 1 - Aug 31: 8.0 mg/L absolute min. or w/ data: 8.0 mg/L -30 day mean min. 6.5 mg/L -7 day min mean 6.0 mg/L absolute min Cool waters: 6.5mg/L absolute min or w/ data: 6.5mg/L -30 day mean min 5.0 mg/L -7 day min mean 4.0 mg/L - absolute min --------------------------------- - *<u>Basin Waters</u>: not less than 90% saturation; Salmon spawning areas: 95% saturation* *<u>Columbia River</u>: RM 203-RM 218: 90% sat*	6.5 - 8.5 Cascade Lakes:>3000' 6.0 - 8.5 Columbia River:7.0 - 8.5 ------------------------------ *Columbia River: 7.0-8.5* *All Others: 6.5-8.5*

Location/Species	Comments from Policy Memo	Temperature	DO	pH
John Day Basin Bull Trout Spring Chinook Cutthroat Summer Steelhead Redband Trout	Salmonid spawning to fry emergence: Oct. 1 - June 30 Spawning is typically occurs in upper portions of the basin Cool Water and Cold Water designation (per policy memo and ecoregion map)	Bull Trout waters: 50°F Other Waters: Oct 1 - June 30: 55°F July 1 - Sept 30: 64°F Columbia River: 68°F -------------------- *Basin waters: no increase above 68°F. For waters 67.5°F, no incr more than .5°F. For waters 66°F, no incr more than 2°F.*	Spawning waters: Oct 1 - June 30: 11mg/L - waters 6.0 mg/L - intergravels July 1 - Aug 31: 8.0mg/L absolute min or w/ data: 8.0mg/L - 30day mean min. 6.5mg/L - 7day min meam 6.0mg/L - absolute min. Cool waters: 6.5mg/L absolute min or w/ data: 6.5mg/L 30 day mean min 5.0 mg/L 7 day min mean 4.0 mg/L absolute min -------------------- - *Basin Waters: not less than 75% saturation; Salmon spawning areas: 95% saturation Columbia River: RM 218- RM 247: 90% sat*	6.5 - 9.0 Columbia River: 7.0-8.5 -------------------- *Columbia River: 7.0-8.5* *All Others: 6.5-8.5*

<u>Umatilla/Walla Walla</u> Bull Trout Fall Chinook Spring Chinook Coho Salmon Summer Steelhead Redband Trout	Spawning - Fry Emergence: Oct. 1-June 30 Spawning typically occurs in upper portions of the basin Cool Water designation (per policy memo and ecoregion map)	Waters w/ Bull Trout: 50°F Waters w/out Bull Trout: Oct. 1-June 30: 55°F July 1- Sept. 30: 64°F ------------------------------------ ***<u>Basin waters</u>**: no increase above 68°F. For waters 67.5°F, no incr more than .5°F. For waters 66°F, no incr more than 2°F.* *(No temperature standard given)*	Oct. 1 - June 30: 11 mg/L - waters 6.0 mg/L - intergravel July 1 - Sept. 30: Cool Water: 6.5 mg/L or w/ data: 6.5 mg/L- 30 day mean 5.0 mg/L- 7 day min. mean 4.0 mg/L- absolute mean ------------------------------------ - ***<u>Basin Waters</u>**: not less than 75% saturation; Salmon spawning areas: 95% saturation* ***<u>Columbia River</u>**: RM 247- RM 309: 90% sat*	6.5-9.0 Col. River: 7.0-8.5 ------------------------------ *Columbia River: 7.0-8.5* *All Others: 6.5-8.5* *Basin waters: 6.5-8.5*

Location/Species	Comments from Policy Memo	Temperature	DO	pH
<u>Grande Ronde</u> Bull Trout Fall Chinook Spring Chinook Summer Steelhead Rainbow Trout Redhand Trout	Spawning - Fry Emergence: Oct. 1-June 30 Spawning typically occurs in upper portions of the basin Cool Water and Cold Water designations (per policy memo and ecoregion map)	Waters w/ Bull Trout: 50°F Waters w/out Bull Trout: Oct. 1-June 30: 55°F July 1- Sept. 30: 64°F ------------------------------------ *<u>Basin waters</u>: no increase above 68°F. For waters 67.5°F, no incr more than .5°F. For waters 66°F, no incr more than 2°F.*	Oct. 1 - June 30: 11 mg/L - waters 6.0 mg/L - intergravel July 1 - Sept. 30: Cool Water areas: 6.5 mg/L w/ data: 6.5mg/L - 30 day mean 5.0 mg/L - 7 day min. mean 4.0mg/L - absolute min. Cold Water areas: 8.0 mg/L or w/ data: 8.0mg/L - 30 day mean 6.5mg/L - 7 day min. Mean 6.0 mg/L - absolute mean ------------------------------------ *<u>Basin Waters</u>: not less than 75% saturation; Salmon spawning areas: 95% saturation*	6.5-9.0 Snake River: 7.0-9.0 ------------------------------ *Snake River: 7.0-9.0* *All Others: 6.5-8.5*
<u>Powder</u> Bull Trout Rainbow Trout Redband Trout	Spawning - Fry Emergence: March 1-June 30 Spawning is typically in upper portion of the basin Cool water designation (per policy memo and ecoregion map)	Waters w/ Bull Trout: 50°F Waters w/out Bull Trout: Mar. 1-June 30: 55°F July 1- Feb. 29: 64°F ------------------------------------ *<u>Snake River</u>: no increase above 68°F* *<u>Basin waters</u>: no increase above 64°F. For waters 63.5°F, no incr more than .5°F. For waters 62°F, no incr more than 2°F.*	Mar. 1-June 30: 11 mg/L - waters 6.0 mg/L - intergravel July 1-Feb. 29: 6.5 mg/L or w/ data: 6.5 mg/L- 30 day mean 5.0 mg/L- 7 day min. mean 4.0 mg/L- absolute min. ------------------------------------ *<u>Basin Waters</u>: not less than 75% saturation; Salmon spawning areas: 95% saturation*	6.5-9.0 Snake River: 7.0-9.0 ------------------------------ *Snake River: 7.0-9.0* *All Others: 6.5-8.5*

Location/Species	Comments from Policy Memo	Temperature	DO	pH
<u>Malheur River</u> Bull Trout Rainbow Trout Redband Trout	Salmonid spawning to fry emergence: Mar. 1 - June 30 No spawning in the Malheur River (Narmoff to mouth), Willow Creek (Brogan to mouth), Bully Creek (reservoir to mouth), Malheur reservoir, Bully Creek reservoior Beulah & Warm Springs reservoir. Spawning occurs in upper basin Malheur River (mouth to Narmoff), will Creek (mouth to Brogan), and Bully Creek are designated Warm Waters. Other waters designated Cool Waters (per policy memo and ecoregion map)	Bull Trout Waters: 50°F Other waters: Mar. 1. - June 30: 55°F July 1 - Feb.30: 64°F Warm Water Areas: "No measurable surface water temperature increase resulting from anthropogenic activities is allowed in waters when the DO levels are within .5mg/L or 10% saturation of the water column or intergravel DO criterion for a given stream reach or subbasin". ------------------------------ *<u>Basin waters</u>: no increase above 68°F. For waters 67.5°F, no incr more than .5°F. For waters 66°F, no incr more than 2°F.*	Spawning waters: Mar.1 - June 30: 11mg/L - waters 6.0 mg/L - intergravel July1 - Feb 30: 6.5 mg/L absolute min or w/ data: 6.5mg/L 30 mean min 5 .0 mg/L 7 day min mean 4.0 mg/L absolute min Warm Water areas: 5.5 mg/L absolute min ------------------------------ *<u>Basin Waters</u>: not less than 75% saturation: Salmon spawning areas: 95% saturation*	7.0 - 9.0 ------------------------------ *All Waters: 7.0-9.0*

Location/Species	Comments from Policy Memo	Temperature	DO	pH
<u>Owhyee Basin</u> Lahontan Cutthroat Trout Rainbow Trout Redband Trout	Salmonid spawning to fry emergence: Mar. 1 - June 30 No spawning occurs in the Owhyee River (RM 0 - 18), and in Antelope, Cow Creek, & Owhyee reservoirs. Spawning occurs in upper basin Owhyee River from mouth to RM 8 is designated Warm Waters. Other waters designated Cool Waters (per policy memo and ecoregion map)	Mar. 1. - June 30: 55°F July 1 - Feb.30: 64°F Warm Water Areas: "No measurable surface water temperature increase resulting from anthropogenic activities is allowed in waters when the DO levels are within .5mg/L or 10% saturation of the water column or intergravel DO criterion for a given stream reach or subbasin". ------------------------------ ***<u>Basin waters</u>*: no increase above 68°F. For waters 67.5°F, no incr more than .5°F. For waters 66°F, no incr more than 2°F.**	Spawning waters: Mar.1 - June 30: 11mg/L - waters 6.0 mg/L - intergravel July1 - Feb 30: 6.5 mg/L absolute min or w/ data: 6.5mg/L 30 mean min 5 .0 mg/L 7 day min mean 4.0 mg/L absolute min Warm Water areas: 5.5 mg/L absolute min ------------------------------ ***<u>Basin Waters</u>*: not less than 75% saturation; Salmon spawning areas: 95% saturation**	7.0 - 9.0 ------------------------------ *All Waters: 7.0-9.0*

Location/Species	Comments from Policy Memo	Temperature	DO	pH
<u>Malheur Lake Basin</u> Redband Trout Rainbow Trout Lahontan Cutthroat Trout Borax Lake Chub	No salmonids occurs in the natural lakes in the basin; spawning typically occurs in upper portions of the basin Spawning occurs: Mar. 1-June 30 Natural lakes in basin are designated warm water Other waters designated cool water (per policy memo and ecoregion map)	Upper basin salmonid spawning waters: Mar. 1- June 30: 55°F July 1-Feb. 29: 64°F Other waters: •Natural Lakes: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in natural lakes. •Other Streams: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in waters when the dissolved oxygen (DO) levels are w/in .5mg/L or 10% saturation of the water column or intergravel DO criterion for a given stream reach or subbasin. And/or: • "no measurable surface water temperature increase resulting from anthropogenic activities in stream segments containing federally listed T&E species if the increase would impair the biological integrity of the T&E population." ------------------------------------ *<u>Basin waters</u>: no increase above 68°F. For waters 67.5°F, no incr more than .5°F. For waters 66°F, no incr more than 2°F.*	Upper Basin Waters: Mar. 1 - June 30: 11 mg/L - waters 6.0 mg/L - intergravel July 1 - Feb. 29: 6.5 mg/L absolute min. or w/ data: 6.5 mg/L- 30 day mean 5.0 mg/L- 7 day min. mean 4.0 mg/L- absolute mean Natural Lakes: 5.5 mg/L absolute min. Other Waters: 6.5 mg/L absolute min. or w/data: 6.5 mg/L- 30 day mean 5.0 mg/L- 7 day min. mean 4.0 mg/L- absolute mean ------------------------------------ *<u>Basin Waters</u>: not less than 75% saturation; Salmon spawning areas: 95% saturation*	7.0-9.0 ------------------------------ *All Waters: 7.0-9.0*

Location/Species	Comments from Policy Memo	Temperature	DO	pH
<u>Goose and Summer Lakes Basin</u> Brook Trout Rainbow trout Warner Sucker Hutton Spring Tui Chub Foskett Speckled Dace	▸no salmonid spawning occurs in Goose Lake and other higly alkaline and saline lakes; spawning is typically in upper portion of the basin ▸salmonid spawning occurs: March 1-June 30 ▸High alkaline & saline lakes are designated Warm Water Other waters designated Cool Water (per policy memo & ecoregion map)	Upper basin salmonid spawning waters: Mar. 1- June 30: 55°F July 1-Feb. 29: 64°F Other waters: ▸Natural Lakes: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in natural lakes. ▸Other Streams: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in waters when the dissolved oxygen (DO) levels are w/in .5mg/L or 10% saturation of the water column or intergravel DO criterion for a given stream reach or subbasin. And/or: ▸ "no measurable surface water temperature increase resulting from anthropogenic activities in stream segments containing federally listed T&E species if the increase would impair the biological integrity of the T&E population." ------------------------------------ *<u>Basin waters</u>: no increase above 68°F. For waters 67.5°F, no incr more than .5°F. For waters 66°F, no incr more than 2°F.* *<u>Goose Lake</u>: 70°F*	Upper Basin Salmonid Spwaning Waters: Mar. 1 - June 30: 11 mg/L - waters 6.0 mg/L - intergravel July 1 - Feb. 29: 6.5 mg/L absolute min. or w/ data: 6.5 mg/L- 30 day mean 5.0 mg/L- 7 day min. mean 4.0 mg/L- absolute mean Alkaline Lakes: 5.5 mg/L absolute min. Other waters: 6.5 mg/L absolute min. or w/ data: 6.5 mg/L- 30 day mean 5.0 mg/L- 7 day min. mean 4.0 mg/L- absolute mean ------------------------------------ *<u>Basin Waters except G. Lk.</u>: not less than 75% saturation; Salmon spawning areas: 95% saturation* *<u>Goose Lake</u>: 7 mg/L*	Goose Lake: 7.5-9.5 Other Waters: 7.0-9.0 ------------------------------ *Goose Lake: 7.5-9.0* *All Waters: 7.0-9.0*

Location/Species	Comments from Policy Memo	Temperature	DO	pH
Klamath Basin Bull Trout Rainbow Trout Redband Trout Lost River Sucker Shortnose Sucker	▸Spawning occurs where natural conditions are suitable for salmonid fish use. No spawning occurs in the Klamath River from Klamath Lake to Keno Dam (RM 255-232.5), Lost River (RM 5 to 65) and Lost River Diversion Channel. ▸Spawning occurs March 1 to June 30. ▸Warm Water designation for: Klamath River from Klamath Lake to Keno Dam (RM 255-232.5), Lost River (RM 5 to 65) and Lost River Diversion Channel. Other waters designated Cool Waters and Cold Water (per policy memo and ecoregion map)	Bull Trout Waters: 50°F Upper basin spawning waters: Mar. 1- June 30: 55°F July 1-Feb. 29: 64°F ▸Natural Lakes: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in natural lakes. ▸Other Streams: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in waters when the dissolved oxygen (DO) levels are w/in .5mg/L or 10% saturation of the water column or intergravel DO criterion for a given stream reach or subbasin. And/or: ▸ "no measurable surface water temperature increase resulting from anthropogenic activities in stream segments containing federally listed T&E species if the increase would impair the biological integrity of the T&E population." ------------------------------ *Salmonid waters: no incr above 58°F. For waters 57.5 °F, no incr more than .5°F. For waters 56°F, no incr, no incr more than 2°F.* *Non-salmonid waters: no incr above 72°F For waters 71.5°F, no incr more than .5°F. For waters 56°F, more than 2°F.*	Salmonid Spawning Waters: Mar. 1 - June 30: 11 mg/L - waters 6.0 mg/L - intergravel July 1 - Feb.29 : 8.0 mg/L or w/ data: 8.0 mg/L- 30 day mean 6.5 mg/L- 7 day min. mean 6.0 mg/L- absolute mean Klamath River (RM 255-232.5), and Lost River (RM 5 to 65) and Lost River Channel: 5.5 mg/L absolute min. Other Waters: 6.5 mg/L absolute min. or w/ data: 6.5 mg/L- 30 day mean 5.0 mg/L- 7 day min. mean 4.0 mg/L- absolute mean ------------------------------ *Main Stem 255-232.5 & K. Lake: 5 mg/L* *Main Stem RM 232.5-208.5: 7 mg/L* *All Basin waters:* *Salmonid water: 90% sat* *Non-salmonid waters: 6 mg/L*	6.5-9.0 Cascade Lakes > 5000': 6.0-8.5 ------------------------------ *All Waters: 7.0-9.0*

APPENDIX E

Maps of the status of listed salmonids and 303(d) listed waters for DO, T, pH

(Map transmitted separately to USFWS and NMFS. May be obtained from Dru Keenan, EPA Region 10)

APPENDIX F

Map of the location of Bull Trout in Oregon

(This map transmitted separately to USFWS and NMFS. May be obtained from Dru Keenan, EPA Region 10)

APPENDIX G

Ecoregion Map

(May be obtained from Dru Keenan, EPA Region 10)

APPENDIX H

Oregon Temperature Standard Review, by Cara Berman, EPA, Region 10

Analysis of Temperature Requirements for Salmonids, Charles Coutant

Oregon Temperature Standard Review: Cara Berman, EPA, Region 10
September 3, 1998

Note: "Viability" as used in this document is intended to convey the ecological meaning of "long-term capability of salmonids to live and develop" rather than the regulatory definition pursuant to the ESA.

I. Oregon Temperature Standard: Numeric Criteria

Salmonid spawning, egg incubation, and fry emergence from the egg and the gravel: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin which exceeds 12.8°C."

Salmonid rearing: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin for which salmonid rearing is a designated beneficial use, and in which surface waters exceed 17.8°C."

Bull trout: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in waters **determined by the Department to support or to be necessary to maintain the viability of native Oregon bull trout, when surface water temperatures exceed 10°C." The temperature criteria applies to waters containing spawning, rearing, or resident adult bull trout.**

In the Columbia River or its associated sloughs and channels from the mouth to river mile 309: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed when surface water temperatures exceed 20°C."

In the Willamette River or its associated sloughs and channels from the mouth to river mile 50: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed when surface water temperatures exceed 20°C."

Adult migration, adult holding, smoltification, and juvenile emigration are not identified as distinct designations. Although the standard states that, "The temperature criteria of 17.8°C will be applied to all water bodies that support salmonid fish rearing...." it is unclear how the standard will address other life history stages.

The following analysis was conducted using 17.8°C as the criterion for all life history stages with the exception of spawning, incubation, and fry emergence. A criterion of 20°C was applied to species and life history stages occupying the mainstem Columbia River to river mile 309 and the Willamette River to river mile 50.

II. Endangered Species Act - Endangered, Threatened, and Proposed Species:

1. Snake River Sockeye Salmon (listed)

2. Snake River Spring/Summer Chinook Salmon (listed)

3. Snake River Fall Chinook Salmon (listed)

4. S. Oregon/N. California Coastal Chinook Salmon (proposed)

5. Lower Columbia River Chinook Salmon (proposed)

6. Upper Willamette River Chinook Salmon (proposed)

7. Snake River Basin Steelhead (listed)

8. Lower Columbia River Steelhead (listed)

9. Middle Columbia River Steelhead (proposed)

10. Upper Willamette River Steelhead (proposed)

11. S. Oregon/N. California Coast Coho Salmon (listed)

12. Oregon Coastal Coho (listed)

13. Columbia River Chum Salmon (proposed)

14. Umpqua River Cutthroat Trout (listed)

15. Columbia River Basin Bull Trout (listed)

16. Klamath Basin Bull Trout (listed)

III. Introduction:

Temperature directly governs the metabolic rate of fish and directly influences the life history traits of Pacific salmon. Natural or anthropogenic fluctuations in water temperature can induce a wide array of behavioral and physiological responses in salmonids. Mechanisms have evolved to synchronize the timing of salmonid life history events with their physical environment, and are believed to have been a major factor in the development of specific populations or stocks. Several authors have linked variation in temperature requirements to physiological and behavioral differences imposed by a variety of environmental temperature regimes.

Previous research on temperature sensitivity of fishes emphasized lethal limits and temperature preferences. However, current concerns have centered on the effects of sublethal temperatures and ecological context. Holtby (1988) reported that virtually all effects of an altered thermal regime on Carnation Creek coho salmon were associated with relatively small temperature increases. Alteration of tissue and blood chemistry as well as behavioral changes may occur in association with exposure to sublethal elevated temperatures. These alterations may lead to impaired functioning of the individual and decreased viability at the organism, population, and species levels. Feeding, growth, resistance to disease, successful reproduction, and sufficient activity for competition and predator avoidance are all necessary for survival. Inability to maintain any of these activities at moderately extreme temperatures may be as decisive to continued survival as more extreme temperatures are to immediate survival. Duration and intensity of exposure is related to unique species characteristics and environmental context. Maximized species distribution and diverse life history strategies in combination with broadly distributed and interconnected habitat elements are critical in defining the response and effect of altered thermal regimes on native salmon and charr.

This review of the Oregon Temperature Standard is supported by a broad body of knowledge on temperature and its role in defining distribution, abundance, and long-term persistence of native salmon and charr species. This assessment provides (1) a review of the ecological context and critical processes affecting both the stream network and cold-water biota; (2) a summary of baseline condition within the State of Oregon; (3) a review of lethal, sublethal, and intermittent elevated temperature effects on native salmon and charr; (4) an analysis of the temperature measurement unit, the "7 day moving average," and implications for its use; (5) a determination of the effect of Oregon's Temperature Standard on endangered, threatened, and proposed native salmon and charr species; (6) a summary of findings; and (7) a summary of species-specific temperature preferences, tolerances, and thresholds of effect from the technical literature.

Ecological setting, landscape and evolutionary processes, and the physiological and behavioral implications of thermal regime alteration are each important and individually contribute to our understanding of species response to temperature. However, it is only through the integration of these individual elements that a complete understanding of temperature and its role in defining species viability may occur.

IV. Ecological Context and Critical Processes Affecting Stream Networks and Salmonids:

According to the Endangered Species Act (ESA), "critical habitat designations include those physical and biological features of the habitat that are essential to the conservation of the species and that may require special management or protection." Temperature is not only a defining element influencing the behavior and physiology of salmonids, it is an "ecological resource" subjected to competition and partitioning and that directly contributes to fitness (Magnuson et al. 1979). How this "resource" manifests itself spatially and temporally reflects both unique ecoregional features as well as degree of landscape and stream network alteration.

This assessment begins with a discussion of the abiotic environment as it is as crucial to the evaluation of temperature effects on salmonids as the direct physiological and behavioral responses of these organisms to altered thermal regimes. Central to this discussion is the role that abiotic factors play in species viability and fitness. Ecosystem heterogeneity, connectivity, and replication within the landscape provides the template for species flexibility in the face of natural and anthropogenic disturbance. Without ecosystem-based options, species flexibility is diminished.

The ratio between dominant and secondary habitat types is telling of system integrity. Highly diverse systems with well distributed, contiguous patches of cold water are reflective of intact riverine environments while systems lacking complexity and containing relatively small and infrequent patches of cold water are often associated with altered systems. These two scenarios pose very different challenges to riverine biota. McIntosh et al. (1995) using forward-looking infrared videography, contrast two stream systems, one impacted by land management activities (i.e., grazing and logging) and one within a designated wilderness area. The managed system was characterized as spatially heterogenous with disjunct patches of relatively cooler water. In contrast, the wilderness reaches were 5-7°C cooler, spatially uniform in temperature with ambient temperatures gradually increased in a downstream direction. Although thermal regimes reflect controlling variables unique to individual landscapes, it is interesting to note that intact stream networks may provide larger more contiguous areas of cold water during summer months. Additionally, unmanaged systems often provide greater habitat diversity than managed systems. This spatial complexity is seen as an important factor influencing species diversity and ecosystem stability (Quigley 1997).

Ecosystem stability is a gage of the diversity, connectivity, and distribution of ecosystems and habitat. This complexity is important as it offers organisms habitat alternatives or options to mitigate the effect of disturbance events. Anthropogenic disturbances often vary from natural disturbances in magnitude, frequency, and duration of events. The resultant landscape with relatively smaller, isolated patches of suitable habitat may differ significantly from a comparable unmanaged system. Cumulatively, anthropogenic disturbances may decrease system heterogeneity as well as system connectivity and, in turn, may reduce the options available to species during disturbance events. Alternatively, natural disturbance regimes may be required to maintain system heterogeneity (Reeves et al. 1995). Heterogeneity of the riverine network supports the development and maintenance of well distributed and interconnected habitat types necessary for salmonid persistence.

Water temperature varies both spatially and temporally. Ambient water temperatures may periodically or annually approach cold-water biota thresholds for chronic or acute species response. However, system heterogeneity provides alternatives in the form of refugia. In these instances, the abundance, distribution, and accessability of cold water refugia play a critical role in population and species level persistence. Where annual temperatures approach thermal thresholds, species variability in the form of unique life history strategies allow individuals to utilize these systems during periods when suitable conditions exist. Shifts in annual thermal regimes and loss of thermal refugia would expose these populations to sublethal or lethal temperatures thereby negatively affecting population viability.

Refugia are habitats or environmental factors that convey spatial and temporal resistance and resilience to biotic communities impacted by biophysical disturbances. Landscape features associated with refugia operate at various spatial and temporal scales and may include localized micro-habitats and zones generated by riparian structure, floodplain development, hyporheic zones, and ground water input as well as macro-habitat features such as spatially relevant reaches, tributaries, and subbasins (Sedell et al. 1990, Berman and Quinn 1991). Refugia at various scales may reduce or eliminate exposure to sublethal and lethal temperatures. Additionally, refugia may serve as source areas for recolonization subsequent to disturbance events. Organisms respond to periodic system disturbance both natural and anthropogenic through behavioral responses such as thermoregulation that impart flexibility. Physiological adaptations such as thermal inertia and acclimatization provide additional yet limited protection from stressful temperatures.

Although salmonids residing in cold-water refugia may be capable of mitigating chronic and acute temperature effects, these areas must be available and accessible. Biota may demonstrate complex behaviors that convey flexibility in the face of perturbations. However, one cannot assume that the necessary micro- and macro-habitat features are available in degraded systems. As the stream network loses complexity, flexibility conferred through behavioral responses also decreases (Berman and Quinn 1991). Because the thermal structure of rivers is dynamic and can become more so after anthropogenic alterations, the duration of stressful conditions and the availability of suitable refuges may determine population survival (Berman 1990).

Salmonids historically occupied a broad range and a diverse array of landscapes. Spatial and temporal distribution reduces the overall risk to species in dynamic, disturbance driven systems. As species distribution is reduced and unique population segments are lost, the genetic diversity that allows species to respond and to adapt to change is also reduced. As a result of these factors, species resistance and resilience to disturbance is eroded. Research conducted on the Umpqua River and the Nehalem River supports earlier findings pertaining to the role of temperature in the reduction of areal extent of suitable habitat as well as connectivity between habitat patches (Nawa et al. 1991, Kruzic 1998). In an evaluation of Oregon's bull trout, Pratt (1992) determined that elevated temperatures had reduced species distribution with populations becoming largely fragmented and isolated in the upper reaches of drainages. The connection among spatially diverse and temporally dynamic habitats and populations is a critical factor to persistence and integrity of aquatic communities (Quigley 1997). The maintenance and restoration of spatially diverse, high quality habitats that minimize the risks of extinction is key to beneficial use support of cold water species (Quigley 1997).

The scale of the disturbance and subsequent change in suitable habitat is also important. At the basin scale, as stream temperature increases species or populations may reside in smaller patches of suitable habitat. The result is increased density that exacerbates negative effects associated with thermal stress. Where temperatures increase in a longitudinal direction and refugia no longer exist, organisms may select higher gradient reaches with cooler ambient temperatures. However, inter-specific competition and disturbance frequency, intensity, and magnitude may be greater. In addition to these relatively localized alterations to thermal regimes, global warming may further increase ambient temperatures, thereby reducing species range, fragmenting critical habitat, and altering system productivity (Henderson et al. 1992, Meisner 1990, Meisner et al. 1988). Initial bull trout declines in the southern portion of its range are attributed to a reduction in cold water habitat following the Late Pleistocene retreat of glaciers and snowfields. However, anthropogenic factors have aggravated this situation over time through further loss and fragmentation of suitable habitat (Ratliff and Howell 1992). Biological and landscape diversity will be critical to sustaining cold water biota in the face of global warming predictions.

Maximized species distribution and diverse life history strategies in combination with broadly distributed and well connected habitat elements provides a buffer against dynamic systems and ensures species persistence in the face of disturbance. This strategy reduces the risk of regional extirpation in highly variable environments (Quigley 1997). As elevated temperatures reduce species range and are maintained long after the initial stressor(s) has been removed, options for long-term species maintenance and recovery are diminished. To ensure species persistence, cold water systems and remnant patches should be protected and areas of historic distribution should be identified and thermal regimes restored. This approach is consistent with the Columbia River Basin Fish and Wildlife Program of the Northwest Power Planning Council, the Oregon Chapter of the American Fisheries Society's recommendations concerning the use of Aquatic Diversity Areas, the Bradbury Report, the Oregon Biodiversity Project, and the Northwest Forest Plan Key Watershed designations.

The preceding discussion has focused on the dynamic nature of Pacific Northwest rivers and the importance of maximized species distributions and diverse, well distributed, and interconnected habitat to the long-term persistence of native salmon and charr. If life history designations or species distributions are narrowly identified on the landscape for purposes of implementing Oregon's Temperature Standard, then we may be imposing additional risks on these species as future disturbance events move across the landscape. Additionally, we may be jeopardizing our ability to restore populations to adequate numbers for long-term persistence. The standard should reflect the ecology of the riverine environment and should provide the flexibility to accommodate future change. Beneficial use designation should maximize species distribution and life history diversity.

There are many factors that affect ambient water temperature as well as the number, distribution, and accessibility of thermal refugia. Processes controlling air temperature, channel morphology, riparian structure, hyporheic zones and ground water, wetland complexes, and flow volume shape stream temperature. Alteration of one or more of these parameters leads to thermal alteration through the following mechanisms: increased solar radiation intensity per unit surface area; increased stream surface area; increased energy imparted to the stream per unit volume; and decreased cold water inflow. Temperature may be perceived as a single water quality parameter. However, thermal regimes are established through the complex interaction of the above controlling factors.

Anthropogenic alteration may affect one or several of these factors. Recent restoration activities have highlighted the complexity of these interactions. In eastern Oregon, the role of ground and surface water interchange in maintaining stream temperatures was demonstrated. Restoration of a wet meadow system and stream channel included redirecting stream flow from a ditched system to an old meander channel, reconnecting the stream channel to its floodplain, and providing for the connection of subsurface and surface flows. This action lead to a significant decrease in surface water temperature. Ambient temperature decreased by 5°F with a greater than 10°F decrease in seep generated micro-habitat (Allen Childs, pers. com.). In addition, significant modulation of diurnal fluctuation occurred. Although eastern Oregon summer air temperatures may be relatively high, restoration of critical controlling factors significantly decreased ambient stream temperature in a managed system.

The question of summer maximum temperatures often arises. There are those that contend basins east of the Cascades have always exhibited high summer water temperatures. There are obvious differences between east and west-side ecoregions (e.g., physiography, Geology, climate, soils, potential natural vegetation, land use, and land cover). However, stream temperature is an integrator of multiple factors and reflects the integrity of a variety of processes affecting the stream network at varying scales. In other words, air temperature is not the sole determinant of ambient water temperature.

Salmonids have adapted to these east-side environments. Modified migration, spawning, and emergence timing as well as exploitation of suitable habitat have allowed these species to exist in landscapes that may at first glance appear inhospitable. Results of a recent assessment of water temperature extending from the Canadian border to the Oregon and Nevada border identified areas where conditions have changed substantially from historical baseline (Quigley et al. 1997). Geographic regions identified in eastern Oregon as exhibiting significantly altered thermal regimes include the Blue Mountains, Southern Cascades, Northern Great Basin, and Upper Klamath. Current diel and annual temperature ranges extend historical ranges within these systems with summer temperatures significantly increased over historical records. Several examples provide evidence that summer maximum temperatures are 10°C to 15°C warmer than those recorded historically (Quigley 1997). In addition, phase shifts in annual thermal regimes and loss of cold-water refugia have occurred. Restoration programs and historical records provide evidence that current land use practices have altered thermal regimes producing both higher maximum temperatures and greater diel fluctuations.

There are numerous threats to the remaining populations of native salmon and charr (Quigley 1997, Ratliff and Howell 1992). However, the present or threatened destruction, modification, or curtailment of habitat or range has been cited by numerous authors as the single most important factor in the decline as well as recovery of these species (Quigley 1997, Nehlsen et al. 1991). Critical to defining species range and habitat suitability is temperature. Historical distribution of native salmon and charr has been significantly reduced. In the process, population extinctions with concomitant loss in genetic and life history variability have occurred. Nehlsen et al. (1991) provide a partial list of extinct native salmonid stocks in Oregon including spring/summer chinook salmon in the Sprague River, Williamson River, Wood River, Klamath River, Umatilla River, Metolius River, Priest Rapids, Walla Walla River, Malheur River, and Owyhee River; Fall chinook in the Sprague River, Williamsom River, Wood River, Klamath River, Umatilla River, Willamette River, Snake River and tributaries above Hells Canyon Dam, and Walla Walla River; coho salmon in the Grande Ronde River, Wallowa River, Walla Walla River, Snake River, Columbia River small tributaries from Bonneville Dam to Priest Rapids Dam, Umatilla River, and Euchre Creek; sockeye salmon from the Metolius River and Wallowa River; chum salmon from the Walla Walla River; and steelhead from the Owyhee River, Malheur River, Sandy River (summer), Powder River, Burnt River, and South Umpqua River (summer). It should be noted that the State of Oregon has designated historical salmonid habitat as appropriate for "cool water" and "warm water" uses.

Although temperature preferences and stress response thresholds may vary across salmonid populations and species, they share a common range of preferred, sublethal, and lethal temperatures reflective of cold-water biota requirements. Spence et al. (1996) and Brett (1952) found that the range of greatest preference by all species of Pacific salmon was from 12°C to 14°C for acclimation temperatures ranging from 5°C to 24°C. They also noted a definite avoidance of water over 15°C. Given the importance of temperature to salmonids and other poikilotherms, it would seem appropriate to use biological data in conjunction with physical process models to characterize "potential" temperature regimes. Using this biological information, one can illustrate predicted annual temperatures within a hypothesized basin containing listed, proposed, and candidate salmonid species.

Mainstem ambient summer temperatures would be less than 12°C in May and would increase to less than 16°C to 18°C in August. This portion of the riverine network would provide adult and smolt migratory habitat.

As outmigrating smolts generally require temperatures of less than approximately 13°C their needs would be met through emigration timing and the availability of cold water refugia. As one moves upstream to areas of fall chinook spawning, ambient temperatures from September to November would be less than 13°C to 14°C, and from March through May would be less than 14°C. Summer chinook spawning and spring chinook holding habitat would experience temperatures less than 14°C to 15°C during June through August. Proceeding longitudinally, spring chinook spawning and rearing habitat temperatures during June through August would be less than approximately 15°C and less than 13°C during September and October. Steelhead and coho salmon occupy portions of the stream network where ambient temperatures during March, April, and May would be less than 12°C and less than 13°C to 14°C in June, July, and August. Bull trout habitat would exhibit ambient water temperatures less than 12°C in June and July and less than 9°C during spawning periods from August through October. Additionally, refugia both localized and larger would generally be available and accessible during all years. This scenario does not preclude larger magnitude or duration disturbance events where population affects might be observed. These biologically derived temperatures appear to support historical water quality assessment data identified in Quigley (1997).

Several issues serve to support an opinion that both west and east-side ambient temperatures have been altered by land use practices. Firstly, forward looking infrared videography has illustrated the decrease in cold-water extent and the increase in discontinuous cold water patches in systems affected by land use. Secondly, research efforts have recorded the loss and fragmentation of habitat and the subsequent decrease in species distribution. Thirdly, restoration efforts have significantly reduced both maximum temperatures as well as the magnitude of diel fluctuation. Fourthly, historical thermal regimes were recorded and differ significantly from current conditions. Finally, the extinction of salmonids native to both west and east-side rivers reflects the magnitude of alteration to the physical, chemical, and biological characteristics of these systems.

To summarize(1) both the spatial extent of cold-water as well as the number, distribution, and accessability of cold-water refugia are critical in modulating the impact of temperature on salmonids; (2) maximized species distribution and diverse life history strategies in combination with broadly distributed and well connected habitat elements provide a buffer against dynamic systems and ensures species persistence in the face of disturbance; (3) biological data in conjunction with physical process models may better characterize "potential" temperature regimes; (4) loss of landscape complexity reduces species options in dynamic systems; (5) thermal regimes are established through the complex interaction of a suite of controlling factors; and (6) both west and east-side ambient water temperatures have been altered by land use practices.

V. Summary of Baseline Condition:

Land use practices have altered stream temperature profiles in Oregon. Major habitat changes include the loss or reduction of the large tree component in riparian zones and the concomitant decline of large woody debris in stream channels; loss of deep pools; alteration of upslope hydrological and erosional processes and the associated reduction in channel depth and increased fine and course sediment load; and loss of stream and ground water flow to the channel and associated riparian and wetland areas. These parameters and the underlying terrestrial and riverine processes are critical to both thermal regime maintenance and alteration. Grazing, logging, stream channelization, irrigation, chemical and nutrient applications, mining, agriculture, road construction, dam development and operation, urban and rural development, and recreation all play a role in ecosystem alteration (Quigley 1997, Wissmar et al. 1994).

The condition of Oregon's rivers reflect both localized and regional changes to controlling factors critical to maintaining characteristic thermal regimes. According to Oregon's 1998 draft 303(d) Stream Summary Report prepared by the Department of Environmental Quality, 13,796 stream miles are included in the 1998 303(d) list. The 1994/1996 list included 11,899 stream miles. Of that total, 12,146 miles are listed for temperature impairment; 2,172 miles for habitat modification; 1,426 miles for sediment impairment; and 1,624 miles for flow modification i.e., impairment associated with water quantity. By far, temperature is the most ubiquitous parameter associated with listed stream segments. Of the systems that were reviewed by the State, 930 waterbody segments have been listed for temperature, 542 require additional data or are of potential concern, and 559 segments were meeting the temperature standard.

Of concern in this analysis is the representativeness, completeness, and accuracy of the stream and salmonid use data as well as the accuracy of the beneficial use designations. Oregon has made much progress in data collection and information management. However, more detail is required for waterbodies where limited or no information exists. Additionally, the extent of our knowledge concerning distribution and life history requirements of native salmon and charr should not be overestimated. Presence-absence data alone should not be used to define species ranges that are dynamic and vary over time according to natural disturbance regimes and habitat suitability. As with species range, within range habitat critical to single life history stages such as spawning and rearing may be "stable" in the short-term, but may vary significantly over the long-term. Therefore, beneficial use designations that do not account for the dynamic nature of ecological systems may not accurately reflect species range or spawning and rearing habitat. To illustrate potential inaccuracies in range identification, existing salmonid habitat is designated for "cool water" uses and historical habitat for "cool water" and "warm water" uses. As the spawning and rearing designations are also based on presence-absence data, it is likely that identified spawning and rearing habitat underestimates the total quantity of available habitat. Designating only a portion of the overall range exposes species to additional risks. Those spawning or rearing areas inappropriately designated may be systematically degraded as a higher temperature criterion is applied. Further analysis of species distributions, current temperature profiles, and beneficial use designations is required.

Based on our analysis, the following conclusions may be drawn: (1) suitable salmonid habitat and hence distribution has been decreased due to elevated temperatures, (2) the effect of elevated temperatures on the physiology and behavior of salmonids poses a significant risk to these species, (3) the majority of stream reaches are currently exceeding state water quality standards and attempts to reduce temperatures will require time, (4) as recovery requires time, areas currently meeting water quality standards should be protected from degradation, (5) beneficial use designations may not accurately reflect species presence or spawning and rearing requirements, (6) the representativeness, completeness, and accuracy of the stream and salmonid use data is unknown and should be evaluated, and (7) juxtaposition of various designations should be reviewed for effect on water quality attainment and beneficial use support.

VI. Lethal and Sub-Lethal Temperature Effects:

Temperature directly governs the metabolic rate of fish and directly influences the life history traits of Pacific salmon. Although lethal temperatures produce obvious deleterious effects (see review by Elliott 1981), sublethal temperatures have proven to be the more ecologically relevant parameter in assessing species viability. The natural or anthropogenic fluctuations in water temperature discussed in the previous section induce a wide array of behavioral and physiological responses in salmonids.

Much of the literature focuses on "preferred," "optimum," and "lethal" temperatures or temperature ranges (see appendix for definitions). These studies normally occur in laboratories and although they may be reflective of physiological requirements, they are not reflective of ecological requirements (Spence et al. 1996). To understand possible exposure scenarios and species responses, we must evaluate the role of the environment in modulating the duration and magnitude of salmonid exposure to elevated temperatures. The role that temperature plays in the aquatic environment is complex as is the suite of behavioral and physiological responses salmonids display to varied thermal regimes. As we move to protect and restore threatened and endangered salmonid species and associated genetic and life history diversity, it is critical that we move away from discussion of lethal effects and move toward a focused discussion of exposure history and effects associated with sublethal temperatures. Chronic stress related to elevated temperatures directly affects physiological and behavioral parameters and weakens organism resistance to other stressors both natural and anthropogenic. To persist in the face of disturbance, sublethal temperature effects, both physiological as well as behavioral, must be addressed.

The effect of sublethal temperatures may be observed at all levels of biological organization. The response of fishes to stress can be broadly classed as either primary or secondary. Primary responses include neuro-endocrine and endocrine reactions while secondary responses include disturbances in osmotic and ionic regulation, metabolic processes, growth, reproduction, and behavior (Elliott 1981). Beyond the individual organism, responses may affect demographic and metapopulations dynamics as well as species persistence. Holtby (1988) demonstrated that elevated temperatures (1) can have quantifiable effects on salmonid populations; (2) these effects can influence more than one life stage simultaneously and in opposite directions; (3) the effects of perturbations at one life stage can persist throughout the remainder of the life cycle; and (4) for anadromous species, the effects of habitat perturbations during freshwater rearing can persist into the marine phase. Therefore, sublethal temperatures experienced at any one life stage may have repercussions for individual fitness and ultimately population and species viability.

Temperature plays a critical role in mediating molecular level reactions including endocrine-receptor binding efficiency and enzymatic reactions. The binding efficiency of reproductive hormones at receptor sites increases as species approach preferred temperature ranges. Optimal rates for enzymatic reactions also reflect preferred temperature ranges (Elliott 1981). Gill Na^{+}-K^{+} ATPase activity, an indicator of smoltification, is important to the maintenance of electrolyte balance and is related to the ability of smolts to adapt to saline waters from freshwater. Bjornn and Reiser (1991) observed that the parr-to-smolt transition is often incomplete when fish begin to migrate and may fail to develop fully if fish encounter high temperatures. Sauter (unpublished data), demonstrated the inhibitory effect of elevated water temperature on gill Na^{+}-K^{+} ATPase activity. Fall chinook salmon held at 8°C and 13°C exhibited increased ATPase activity over a 6 week period, whereas at 18°C, ATPase activity decreased over the same time period. In a related study, steelhead smolts were held at 6.5°C, 10°C, 15°C, and 20°C. Smolts from the 6.5°C and 10°C groups exposed to a seawater challenge responded with increased levels of ATPase activity, whereas, individuals from the 15°C and 20°C groups responded with low levels of ATPase activity (Hicks 1998). All four of the smolts held at 20°C and three of the four smolts held at 15°C died within three days of the saltwater challenge. No mortalities occurred at 6.5°C or 10°C (Hicks 1998). Adams et al. (1973) observed the suppression of some parr-to-smolt physiological processes when fish were held at relatively high water temperatures, approximately 15°C to 20°C. Decreased ATPase activity may lead directly or indirectly to increased estuarine and ocean mortality as well as freshwater residualization. Once temperatures exceed a threshold level in spring, salmonid smolts will residualize, reverting to pre-smolt physiology, and remain within freshwater (Spence et al. 1996).

At the organism, population, and species levels, the effects of elevated sublethal temperatures are also apparent. The magnitude of the effect reflects the duration, frequency, and magnitude of the exposure. Exposure history, in turn, reflects unique landscape factors including inherent capacity, disturbance history, and complexity.

Temperature controls key processes critical to successful completion of salmonid life history stages. Fundamental to juvenile salmonids is the rate of growth and size at emigration. Growth, in turn, is critical to emigration timing and estuarine and ocean survival (Holtby et al. 1989). Magnuson et al. (1979) determined that the percentage of maximum growth achieved by fishes in three different thermal guilds held 2°C from the center of their fundamental or optimal niches is 98 and 93% on the cool and warm side, respectively. For those 5°C from the center of their fundamental niche, growth was about 82 and 54% of maximum. Additionally, growth declines more rapidly at warmer temperatures as all three growth curves are skewed towards cooler temperatures (Magnuson et al. 1979). These percentage changes in maximum growth reflect significant reductions in fitness (Murray and McPhail 1988). Sea-run cutthroat trout released when they were 21 cm in fork length or larger averaged 12.8% return compared to 2.3% return for smolts less than 21 cm (Tipping 1986). Residualization or nonmigration of smolts may account for a portion of this reduction. Size-related residualization was also noted for steelhead. Additionally, differences in mean size of male and female smolts could explain skewed sex ratios observed at the Cowlitz River, WA hatchery

(Tipping 1986).

Temperature effects on emergence timing and growth rate also translate into altered time of seaward migration. Emigration timing-temperature relationships and timing of adult salmonid spawning represent adaptations for synchronizing emigration with windows of opportunity in the ocean or stream (Holtby et al. 1989). As in Carnation Creek, changes to smoltification and emigration timing may lead to decreased smolt survival (Holtby 1988, Scrivener et al. 1984). Virtually all effects of altered thermal regime on coho production in Carnation Creek were associated with relatively small temperature increases over short periods in the late winter and spring (Holtby 1988).

The timing and duration of emigration are determined by the timing and duration of adult spawning and by the interaction of developmental rates with local temperature conditions. The consistency of development rates over large geographic areas suggests that adaptation to local conditions is mediated by spawner behavior rather then by variable development rates (Holtby 1988). The time of spawning, probably on a scale of weeks, or even days, and spawning duration should therefore be viewed as important adaptations to local conditions. Quinn and Adams (1996) reported that Columbia Basin sockeye salmon migrate approximately six days earlier than historically. This change reflects alteration to thermal and hydrological regimes. A shift in migration timing may have both immediate and long-term implications. Failure to recognize the importance of timing and duration of critical life history events has compromised stock rebuilding programs (Holtby et al. 1989).

Sublethal effects due to cold water temperatures may also occur. Although this issue is normally overlooked, periods of declining water temperature in conjunction with high stream discharge, impose considerable energy demands. It is suggested that stream-dwelling fish suffer a metabolic deficit during acclimation to rapidly declining water temperatures in November and December (Cunjak 1988). Highly altered stream systems often lack riparian canopy and therefore may exhibit colder winter temperatures as well as increased formation of anchor ice. Anchor ice may lead to decreased water interchange in gravel as well as physical disruption of redds with subsequent loss of production.

In addition to migration and spawning timing, the abiotic conditions experienced by reproductively mature salmonids are important to successful reproduction e.g., the development and survival of gametes, embryos, and the successful emergence of fry. Taranger and Hansen (1993) and Smith et al. (1983) determined that high water temperatures during the spawning season inhibit ovulation and are detrimental to gamete quality in Atlantic salmon and cutthroat trout. Reproductively mature spring chinook salmon held at temperatures ranging from 17.5° to 19°C produced a greater number of pre-hatch mortalities and developmental abnormalities, as well as smaller eggs and alevins than adults held at 14°C to 15.5°C (Berman 1990). Mortality that occurs within the redd is not apparent to the observer and therefore may be considered an undetected or hidden mortality. However, this reduction in production although undetected can have significant repercussions for long-term population and species viability. Additionally, alevin size mediates survival with smaller alevins and subsequent fry being more vulnerable to predation as well as experiencing reductions in overwinter survival and deleterious alterations to emigration timing.

Although important to all reproductively mature organisms, energy conservation is critical to anadromous, fluvial, and adfluvial life history forms migrating over large distances. Energy conservation prior to spawning may be critical to reproductive success. Bouck et al. (1977) observed that adult sockeye salmon held at 10°C lost 7.5% of their body weight and had visible fat reserves. However, at 16.2°C, they lost 12% of their body weight and visible fat reserves were essentially depleted. Females with developing eggs lost more body weight than males and also exhibited adverse gonadal development (Bouck et al. 1977). Gilhousen (1980) determined that between 5 and 26% of fat and 40 and 70% of protein remained in post-spawning Fraser River sockeye salmon, with males retaining more than females. Excess energy expenditure prior to spawning, especially by females, may reduce spawning success (Berman 1991). Behavior during spawning migration that allows fish to exploit refuge areas of decreased temperature and flow may decrease energy expenditure, and hence, increase energy devoted to behavioral and physiological processes such as gamete production, mate selection, redd construction, spawning, and redd guarding by females involved in successful reproduction (Berman 1991).

Using bioenergetic data obtained from sockeye salmon and extrapolated to spring chinook salmon, Berman and Quinn (1991) demonstrated that a 2.5°C decrease in internal temperature produces a 12 to 20% decrease in basal metabolic rate or a savings of 17.3 to 29.9 cal/kg/h. At the maximum or active metabolic rate, a 3.2 to 6.2% decrease in metabolic rate would result in a savings of 71.5 to 130 cal/kg/h. Energy savings per day would therefore be 3.2 to 20% of the total daily energy expenditure, depending on activity level. Quinn and Adams (1996) have demonstrated that the upriver migration of sockeye salmon in the Columbia River basin is earlier than in past years owing to changes in thermal and hydrological regimes. However, the change in timing lags behind the rate of environmental change, and they are now experiencing approximately 2.5°C warmer temperatures than in past years. Additionally, elevated temperatures such as observed near the confluence of the Snake and Columbia Rivers can create delays in upstream migration. Beschta et al. (1987) reported the occurrence of migratory inhibition at 21°C. As energy reserves are important to successful reproductive efforts, elevated temperatures during migration or on the spawning ground can directly affect population and species viability.

In addition to embryo and alevin effects, temperature during migration and on the spawning ground were significantly related to prespawning mortality (Gilhousen 1990). A delay in upstream migration of only 5 days caused significant mortality in Fraser River sockeye salmon; few of the salmon reached the spawning grounds when subjected to delays of 10 to 12 days (Snyder and Blahm 1971). Although thermal refugia may mitigate the effects of elevated temperatures, they must be available, accessible, and well distributed. Managed systems lacking a network of well distributed refugia may not ameliorate naturally or anthropogenically derived elevated temperatures; thereby exposing salmonids to sublethal temperatures and concomitant physiological effects.

An important factor related to thermal stress is resistance to disease and immunological response. Many disease organisms are not only capable of surviving at elevated temperatures, but are capable of increased virulence at these temperatures. Additionally, fish exposed to elevated temperatures undergo compensatory reactions to reduce the effect of the stressor. However, prolonged exposure to elevated temperatures and hence long-term compensatory reactions may weaken the fish's ability to resist infection or infestation (Wedemeyer and Goodyear 1984). Adult spring chinook salmon held at 17.5°C to 19°C experienced 88% mortality owing to *Flexibacter columnaris* (Berman 1990). Although *Flexibacter columnaris* was present on the gills of fish held at temperatures ranging from 14°C to 15.5°C, there were no mortalities among this group. This same trend is evident in other bacterial and viral diseases as well (Marine 1992, Post 1987). Direct mortality via disease as well as indirect effects through compensatory responses may significantly affect population and species viability. Although disease related mortality may be difficult to observe, one suspects that the ramifications are great.

Sublethal temperatures also mediate competitive success. Thermal niche shifts in the face of interspecific competition for areas of preferred temperature have occurred (Magnus on et al. 1979). Reeves et al. (1987) demonstrated that temperature influenced interactions between redside shiner and juvenile steelhead trout in the field and laboratory. Steelhead distribution was not influenced by shiner in cool water, but was influenced at warmer temperatures. A shift in competitive advantage is also evident between native bull trout and introduced brook trout. Brook trout pose a serious threat to bull trout populations (Ratliff and Howell 1992). Temperature, therefore, not only affects behavioral and physiological processes, but mediates species distribution as well. Operating within a "realized" niche as a result of competitive interaction rather than a "fundamental" or preferred niche may deprive an organism of energy for activities such as growth, defense, predator avoidance, and osmoregulation. If temperature is critical to the successful completion of life history stages then operating outside the "scope for activity or growth" may reduce species fitness. As is evident from this discussion of sub-lethal effects, short-term as well as long-term and cumulative exposure to sublethal temperatures pose a serious threat to population and species viability.

We began our discussion of sublethal temperature effects with the understanding that temperature can affect more than one life stage simultaneously and in opposite directions and that the effects of perturbations at one life stage can persist throughout the remainder of the life cycle. As we discussed in section IV, these effects do not occur in isolation. Other stressors operate within the riverine system. Biotic factors such as species introductions as well as abiotic factors including system fragmentation and alteration to the abundance and distribution of critical habitat elements are equally important. These factors influence species distribution, demographics, and metapopulation dynamics and, in turn, genetic and life history diversity. As biological and ecological options are reduced, resistance and resilience to disturbance is reduced. The cumulative and synergistic effects of these stressors have long-term implications for species viability.

VII. Intermittent Elevated Temperature Exposure:

Because the thermal structure of rivers is dynamic and can become more so after anthropogenic alterations, the duration of stressful conditions may determine population and species survival (Berman 1990). Anthropogenic alterations may lead to: (1) higher summer maximum temperatures; (2) decreased winter temperatures; (3) decreased areal extent of contiguous cold-water habitat as well as decreased abundance and distribution of cold-water refugia; (4) phase shifts in annual thermal regimes with warmer temperatures occurring earlier in the spring and extending later into the fall; and (5) greater diel fluctuation and intermittently elevated temperatures.

Previous sections have dealt with changes to maximum and minimum temperatures and related system alterations. Shifts in the annual thermal regimes of river systems may generate a cascade of changes affecting the successful completion of life history stages. The phase shift of riverine temperatures should be evaluated in conjunction with single maxima. Species are adapted to the abiotic conditions of riverine systems. Phase shifts may negatively affect egg development and the timing of emergence, reproduction, and emigration (Naiman et al. 1992, Holtby 1988). State standards use daily or weekly criteria to protect perceived sensitive life history stages. However, this approach may not be fully protective of poikilothermic species such as salmonids (see Section VI). Modifications to the timing of seasonal temperature shifts are as important to salmonid viability as daily maximum, minimum, and averages temperatures. This topic should be the basis of future discussions related to temperature standard development.

The term "fluctuation" is typically used to describe diel temperature patterns. However, in the context of water quality standards, fluctuation may also pertain to the oscillation of hourly temperature around a set point, the numeric criteria. This latter definition is meant to address diel temperature patterns. The assumption is that some flexibility in the daily maximum temperature is warranted because the daily minimum and mean temperatures reduce potential thermal effects to aquatic biota. Oregon employs a "seven-day moving average of the daily maximum temperature" to assess compliance with numeric temperature criteria. This measurement unit provides some flexibility in meeting the temperature standard. However, several questions arise regarding temperature fluctuation and the use of a seven-day average to assess biotic condition. The assumption that this measurement unit a) accurately assesses temperature patterns and b) adequately protects sensitive species requires further analysis.

Although diel fluctuation is the norm, anthropogenic alteration can affect the magnitude of this fluctuation. Mean stream temperatures in a mature, undisturbed, old growth forest and a nearby stream in a recently harvested forest on Prince of Wales Island, southeastern Alaska, differed by only 1.2°C in summer. However, the mean daily temperature range of the stream in the harvested area (9.1°C) was double that of the forested stream (4.8°C). The response of organisms to fluctuating temperatures is critical to an evaluation of Oregon's numeric criteria as well as the selected measurement unit.

Coho presmolts exposed to a 6.5°C to 20°C diel temperature regime experienced plasma cortisol concentrations 25 to 50% higher than presmolts experiencing cooler maximums (Thomas et al. 1986). Presmolts were at a minimum responding to the daily maximum temperature. Elevated concentrations of plasma cortisol, a primary response of vertebrates to stress, indicate that fish have been chronically stressed (Barton and Schreck 1987). In this 19-day test, presmolt mortality did not occur. However, the absence of mortality may be an artifact of the study design. Modifications that would have allowed the study to more closely mirror natural conditions include: investigation of long-term results of exposure and inclusion of a multiple parameter challenge (i.e., diel temperature fluctuation and smoltification, competition, and/or disease resistance). Juvenile coho response to fluctuating temperature regimes was also investigated following the eruption of Mt. St. Helens, Washington. Maximum diel fluctuation was highly correlated, and the maximum monthly mean temperature was moderately correlated with population mortality and out-migration of juvenile coho salmon exposed to the post-eruption thermal regime (Hicks 1998).

Salmonids respond not only to daily maximum temperatures, but also to maximum diel fluctuation, maximum mean temperatures, and cumulative exposure history. Survival tests of 0+ age chinook migrants were conducted in liveboxes in the Grande Ronde River, Oregon (Burck 1994). A diel temperature regime of 25.6°C to 16.1°C (mean 20.9°C), resulted in 0% survival over a 24 hour period. In a four-day test where maximum temperatures were 23.9°C-25.6°C and minimum temperatures were 11.1°C to 13.3°C, survival was 20%. Minimally improved survival may be attributable to lower minimum and lower average temperatures, as well as less cumulative time spent at temperatures above 20°C. At a second site where daily maximum temperatures ranged from 19.4°C to 22.2°C over a four day period, survival was 100% in most tests with one test at 50% survival. Information on daily minimum temperatures and survival over all tests was not provided, and therefore, it is difficult to interpret the results. As with the previous study, use of a multiple parameter challenge and an investigation of long-term effects would have increased the utility of the study.

Preference tests provide useful information pertaining to how organisms experience temperature and the role of behavioral thermoregulation in maintaining optimum temperatures. Steelhead fry and yearlings were held in fluctuating (8°C-19°C) and constant temperatures (8.5°C, 13.5°C, 18.5°C). As many fish remained in fluctuating as in constant 13.5°C temperatures; twice as many remained in fluctuating as in constant 18.5°C temperatures; and twice as many fish remained in constant 8.5°C as in fluctuating temperatures (Hicks 1998). Results indicate that steelhead preferred the lowest temperature provided whether produced as a constant or a mean temperature. It appears that individuals responded to the daily minimum, maximum, and average temperatures depending on the setting and array of temperatures provided. This evidence is critical to the establishment of numeric criteria and the selection of an appropriate temperature measurement unit.

These findings compare well to field studies where individuals consistently seek the lowest temperature available within a fluctuating environment. Through behavioral thermoregulation fish are able to maintain internal body temperatures at or near preferred temperatures. Resistance to internal temperature fluctuation may allow salmonids to maintain energy benefits derived from cold-water refugia for a period of time, the length of which is size dependent (Berman and Quinn 1991). Thermal inertia provides an approximately 30 minute window before thermal equilibration occurs (Berman 1990). Therefore, there is an advantage to organisms that are able to locate cool water. This advantage may reduce the effect of intermittently elevated temperatures. However, riverine systems have been greatly altered with ambient temperatures increasing and cold-water refugia abundance, distribution, and accessability decreasing. Therefore, the availability of cold-water refugia cannot be relied upon to mitigate the effect of intermittent elevated temperatures.

Although research on fluctuating or intermittently elevated temperatures may not be exhaustive, the studies that have been conducted point to the risks associated with this type of exposure. Organisms respond to maximum diel fluctuation, maximum daily temperatures, mean daily temperatures, mean monthly temperatures, and cumulative thermal history with both physiological and behavioral changes. Response depends upon the setting and array of temperatures provided. These results are corroborated by previous studies that established the ability of freshwater fishes to detect temperature changes as slight as 0.05°C (Berman and Quinn 1991). Given this information, numeric temperature criteria should be established below demonstrated sublethal temperature ranges. Temperature measurement units that mask or allow excursions above sublethal effects thresholds or that do not adequately consider cumulative exposure history should not be used. Exposure to mean or daily maximum temperatures at or above the threshold for sublethal response may not be offset by daily minimum temperatures.

The use of a "seven-day moving average of the daily maximum temperature" allows for some flexibility in daily maximum temperatures that might occur over time. The daily maximum reportedly can exceed the maximum weekly average temperature by approximately 0.5 to 2°C (Buchanan and Gregory 1997). As previously discussed, "flexibility" may not adequately protect salmonids from exposure to sublethal temperatures. This type of measurement unit masks the magnitude of temperature fluctuation and the duration of exposure to daily maximum temperatures. Additionally, daily mean temperatures and cumulative exposure history are not addressed. The ability of Oregon's temperature measurement unit to adequately protect native salmon and charr lies in (1) the protectiveness of the numeric criteria selected,

(2) the ability to define unacceptable maximum diel fluctuation, and (3) the ability to track and respond to cumulative exposure history. If, as in the current case, the measurement unit in conjunction with numeric criteria masks salmonid exposure to sublethal and lethal temperatures then the measurement unit, the criteria, or both must be modified. Establishment of conservative numeric criteria would lessen concerns surrounding the magnitude of fluctuation and cumulative exposure. However, in the long-term these issues should be factored into the temperature standard.

The basis of the Oregon temperature standard rests on the assumption that the criteria represent a "maximum" condition, given diurnal variability...." The June 22, 1998 letter from Michael T. Llewelyn, Administrator, Water Quality Unit, Oregon Department of Environmental Quality to Philip Millam, Director, Office of Water, EPA, provides clarification of the standard. The letter states, "A review of the literature indicates that it is difficult to establish a temperature criteria for waters that experience diurnal temperature changes that would assure no effects due to *C. columnaris*...the technical committee has recommended a temperature range (58-64°F; 14.4-17.8°C) as being protective of salmonid rearing. While 64°F is the upper end of the range, the key to this recommendation is the temperature unit that is used in the standard - the seven-day moving average of the daily maximum temperatures." A 64°F (17.8°C) threshold was selected as it was believed that "the criteria represent a "maximum" condition, given diurnal variability..."

Firstly, we have previously established that sublethal temperatures do affect organisms in complex ways including a decrease in disease resistance and increases in disease virulence. Exposure and response to *columnaris* is but one outcome in an array of possible stressor-response scenarios. Section VI provides an overview of physiological and behavioral responses of organisms to sublethal temperatures. If we focus on disease resistance, we find that the literature is clear regarding the connection between temperature and disease virulence as well as temperature and immune response. Research conducted by Berman (1990) found that temperatures of 15.5°C or less protected adult spring chinook salmon from *columnaris* related mortality. Other authors have also commented on a temperature threshold of 15°C related to *columnaris* infection and mortality. Given the previous discussion concerning organism response to daily minimum, maximum, and average temperatures, the threshold for effect appears to be a daily maximum of 15°C or a daily mean of 15°C.

Secondly, the June 22, 1998 clarification letter asserts that diurnal fluctuation is normal. This is of course true. However, the magnitude of fluctuation and the duration of elevated temperatures is greater in an altered system. Concomitantly, the abundance and distribution of cold-water refugia is decreased. Based on Oregon's 303(d) list, it is likely that the diel fluctuation in many Oregon streams is reflective of altered systems and is therefore not "normal." As was illustrated by the Mt St. Helens study, salmonids do respond to maximum diel fluctuation through increased mortality and, where possible, migration.

Using a hypothetical seven-day period to evaluate potential time spent at or above sublethal thresholds, there is compelling evidence to conclude that the combination of measurement unit and numeric criteria will lead to a reduction in species fitness and viability.

Example: "Stream XYZ" - Rearing Criterion 64°F (17.8°C)

Day 1: daily temperatures:
16.5°C, 17.7°C, 18°C, 18.5°, 18.3°C, 17.7°C, 16.6°C
maximum temperature: 18.5°C
mean temperature: 17.6°C

Day 2: daily temperatures:
15.5°C, 15.8°C, 16.8°C, 17.2°C. 17°C, 16.8°C, 16.2°C
maximum temperature: 17.2°C
mean temperature: 16.5°C

Day 3: daily temperatures:
15.5°C, 15.8°C, 16.9°C, 17.2°C. 17°C, 16.8°C, 16.3°C
maximum temperature: 17.2°C
mean temperature: 16.5°C

Day 4: daily temperatures:
16°C, 17.2°C, 17.8°C, 18.3°C, 17.9°C, 17.5°C, 16.9°C
maximum temperature: 18.3°C
mean temperature: 17.4°C

Day 5: daily temperatures:
16.8°C, 17.3°C, 17.9°C, 18°C, 17.8°C, 17.4°C, 16.9°C
maximum temperature: 18°C
mean temperature: 17.4°C

Day 6: daily temperatures:
16.2°C, 17.2°C, 17.6°C, 17.8°C, 17.8°C, 17.2°C, 16.9°C
maximum temperature: 17.8°C
mean temperature: 17.2°C

Day 7: daily temperatures:
16.8°C, 17.4°C, 17.7°C, 17.8°C, 17.8°C, 17.5°C, 16.9°C
maximum temperature: 17.8°C
mean temperature: 17.4°C

Seven-Day Moving Average of the Daily Maximum Temperature: 17.8°C

This example provides evidence that the "seven-day moving average" masks the magnitude of temperature fluctuation and the duration of exposure to daily maximum temperatures as well as neglects mean temperatures and cumulative exposure history. From the example, we find that on five of the seven days, the daily maximum temperature is at or above the rearing criterion. Although daily mean temperatures do not exceed the criterion, they are less than 1°C from the criterion on five of the seven days. Where daily maximum temperatures are 17.8°C or greater, organisms are exposed to temperatures equal to or greater than the criterion over a potentially significant portion of the day. Finally, the "seven-day moving average of the daily maximum temperature" meets the rearing criterion of 17.8°C even though the cumulative exposure history of an organism in "Stream XYZ" is often at or above the standard and is well within the sublethal to lethal range. The assumption that "the criteria represent a "maximum" condition, given diurnal variability..." appears unfounded. Based on current numeric criteria, the temperature measurement unit does not adequately protect native salmon and charr. Establishment of conservative numeric temperature criteria would lessen concerns surrounding the magnitude of fluctuation and cumulative exposure.

As most riverine networks currently exceeding temperature standards exceed other water quality standards as well, the standard may not adequately address the synergistic effects of multiple stressors. Additionally, it is important to recognize that these systems do not contain the system diversity and resilience to provide refuge from elevated temperatures. Shifts in the thermal regime affect all life history forms to different degrees and different magnitudes. These effects are cumulative. Loss of organism integrity due to elevated temperatures weakens the ability of individuals to respond to additional stressors.

VIII. Determination of Effects: Effect of Criteria on ESA Proposed, Threatened and Endangered Salmon and Charr

Oregon Temperature Standard: Numeric Criteria

Salmonid spawning, egg incubation, and fry emergence from the egg and the gravel: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin which exceeds 12.8°C."

Salmonid rearing: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin for which salmonid rearing is a designated beneficial use, and in which surface waters exceed 17.8°C."

Bull trout: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in waters determined by the Department to support or to be necessary to maintain the viability of native Oregon bull trout, when surface water temperatures exceed 10°C." The temperature criteria applies to waters containing spawning, rearing, or resident adult bull trout.

In the Columbia River or its associated sloughs and channels from the mouth to river mile 309: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed when surface water temperatures exceed 20°C."

In the Willamette River or its associated sloughs and channels from the mouth to river mile 50: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed when surface water temperatures exceed 20°C."

Adult migration, adult holding, smoltification, and juvenile emigration are not identified as distinct designations. Although the standard states that, "The temperature criteria of 17.8°C will be applied to all water bodies that support salmonid fish rearing...." it is unclear how the standard will address other life history stages.

The following analysis was conducted using 17.8°C as the criterion for all life history stages with the exception of spawning, incubation, and fry emergence. A criterion of 20°C was applied to species and life history stages occupying the mainstem Columbia River to river mile 309 and the Willamette River to river mile 50.

1. Snake River Sockeye Salmon:

A. The Oregon Water Quality Standards contain the following criterion for "salmonid spawning, egg incubation, and fry emergence from the egg and the gravel: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin which exceeds 12.8°C.

Sockeye salmon spawning preference has been recorded as 10.6°C to 12.2°C (Spence et al. 1996, Bjornn and Reiser 1991, Bell 1986). The Independent Scientific Group (1996) provides temperature ranges for chinook salmon. However, the authors state that, "other salmon species are not markedly different in their requirements." They cite 10°C as the optimum spawning temperature with a range of 8°C to 13°C. Stressful conditions occur at temperatures equal to or greater than 15.6°C and lethal temperature effects occur at 21°C (Independent Scientific Group 1996). Incubation optimum have been cited as 4.4°C to 13.5°C (Combs 1965), 4.4°C to 13.3°C (Spence et al. 1996, Bell 1986), and 10°C (Department of Fisheries, Canada, 1952). Incubation temperatures greater than 12.8°C have lead to significant mortality among developing embryos (Department of Fisheries, Canada, 1965).

Based on cited temperature preferences as well as effects studies for spawning, incubation, and emergence, EPA has determined that the criterion is protective of Snake River sockeye salmon. However, we are concerned that all appropriate habitat and periods of spawning, incubation, and emergence are correctly identified. If designations are too narrowly applied they may not be sufficiently protective.

The criterion is not likely to adversely affect Snake River sockeye salmon.

B. The Oregon Water Quality Standards contain the following criterion for salmonid rearing: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin for which salmonid rearing is a designated beneficial use, and in which surface waters exceed 17.8°C." In addition, "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in the Columbia River or its associated sloughs and channels from the mouth to river mile 309 when surface water temperatures exceed 20°C."

Adult migration, adult holding, smoltification, and juvenile emigration are not identified as distinct designations. Therefore, it is presumed that the salmonid rearing criterion of 17.8°C includes these additional life history stages. The following analysis will be conducted with 17.8°C and, where appropriate, 20°C as the criterion for all life history stages with the exception of spawning, incubation, and fry emergence.

Temperature preferences for migrating adult sockeye salmon have been recorded as 7.2°C to 15.6°C (Spence et al. 1996, Bjornn and Reiser 1991, Bell 1986). The Independent Scientific Group (1996) provides a general recommendation for salmonid migration with an optimum of 10°C and a range of 8.0°C to 13.0°C. Stressful conditions begin at temperatures greater than 15.6°C and the lethal temperature is 21°C (Independent Scientific Group 1996). In a study by Bouck et al. (1977), adult sockeye salmon held at 10°C lost 7.5% of their body weight and had visible fat reserves. Adults held at 16.2°C lost 12% of their body weight and visible fat reserves were essentially depleted. Females with developing eggs lost more body weight than male counterparts and exhibited abnormal gonadal development. Beschta et al. (1987) reported the occurrence of migratory inhibition at 21°C. As energy reserves are important to successful reproductive efforts, elevated temperatures during migration or on the spawning ground can directly affect population and species viability (see discussion Section VI). Additionally, delays in upstream migration of only 5 days caused significant mortality in Fraser River sockeye salmon; few of the salmon reached the spawning grounds when subjected to delays of 10 to 12 days (Snyder and Blahm 1971).

Rearing temperature preferences of 10°C to 12.8°C (Bell 1986), 10.6°C (Burgner 1991, Huntsman 1942), 10.6°C to 12.8°C (Coutant 1977), 14.5°C (Coutant 1977, Ferguson 1958, Huntsman 1942), 12°C to 14°C (Brett 1952), 11.2°C to 14.6°C (Beschta et al. 1987), and a physiological optimum of 15°C (Brett et al. 1958) have been reported. The Independent Scientific Group (1996) cites general recommendations for salmonid rearing with 15°C as the optimum and a range of 12°C to 17°C. Stressful conditions occur at temperatures equal to or greater than 18.3°C and lethal effects occur at 25°C (Independent Scientific Group 1996).

The National Marine Fisheries Service's (NMFS) document entitled, "Making ESA Determinations of Effect for Individual or Grouped Actions at the Watershed Scale" states that "properly functioning" riverine systems exhibit temperatures of 10°C to 14°C; between 14°C and 17.8°C they are "at risk" with reference to migratory and rearing life history stages; and at greater than 17.8°C they are "not properly functioning" with reference to migratory and rearing life history stages. Spence et al. (1996) states that the upper lethal temperature for sockeye salmon acclimated to 20°C is 25.8°C. At this temperature, 50% mortality occurs.

Smolt temperature preference during emigration was cited by Spence et al. (1996) as 2°C to 10°C with termination of migration occurring at 12°C to 14°C.

Exposing Snake River sockeye salmon to the temperature criteria during migration, rearing, and smoltification poses a significant and unacceptable risk to their viability. EPA has reviewed the literature concerning lethal and sublethal effects of temperature on salmonids as well as the compounding effect of habitat simplification and loss. Based on this review, there is compelling reason to believe that mortality from both lethal and sublethal effects (e.g., reproductive failure, prespawning mortality, residualization and delay of smolts, decreased competitive success, disease resistance) will occur. Additionally, if designated "spawning or rearing habitat" underestimates available habitat then the designation may not be sufficiently protective of sockeye salmon.

The rearing criterion is likely to adversely affect Snake River sockeye salmon. This criterion should be reassessed and a new temperature criterion protective of Snake River sockeye salmon during migration, rearing, and smoltification be developed.

2. Snake River Spring/Summer Chinook Salmon, Southern Oregon and California Coastal Spring Chinook Salmon, Lower Columbia River Spring Chinook Salmon, Upper Willamette River Spring Chinook Salmon:

A. The Oregon Water Quality Standards contain the following criterion for "salmonid spawning, egg incubation, and fry emergence from the egg and the gravel: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin which exceeds 12.8°C.

Spring chinook spawning preferences of 5.6°C to 14.4°C (Olson and Foster 1955), 5.6°C to 13.9°C (Spence et al. 1996, Bell 1986), and 5.6°C to 12.8°C (Temperature Subcommittee, DEQ 1995) have been recorded. Temperature preferences for spawning summer chinook have been cited as 5.6°C to 14.4°C (Olson and Foster 1955), 6.1°C to 18.0°C (Olson and Foster 1955), and 5.6°C to 13.9°C (Spence et al. 1996, Bjornn and Reiser 1991). A spawning optimum of 10°C with a range of 8.0°C to 13°C has been reported by the Independent Scientific Group (1996). Stressful conditions begin at temperatures greater than 15.6°C, lethal effects occur at 21°C (Independent Scientific Group 1996).

The National Marine Fisheries Service's Chinook Habitat Assessment provides a 10°C to 13.9°C range for "properly functioning" condition and a range of 14°C to 15.5°C as "at risk" with reference to spawning.

Spring chinook incubation optimum of 5°C to 14.4°C (Spence et al 1996, Bell 1986) and 4.5°C to 12.8°C (Temperature Subcommittee, DEQ 1995) have been cited. The optimum temperature range for summer chinook incubation is 5.0°C to 14.4°C (Spence et al. 1996, Bjornn and Reiser 1991). The Independent Scientific Group (1996) cites temperatures of less than 10°C as optimum for incubation with a range of 8.0°C to 12.0°C. Stressful conditions begin at temperatures greater than 13.3°C, lethal effects occur at temperatures greater than 15.6°C (Independent Scientific Group 1996). The National Marine Fisheries Service's Chinook Habitat Assessment cites temperatures of 10°C to 13.9°C as "properly functioning."

Based on cited temperature preferences as well as effects studies for spawning, incubation, and emergence, EPA has determined that the criterion is protective of Snake River spring/summer chinook salmon, Southern Oregon and California Coastal spring chinook salmon, Lower Columbia River spring chinook salmon, and Upper Willamette River spring chinook salmon. However, we are concerned that all appropriate habitat and periods of spawning, incubation, and emergence are correctly identified. If designations are too narrowly applied they may not be sufficiently protective.

The criterion is not likely to adversely affect Snake River spring/summer chinook salmon, Southern Oregon and California Coastal spring chinook salmon, Lower Columbia River spring chinook salmon, and Upper Willamette River spring chinook salmon.

B. The Oregon Water Quality Standards contain the following criterion for salmonid rearing: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin for which salmonid rearing is a designated beneficial use, and in which surface waters exceed 17.8°C." In addition, "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in the Columbia River or its associated sloughs and channels from the mouth to river mile 309 or in the Willamette River or its associated sloughs and channels from the mouth to river mile 50 when surface water temperatures exceed 20°C."

Adult migration, adult holding, smoltification, and juvenile emigration are not identified as distinct designations. Therefore, it is presumed that the salmonid rearing criterion of 17.8°C includes these additional life history stages. The following analysis will be conducted with 17.8°C and, where appropriate, 20°C as the criterion for all life history stages with the exception of spawning, incubation, and fry emergence.

The temperature preference range for migrating adult spring chinook salmon is 3.3°C to 13.3°C (Spence et al. 1996, Bjornn and Reiser 1991, Bell 1986). At temperatures of 21°C, migratory inhibition occurs (Temperature Subcommittee, DEQ 1995). Migrating adult summer chinook temperature preferences have been cited as 13.9°C to 20°C (Spence et al. 1996, Bjornn and Reiser 1991, Bell 1986).

The Independent Scientific Group (1996) cites 10°C as the optimum temperature for chinook migration with a range of 8.0°C to 13.0°C. Stressful conditions begin at temperatures greater than 15.6°C and the lethal temperature is 21°C (Independent Scientific Group 1996). "Properly functioning" condition is reported by the National Marine Fisheries Service Chinook Habitat Assessment to occur at 10°C to 13.9°C with riverine systems "at risk" for migrating chinook salmon at temperatures between 14°C and 17.5°C. Spence et al. (1996) cite 26.2°C as the upper lethal temperature for chinook salmon acclimated to 20°C while Brett (1952) reports an upper lethal temperature of 25.1°C. At these temperatures 50% mortality occurs.

In addition to migratory preference, spring chinook salmon research has addressed the role of temperature during adult holding in freshwater. As spring chinook salmon spend extended periods in freshwater prior to spawning, water temperature during this period is critical to successful reproduction. The Oregon Water Quality Standards Review (Temperature Subcommittee, DEQ 1995) cites temperatures of 8.0°C to 12.5°C as appropriate for adult spring chinook salmon holding. In addition, the Oregon Water Quality Standards Review (Temperature Subcommittee, DEQ 1995) states that temperatures between 13.0°C and 15.5°C could produce pronounced mortality in adult spring chinook. Marine (1992) cites information demonstrating that temperatures between 6.0°C and 14.0°C provided optimal pre-spawning survival, maturation, and spawning. Marine (1992) and Berman (1990) identified a sublethal temperature range of 15°C to 17°C. Lethal temperatures for adult spring chinook holding in freshwater have been reported as 18°C to 21°C (Marine 1992) and greater than or equal to 17.5°C (Berman 1990).

Rearing preferences for spring chinook salmon of 11.7°C (Coutant 1977, Ferguson 1958, Huntsman 1942), 10°C to 12.8°C (Bell 1986), and 10°C to 14.8°C (Temperature Subcommittee, DEQ 1995) have been recorded. Optimum production occurs at 10°C, and maximum growth at 14.8°C (Temperature Subcommittee, DEQ 1995). Summer chinook rearing preference is cited as 11.7°C (Coutant 1977, Ferguson 1958, Huntsman 1942) and 10°C to 12.8°C (Bell 1986). Temperatures greater than 15.5°C increase the likelihood of disease-related mortality in chinook salmon (Temperature Subcommittee, DEQ 1995).

The Independent Scientific Group (1996) report an optimum rearing temperature for chinook salmon of 15°C, with a range of 12°C to 17°C. Stressful conditions begin at temperatures greater than 18.3°C and the lethal temperature is 25°C (Independent Scientific Group 1996). "Properly functioning" condition is cited by the National Marine Fisheries Service Chinook Habitat Assessment as 10°C to 13.9°C with riverine systems "at risk" for rearing chinook salmon at temperatures between 14°C and 17.5°C.

Smoltification and outmigration preference for spring chinook range from 3.3°C to 12.2°C (Temperature Subcommittee, DEQ 1995). Lethal loading stress occurs between 18.0°C and 21°C (Temperature Subcommittee, DEQ 1995, Brett 1952).

Exposing Snake River spring/summer chinook salmon, Southern Oregon and California Coastal spring chinook salmon, Lower Columbia River spring chinook salmon, and Upper Willamette River spring chinook salmon to the temperature criterion during migration, rearing, and smoltification poses a significant and unacceptable risk to their viability. EPA has reviewed the literature concerning lethal and sublethal effects of temperature on salmonids as well as the compounding effect of habitat simplification and loss. Based on this review, there is compelling reason to believe that mortality from both lethal and sublethal effects (e.g., reproductive failure, prespawning mortality, residualization and delay of smolts, decreased competitive success, disease resistance) will occur. Additionally, if designated "spawning or rearing habitat" underestimates available habitat then the designation may not be sufficiently protective of spring/summer chinook salmon.

The rearing criterion is likely to adversely affect Snake River spring/summer chinook salmon, Southern Oregon and California Coastal spring chinook salmon, Lower Columbia River spring chinook salmon, and Upper Willamette River spring chinook salmon. This criterion should be reassessed and a new temperature criterion protective of spring/summer chinook salmon during migration, holding, rearing, and smoltification be developed.

3. Snake River Fall Chinook Salmon, Southern Oregon and California Coastal Fall Chinook Salmon, Lower Columbia River Fall Chinook Salmon:

A. The Oregon Water Quality Standards contain the following criterion for "salmonid spawning, egg incubation, and fry emergence from the egg and the gravel: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin which exceeds 12.8°C.

Fall chinook spawning preferences of 10°C to 12.8°C (Bell 1986), 10°C to 16.7°C (Olson and Foster 1955), and 5.6°C to 13.9°C (Spence et al. 1996) have been recorded. The National Marine Fisheries Service's document entitled, "Making ESA Determinations of Effect for Individual or Grouped Actions at the Watershed Scale" states that "properly functioning" riverine systems exhibit temperatures of 10°C to 14°C, between 14°C and 15.5°C they are "at risk" with reference to spawning, and at temperatures greater than 15.5°C they are "not properly functioning" with reference to spawning. The optimum temperature for spawning is 10°C with a range of 8°C to 13°C (Independent Scientific Group 1996). Stressful conditions occur at temperatures greater than 15.6°C and lethal temperatures occur at 21°C (Independent Scientific Group 1996).

Incubation optimum have been cited as 10°C to 12.8°C (Bell 1986), 10°C to 16.7°C (Olson and Foster 1955), 10°C to 12°C (Neitzel and Becker 1985, Garling and Masterson 1985, Heming 1982), and 5°C to 14.4°C (Spence et al. 1996). Temperatures greater than 12°C may reduce alevin survival (Ringler and Hall 1975). Smith et al. (1983) found that temperatures greater than 15.6°C produce significant mortality. The Independent Scientific Group (1996) cites temperatures less than 10°C as optimum for incubation with a range of 8°C to 12°C. Stressful conditions occur at temperatures greater than 13.3°C and lethal temperatures occur at 15.6°C (Independent Scientific Group 1996).

Based on cited temperature preferences as well as effects studies for spawning, incubation, and emergence, EPA has determined that the criterion is protective of Snake River fall chinook salmon, Southern Oregon and California Coastal fall chinook salmon, and Lower Columbia River fall chinook salmon. However, we are concerned that all appropriate habitat and periods of spawning, incubation, and emergence are correctly identified. If designations are too narrowly applied they may not be sufficiently protective.

The criterion is not likely to adversely affect Snake River fall chinook salmon, Southern Oregon and California Coastal fall chinook salmon, and Lower Columbia River fall chinook salmon.

B. The Oregon Water Quality Standards contain the following criterion for salmonid rearing: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin for which salmonid rearing is a designated beneficial use, and in which surface waters exceed 17.8°C." In addition, "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in the Columbia River or its associated sloughs and channels from the mouth to river mile 309 or in the Willamette River or its associated sloughs and channels from the mouth to river mile 50 when surface water temperatures exceed 20°C."

Adult migration, adult holding, smoltification, and juvenile emigration are not identified as distinct designations. Therefore, it is presumed that the salmonid rearing criterion of 17.8°C includes these additional life history stages. The following analysis will be conducted with 17.8°C and, where appropriate, 20°C as the criterion for all life history stages with the exception of spawning, incubation, and fry emergence.

The temperature preference range for migrating adult fall chinook salmon is 10.6°C to 19.4°C (Spence et al. 1996, Bell 1986). The optimum migration temperature is 10°C with a range of 8°C to 13°C (Independent Scientific Group 1996). Stressful conditions occur at temperatures greater than 15.6°C and lethal effects occur at 21°C. The National Marine Fisheries Service's document entitled, "Making ESA Determinations of Effect for Individual or Grouped Actions at the Watershed Scale" and Chinook Habitat Assessment state that "properly functioning" riverine systems exhibit temperatures of 10°C to 13.9°C-14°C; between 14°C and 17.5°C-17.8°C they are "at risk" with reference to migratory and rearing life history stages; and at temperatures greater than 17.5°C-17.8°C they are "not properly functioning" with reference to migratory and rearing life history stages. The preferred rearing temperature range is 12°C to 14°C (Bell 1986). At temperatures of 15.5°C or greater, disease-related mortality increases (Temperature Subcommittee, DEQ 1995).

Fall chinook salmon research on temperature - smoltification interactions has been conducted. ATPase activity, an indicator of smoltification, is important to the maintenance of electrolyte balance and is related to the ability of smolts to adapt to saline waters from freshwater. At 8°C and 13°C, ATPase activity over a six week period increased. However, at 18°C, ATPase activity decreased over this same period (Sauter unpublished data). Hicks (1998) reported that smolts held at 6.5°C and 10°C responded to a seawater challenge with increased levels of ATPase activity, whereas, individuals held at 15°C and 20°C responded with low levels of ATPase activity. Results demonstrate the inhibitory effect of elevated water temperatures on smoltification. The lethal loading stress occurs between 18°C and 21°C (Temperature Subcommittee, DEQ 1995, Brett 1952).

Exposing Snake River fall chinook salmon, southern Oregon and California coastal fall chinook salmon, and Lower Columbia River fall chinook salmon to the temperature criterion during migration, rearing, and smoltification poses a significant and unacceptable risk to their viability. EPA has reviewed the literature concerning lethal and sublethal effects of temperature on salmonids as well as the compounding effect of habitat simplification and loss. Based on this review, there is compelling reason to believe that mortality from both lethal and sublethal effects (e.g., reproductive failure, prespawning mortality, residualization and delay of smolts, decreased competitive success, disease resistance) will occur. Additionally, if designated "spawning or rearing habitat" underestimates available habitat then the designation may not be sufficiently protective of fall chinook salmon.

The rearing criterion is likely to adversely affect Snake River fall chinook salmon, southern Oregon and California coastal fall chinook salmon, and Lower Columbia River fall chinook salmon. This criterion should be reassessed and a new temperature criterion protective of fall chinook salmon during migration, rearing, and smoltification be developed.

4. Snake River Basin Steelhead, Middle Columbia River Steelhead, Lower Columbia River Steelhead, Upper Willamette River Steelhead:

A. The Oregon Water Quality Standards contain the following criterion for "salmonid spawning, egg incubation, and fry emergence from the egg and the gravel: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin which exceeds 12.8°C.

Cited preferred spawning temperatures are 3.9°C to 9.4°C (Spence et al. 1996, Bell 1986) and 4.4°C to 12.8°C (Swift 1976). A general preferred temperature range of 10°C to 13°C was reported by Bjornn and Reiser (1991). The Independent Scientific Group (1996) provides temperature ranges for chinook salmon. However, the authors state that, "other salmon species are not markedly different in their requirements." They cite 10°C as the optimum spawning temperature with a range of 8°C to 13°C. Stressful conditions occur at temperatures equal to or greater than 15.6°C and lethal temperature effects occur at 21°C (Independent Scientific Group 1996). Few references to optimum incubation temperatures were located. The Washington State hatchery program reported optimal steelhead egg survival from 5.6°C to 11.1°C (Hicks 1998). The Independent Scientific Group's general criteria (1996) cites temperatures less than 10°C as the optimum for incubation with a range of 8°C to 12°C. Stressful conditions occur at temperatures equal to or greater than 13.3°C and lethal effects occur at temperatures greater than 15.6°C (Independent Scientific Group 1996).

Based on available information, EPA has determined that the criterion for spawning, incubation, and emergence adequately protects Snake River Basin steelhead, Middle Columbia River steelhead, Lower Columbia River steelhead, and Upper Willamette River steelhead. However, we are concerned that all appropriate habitat and periods of spawning, incubation, and emergence are correctly identified. If designations are too narrowly applied they may not be sufficiently protective.

As less information exists on steelhead temperature preferences than other salmonid species, monitoring to detect thermal stress during spawning and incubation should be conducted. Collected information should serve as the basis for decision-making during the next triennial review.

The criterion is not likely to adversely affect Snake River Basin steelhead, Middle Columbia River steelhead, Lower Columbia River steelhead, and Upper Willamette River steelhead.

B. The Oregon Water Quality Standards contain the following criterion for salmonid rearing: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin for which salmonid rearing is a designated beneficial use, and in which surface waters exceed 17.8°C." In addition, "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in the Columbia River or its associated sloughs and channels from the mouth to river mile 309 or in the Willamette River or its associated sloughs and channels from the mouth to river mile 50 when surface water temperatures exceed 20°C."

Adult migration, adult holding, smoltification, and juvenile emigration are not identified as distinct designations. Therefore, it is presumed that the salmonid rearing criterion of 17.8°C includes these additional life history stages. The following analysis will be conducted with 17.8°C and, where appropriate, 20°C as the criterion for all life history stages with the exception of spawning, incubation, and fry emergence.

Migration preference data specific to steelhead were not found. However, Beschta et al. (1987), note that migratory inhibition occurred at 21°C. Hicks (1998) reported that the upper incipient lethal limit for steelhead is between 21°C and 22°C. Spence et al. (1996) report an upper lethal temperature for steelhead acclimated to 20°C of 23.9°C. At this temperature, 50% mortality occurs. The National Marine Fisheries Service document entitled, "Making ESA Determinations of Effect for Individual or Grouped Actions at the Watershed Scale" states that "properly functioning" riverine systems exhibit temperatures of 10°C to 14°C; between 14°C to 17.8°C they are "at risk" with reference to migration, and at temperatures greater than 17.8°C they are "not properly functioning" with reference to migration. The Independent Scientific Group (1996) provides a general recommendation for salmonid migration with an optimum of 10°C and a range of 8°C to 13°C. Stressful conditions occur at temperatures greater than 15.6°C and lethal temperature effects occur at 21°C (Independent Scientific Group 1996). A general preferred temperature range of 10°C to 13°C was reported by Bjornn and Reiser (1991).

As summer steelhead enter freshwater in June and spawn the following spring, adult holding temperatures are likely critical to successful reproduction. Similar sublethal effects as described for spring chinook salmon are likely. Reproductively mature spring chinook salmon held at temperatures between 17.5° and 19°C produced a greater number of pre-hatch mortalities and developmental abnormalities, as well as smaller eggs and alevins than adults held at temperatures between 14°C to 15.5°C (Berman 1990). Smith et al. (1983) observed that rainbow trout brood fish must be held at water temperatures below

13.3°C and preferably not above 12.2°C for a period of 2 to 6 months before spawning to produce eggs of good quality. Additionally, Bouck et al. (1977) determined that adult sockeye salmon held at 10°C lost 7.5% of their body weight and had visible fat reserves. However, at 16.2°C, they lost 12% of their body weight and visible fat reserves were essentially depleted. As energy reserves are important to successful reproductive efforts, elevated temperatures during migration or on the spawning ground can directly affect population and species viability.

Preferred rearing temperatures were reported by Bell (1986) as 10°C to 12.8°C. Beschta et al. (1987) reported preferred temperatures of 7.3°C to 14.6°C with 10°C as the optimum. The Independent Scientific Group (1996) cites general recommendations for salmonid rearing with 15°C as the optimum and a range of 12°C to 17°C. Stressful conditions occur at temperatures equal to or greater than 18.3°C and lethal effects occur at 25°C (Independent Scientific Group 1996). The National Marine Fisheries Service document entitled, "Making ESA Determinations of Effect for Individual or Grouped Actions at the Watershed Scale" states that "properly functioning" riverine systems exhibit temperatures of 10°C to 14°C; between 14°C and 17.8°C they are "at risk" with reference to rearing, and at temperatures greater than 17.8°C they are "not properly functioning" with reference to rearing.

Tests conducted on steelhead found that downstream movement could be stopped by placing smolts in temperatures between 11°C and 12.2°C from a starting temperature of 7.2°C (Hicks 1998). Additionally, temperatures above 12°C were found to be detrimental to the migratory behavior and saltwater adaptive responses of Toutle River hatchery steelhead. Exposure of smolts to temperatures of 13°C resulted in migratory delays, decreased emigration behavior, and lower ATPase activity (Hicks 1998). In an additional study, steelhead smolts were held at 6.5°C, 10°C, 15°C, and 20°C. Smolts from the 6.5°C and 10°C groups exposed to a seawater challenge responded with increased levels of ATPase activity, whereas, individuals from the 15°C and 20°C groups responded with low levels of ATPase activity (Hicks 1998). All four of the smolts held at 20°C and three of the four smolts held at 15°C died within three day of the saltwater challenge. No mortalities occurred at 6.5°C or 10°C (Hicks 1998). Given study results, 12°C was recommended as the limit to safe downstream migration of steelhead smolts.

Exposing Snake River Basin steelhead, Middle Columbia River steelhead, Lower Columbia River steelhead, and Upper Willamette River steelhead to the temperature criterion during migration, rearing, and smoltification poses a significant and unacceptable risk to their viability. EPA has reviewed the literature concerning lethal and sublethal effects of temperature on salmonids and the compounding effect of habitat simplification and loss. Based on this review, there is compelling reason to believe that mortality from both lethal and sublethal effects (e.g., reproductive failure, prespawning mortality, residualization and delay of smolts, decreased competitive success, disease resistance) will occur. Additionally, if designated "spawning or rearing habitat" underestimates available habitat then the designation may not be sufficiently protective of steelhead.

The rearing criterion is likely to adversely affect Snake River Basin steelhead, Middle Columbia River steelhead, Lower Columbia River steelhead, and Upper Willamette River steelhead. This criterion should be reassessed and a new temperature criterion protective of steelhead during migration, rearing, and smoltification be developed.

5. Southern Oregon/Northern California Coast and Oregon Coastal Coho Salmon:

A. The Oregon Water Quality Standards contain the following criterion for "salmonid spawning, egg incubation, and fry emergence from the egg and the gravel: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin which exceeds 12.8°C.

Coho salmon spawning preferences of 4.4°C to 9.4°C (Reiser and Bjornn 1973, Brett 1952),10°C to 12.8°C (Bell 1986), and 7.2°C to 12.8°C (Hicks 1998) have been recorded. The Independent Scientific Group (1996) provides temperature ranges for chinook salmon. However, the authors state that, "other salmon species are not markedly different in their requirements." They cite 10°C as the optimum spawning temperature with a range of 8°C to 13°C. Stressful conditions occur at temperatures greater than 15.6°C and lethal temperature effects occur at 21°C (Independent Scientific Group 1996).

Cited optimum incubation temperatures are 4.4°C to 13.3°C (Reiser and Bjornn 1973, Brett 1952), 10°C to 12.8°C (Bell 1986), 8°C to 9°C (Sakh 1984), 4°C to 6.5°C (Dong 1981), and 2°C to 8°C (Tang et al. 1987. The temperature range producing the highest survival rates for eggs and alevins was 1.3°C to 10.9°C (Tang et al. 1987). Increasing egg mortality has been reported at temperatures greater than 11°C (Murray and McPhail 1988), greater than 12°C (Allen 1957 in Murray and McPhail 1988), and at approximately 14°C (Reiser and Bjornn 1973, Brett 1952). An upper lethal limit of 12.5°C to 14.5°C for University of Washington coho and 10.9°C to 12.5°C for Dungeness River, Washington coho was reported by Dong (1981). The lower lethal temperature has been recorded as 0.6°C to 1.3°C (Dong 1981). The Independent Scientific Group's general criteria (1996) cites temperatures less than 10°C as the optimum for incubation with a range of 8°C to 12°C. Stressful conditions occur at temperatures equal to or greater than 13.3°C and lethal effects occur at temperatures greater than 15.6°C (Independent Scientific Group 1996).

Based on the available information, EPA has determined that the criterion for spawning, incubation, and emergence adequately protects Southern Oregon and Northern California Coast and Oregon Coastal coho salmon. However, we are concerned that all appropriate habitat and periods of spawning, incubation, and emergence are correctly identified. If designations are too narrowly applied they may not be sufficiently protective.

Owing to the susceptibility of coho embryos to elevated temperatures, incubation temperatures and embryo viability should be monitored. Collected information should serve as the basis for decision-making during the next triennial review.

The criterion is not likely to adversely affect Southern Oregon and Northern California Coast and Oregon Coastal coho salmon.

B. The Oregon Water Quality Standards contain the following criterion for salmonid rearing: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin for which salmonid rearing is a designated beneficial use, and in which surface waters exceed 17.8°C."

Adult migration, adult holding, smoltification, and juvenile emigration are not identified as distinct designations. Therefore, it is presumed that the salmonid rearing criterion of 17.8°C includes these additional life history stages. The following analysis will be conducted with 17.8°C as the criterion for all life history stages with the exception of spawning, incubation, and fry emergence.

The temperature preference range for migrating adult coho salmon is 7.2°C to 15.6°C (Reiser and Bjornn 1973, Brett 1952). A general preferred temperature range of 12°C to 14°C with temperatures greater than 15°C generally avoided is reported by Brett (1952). The National Marine Fisheries Service document entitled, "Making ESA Determinations of Effect for Individual or Grouped Actions at the Watershed Scale" states that "properly functioning" riverine systems exhibit temperatures of 10°C to 14°C; between 14°C to 17.8°C they are "at risk" with reference to migration, and at temperatures greater than 17.8°C they are "not properly functioning" with reference to migration. The Independent Scientific Group (1996) provides a general recommendation for salmonid migration with an optimum of 10°C and a range of 8°C to 13°C. Stressful conditions occur at temperatures greater than 15.6°C and lethal temperature effects occur at 21°C (Independent Scientific Group 1996). Adult coho final temperature preferendum are reported as 11.4°C when conducted in a laboratory and 16.6°C in Lake Michigan (Coutant 1977). Brett (1952) reports an incipient upper lethal temperature of 26°C (i.e., 50% mortality in 16.7 hours) while the Oregon Water Quality Standards Review (Temperature Subcommittee, DEQ 1995) reports an upper lethal limit of 25°C.

Sandercock (1991) reports that there appears to be little correlation between the time of entry to a spawning stream and the spawning data. Early-run fish may spawn early, but many will hold for weeks or even months before spawning. adult holding temperatures are likely critical to successful reproduction. Similar sublethal effects as described for spring chinook salmon are likely. Reproductively mature spring chinook salmon held at elevated temperatures produced a greater number of pre-hatch mortalities and developmental abnormalities, as well as smaller eggs and alevins than adults held at preferred temperatures (Berman 1990). Additionally, Bouck et al. (1977) determined that adult sockeye salmon held at preferred temperatures [illegible] less of their body weight and maintained visible fat reserves while those held at elevated temperatures lost greater quantities of body weight and visible fat reserves were essentially depleted. As energy reserves are important to successful reproductive efforts, elevated temperatures during migration or on the spawning ground can directly affect population and species viability.

Cited rearing temperature preferences are 11.8°C to 14.6°C (Reiser and Bjornn 1973, Brett 1952), 11.4°C (Coutant 1977), 12°C to 14°C (Bell 1986), and 11.8°C to 14.6°C (Beschta et al. 1987). Cessation of growth occurs at temperatures greater than 20.3°C (Temperature Subcommittee, DEQ 1995, Reiser and Bjornn 1973, Brett 1952). Beschta et al. (1987) report an upper lethal temperature of 25.8°C. The Independent Scientific Group (1996) cites general recommendations for salmonid rearing with 15°C as the optimum and a range of 12°C to 17°C. Stressful conditions occur at temperatures equal to or greater than 18.3°C and lethal effects occur at 25°C (Independent Scientific Group 1996). The National Marine Fisheries Service document entitled, "Making ESA Determinations of Effect for Individual or Grouped Actions at the Watershed Scale" states that "properly functioning" riverine systems exhibit temperatures of 10°C to 14°C; between 14°C and 17.8°C they are "at risk" with reference to rearing, and at temperatures greater than 17.8°C they are "not properly functioning" with reference to rearing.

A preferred smoltification temperature range is 12°C to 15.5°C (Brett et al. 1958). Spence et al. (1996) report observed migration temperatures of 2.5°C to 13.3°C with most fish migrating before temperatures reach 11°C to 12°C.

Based on available information, it is likely that exposure of Southern Oregon/Northern California Coast and Oregon Coast coho salmon to the temperature criterion during migration, rearing, and smoltification poses a significant and unacceptable risk to their viability. EPA has reviewed the literature concerning lethal and sublethal effects of temperature on salmonids and the compounding effect of habitat simplification and loss. Based on this review, there is compelling reason to believe that mortality from both lethal and sublethal effects (e.g., reproductive failure, prespawning mortality, residualization and delay of smolts, decreased competitive success, disease resistance) will occur. Additionally, if designated "spawning or rearing habitat" underestimates available habitat then the designation may not be sufficiently protective of coho salmon.

The rearing criterion is likely to adversely affect Southern Oregon/Northern California Coast and Oregon Coast coho salmon. This criterion should be reassessed and a new temperature criterion protective of coho salmon during migration, rearing, and smoltification be developed.

6. Columbia River Chum Salmon:

A. The Oregon Water Quality Standards contain the following criterion for "salmonid spawning, egg incubation, and fry emergence from the egg and the gravel: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin which exceeds 12.8°C.

A preferred spawning temperature range of 7.2°C to 12.8°C is reported by Bjornn and Reiser (1991). The Independent Scientific Group (1996) provides temperature ranges for chinook salmon. However, the authors state that, "other salmon species are not markedly different in their requirements." They cite 10°C as the optimum spawning temperature with a range of 8°C to 13°C. Stressful conditions occur at temperatures equal to or greater than 15.6°C and lethal temperature effects occur at 21°C (Independent Scientific Group 1996).

Cited optimum incubation temperatures are 8°C (Beacham and Murray 1985) and 4.4°C to 13.3°C (Bjornn and Reiser 1991). The Independent Scientific Group's general criteria (1996) cites temperatures less than 10°C as the optimum for incubation with a range of 8°C to 12°C. Stressful conditions occur at temperatures equal to or greater than 13.3°C and lethal effects occur at temperatures greater than 15.6°C (Independent Scientific Group 1996). The maximum efficiency for conversion of yolk to issue is reported as 6°C to 10°C (Beacham and Murray 1985). Temperatures of 12°C produced alevin mortality one to three days after hatching (Beacham and Murray 1985).

Based on the available information, EPA has determined that the criterion for spawning, incubation, and emergence adequately protects Columbia River chum salmon. However, we are concerned that all appropriate habitat and periods of spawning, incubation, and emergence are correctly identified. If designations are too narrowly applied they may not be sufficiently protective.

Owing to the susceptibility of chum salmon alevins to elevated temperatures, incubation and emergence temperatures and embryo/alevin viability should be monitored. Collected information should serve as the basis for decision-making during the next triennial review.

The criterion is not likely to adversely affect Columbia River chum salmon.

B. The Oregon Water Quality Standards contain the following criterion for salmonid rearing: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin for which salmonid rearing is a designated beneficial use, and in which surface waters exceed 17.8°C." In addition, "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in the Columbia River or its associated sloughs and channels from the mouth to river mile 309 when surface water temperatures exceed 20°C."

Adult migration, adult holding, smoltification, and juvenile emigration are not identified as distinct designations. Therefore, it is presumed that the salmonid rearing criterion of 17.8°C includes these additional life history stages. The following analysis will be conducted with 17.8°C and, where appropriate, 20°C as the criterion for all life history stages with the exception of spawning, incubation, and fry emergence.

Cited preferred migration temperatures are 8.3°C to 15.6°C (Bjornn and Reiser 1991). The National Marine Fisheries Service document entitled, "Making ESA Determinations of Effect for Individual or Grouped Actions at the Watershed Scale" states that "properly functioning" riverine systems exhibit temperatures of 10°C to 14°C; between 14°C to 17.8°C they are "at risk" with reference to migration, and at temperatures greater than 17.8°C they are "not properly functioning" with reference to migration. The Independent Scientific Group (1996) provides a general recommendation for salmonid migration with an optimum of 10°C and a range of 8°C to 13°C. Stressful conditions occur at temperatures greater than 15.6°C and lethal temperature effects occur at 21°C (Independent Scientific Group 1996).

Rearing temperature preferences of 14.1°C (Coutant 1977, Ferguson 1958, Huntsman 1942), 10°C to 12.8°C (Bell 1986), 12°C to 14°C (Brett 1952), and 11.2°C to 14.6°C (Beschta et al. 1987) have been reported. The Independent Scientific Group (1996) cites general recommendations for salmonid rearing with 15°C as the optimum and a range of 12°C to 17°C. Stressful conditions occur at temperatures equal to or greater than 18.3°C and lethal effects occur at 25°C (Independent Scientific Group 1996). The National Marine Fisheries Service document entitled, "Making ESA Determinations of Effect for Individual or Grouped Actions at the Watershed Scale" states that "properly functioning" riverine systems exhibit temperatures of 10°C to 14°C; between 14°C and 17.8°C they are "at risk" with reference to rearing, and at temperatures greater than 17.8°C they are "not properly functioning" with reference to rearing. The optimum temperature is 13.5°C and the upper lethal temperature is 25.8°C (Beschta et al. 1987). Brett (1952) reports an upper incipient lethal temperature of 25.4°C (acclimation 20°C, 50% mortality in 16.7 hours). The final temperature preferendum for underyearlings and yearlings is 14.1°C (Coutant 1977, Ferguson 1958, Huntsman 1942). Data related to smoltification were not found.

Based on available information, it is likely that exposure of Columbia River chum salmon to the temperature criterion during migration, rearing, and smoltification poses a significant and unacceptable risk to their viability. **EPA has reviewed the literature concerning lethal and sublethal effects of temperature on salmonids and the compounding effect of habitat simplification and loss. Based on this review, there is compelling reason to believe that mortality from both lethal and sublethal effects (e.g., reproductive failure, prespawning mortality, residualization and delay of smolts, decreased competitive success, disease resistance) will occur. Additionally, if designated "spawning or rearing habitat" underestimates available habitat then the designation may not be sufficiently protective of chum salmon.**

The rearing criterion is likely to adversely affect Columbia River chum salmon. **This criterion should be reassessed and a new** temperature criterion protective of chum salmon during migration, rearing, and smoltification be developed.

7. Umpqua River Cutthroat Trout:

A. The Oregon Water Quality Standards contain the following criterion for "salmonid spawning, egg incubation, and fry emergence from the egg and the gravel: no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin which exceeds 12.8°C.

There is a paucity of temperature preference data for cutthroat trout in general and Umpqua cutthroat trout specifically. A preferred spawning temperature range for sea-run cutthroat trout of 6.1°C to 17.2°C is reported by Beschta et al. (1987) and Bell (1986). Preferred spawning temperature ranges of 4.4°C to 12.8°C and 5.5°C to 15.5°C have been reported for resident cutthroat trout (Spence et al. 1996). Taranger and Hansen (1993) and Smith et al. (1983) determined that high water temperatures during the spawning season inhibit ovulation and are detrimental to gamete quality in cutthroat trout.

The Independent Scientific Group (1996) provides temperature ranges for chinook salmon. However, the authors state that, "other salmon species are not markedly different in their requirements." They cite 10°C as the optimum spawning temperature with a range of 8°C to 13°C. Stressful conditions occur at temperatures greater than 15.6°C and lethal temperature effects occur at 21°C (Independent Scientific Group 1996). In addition, the Independent Scientific Group's general criteria (1996) cites temperatures less than 10°C as the optimum for incubation with a range of 8°C to 12°C. Stressful conditions occur at temperatures equal to or greater than 13.3°C and lethal effects occur at temperatures greater than 15.6°C (Independent Scientific Group 1996).

Based on the available information, EPA has determined that the criterion for spawning, incubation, and emergence adequately protects Umpqua River cutthroat trout. However, we are concerned that all appropriate habitat and periods of spawning, incubation, and emergence are correctly identified. If designations are too narrowly applied they may not be sufficiently protective.

Owing to the limited availability of information, monitoring to detect thermal stress during spawning, incubation, and emergence should be conducted. Collected information should serve as the basis for decision-making during the next triennial review.

The criterion is not likely to adversely affect Umpqua River cutthroat trout.

B. The Oregon Water Quality Standards contain the following criterion for salmonid rearing: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in a basin for which salmonid rearing is a designated beneficial use, and in which surface waters exceed 17.8°C."

Adult migration, adult holding, smoltification, and juvenile emigration are not identified as distinct designations. Therefore, it is presumed that the salmonid rearing criterion of 17.8°C includes these additional life history stages. The following analysis will be conducted with 17.8°C as the criterion for all life history stages with the exception of spawning, incubation, and fry emergence.

Adult migration preference data specific to Umpqua cutthroat trout were not found. A preferred migration temperature for resident cutthroat trout of 5°C has been reported by Spence et al. (1996). The National Marine Fisheries Service document entitled, "Making ESA Determinations of Effect for Individual or Grouped Actions at the Watershed Scale" states that "properly functioning" riverine systems exhibit temperatures of 10°C to 14°C; between 14°C to 17.8°C they are "at risk" with reference to migration, and at temperatures greater than 17.8°C they are "not properly functioning" with reference to migration. The Independent Scientific Group (1996) provides a general recommendation for salmonid migration with an optimum of 10°C and a range of 8°C to 13°C. Stressful conditions occur at temperatures greater than 15.6°C and lethal temperature effects occur at 21°C (Independent Scientific Group 1996).

The upper lethal temperature range for cutthroat trout is 18°C to 22.8°C (Kruzic 1998, Spence et al. 1996). Beschta et al. (1987) report an upper lethal temperature of 23°C. Kruzic (1998) observed Umpqua River cutthroat trout in upper reaches of the Dumont Creek where water temperatures were 13.5°C, but absent in the lower reaches where temperatures approached 18°C. Westslope cutthroat trout females held in fluctuating temperatures between 2°C and 10°C produced significantly better quality eggs than females held at a constant 10°C. Elevated temperatures experienced by mature females adversely affected subsequent viability and survival of embryos (Smith et al. 1983).

Preferred rearing temperatures of 10°C (Bell 1986) and 9.5°C to 12.9°C (Beschta et al. 1987) have been reported. The Independent Scientific Group (1996) cites general recommendations for salmonid rearing with 15°C as the optimum and a range of 12°C to 17°C. Stressful conditions occur at temperatures equal to or greater than 18.3°C and lethal effects occur at 25°C (Independent Scientific Group 1996). The National Marine Fisheries Service document entitled, "Making ESA Determinations of Effect for Individual or Grouped Actions at the Watershed Scale" states that "properly functioning" riverine systems exhibit temperatures of 10°C to 14°C; between 14°C and 17.8°C they are "at risk" with reference to rearing, and at temperatures greater than 17.8°C they are "not properly functioning" with reference to rearing. Data concerning smoltification/juvenile emigration were not located.

Based on available information, it is likely that exposure of Umpqua River cutthroat trout to the temperature criterion during migration, rearing, and smoltification poses a significant and unacceptable risk to their viability. EPA has reviewed the literature concerning lethal and sublethal effects of temperature on salmonids and the compounding effect of habitat simplification and loss. Based on this review, there is compelling reason to believe that mortality from both lethal and sublethal effects (e.g., reproductive failure, prespawning mortality, residualization and delay of smolts, decreased competitive success, disease resistance) will occur. Additionally, if designated "spawning or rearing habitat" underestimates available habitat then the designation may not be sufficiently protective of cutthroat trout.

The rearing criterion is likely to adversely affect Umpqua River cutthroat trout. However, it is obvious from the paucity of information on this species that additional monitoring should occur.

This criterion should be reassessed and a new temperature criterion protective of Umpqua River cutthroat trout during migration, rearing, and smoltification be developed.

8. Columbia River Basin Bull Trout, Klamath Basin Bull Trout:

A. The Oregon Water Quality Standards contain the following criterion for bull trout: "no measurable surface water temperature increase resulting from anthropogenic activities is allowed in waters determined by the Department to support or to be necessary to maintain the viability of native Oregon bull trout, when surface water temperatures exceed 10°C." The temperature criteria applies to waters containing spawning, rearing, or resident adult bull trout. Migration corridors are not considered.

A preferred migration temperature range of 10°C to 12°C has been reported (Administrative Record, July 21, 1997, Temperature Subcommittee, DEQ 1995). Numerous authors have addressed temperature related to successful bull trout spawning. Temperatures less than 9°C to 10°C are required to initiate spawning in Montana (Temperature Subcommittee, DEQ 1995) and less than 9°C in British Columbia (Spence et al. 1996, Temperature Subcommittee, DEQ 1995, Pratt 1992). Peak spawning activities occur between 5°C and 6.5°C (Administrative Record, July 21, 1997). In the Metolius River, Oregon a spawning temperature of 4.5°C is cited (Spence et al. 1996, Temperature Subcommittee, DEQ 1995). A spawning range of 4°C to 10°C is reported in the Oregon Water Quality Standards Review (Temperature Subcommittee, DEQ 1995).

The Oregon Water Quality Standards Review (Temperature Subcommittee, DEQ 1995) report an optimum incubation temperature range of 4°C to 6°C in Montana systems. In a study of temperature effect on embryo survival in British Columbia, 8°C to 10°C, produced 0-20% survival to hatch, 6°C, produced 60-90% survival to hatch, and 2°C to 4°C, produced 80-95% survival to hatch (Temperature Subcommittee, DEQ 1995). Based on individual studies, Spence et al. (1996) report an optimum temperature range of 2°C to 6°C and the Oregon Water Quality Standards Review (Temperature Subcommittee, DEQ 1995) report an optimum temperature range of 1°C to 6°C.

The optimal temperature for juvenile growth has been reported as 4°C in British Columbia and 4.5°C in the Metolius River, Oregon (Temperature Subcommittee, DEQ 1995). The temperature range for optimum fry growth is reported as 4°C to 4.5°C (Temperature Subcommittee, DEQ 1995). Observed rearing temperatures less than 10°C are reported for the Metolius River, Oregon (Administrative Record, July 21, 1997). The Oregon Water Quality Standards Review (Temperature Subcommittee, DEQ 1995) reports a final optimum juvenile growth range of 4°C to 10°C. Temperatures equal to or greater than 14°C are a barrier in the closely related Arctic charr (Pratt 1992).

Adult resident bull trout in Montana were assessed to determine temperature preferences. At 19°C no bull trout were present; between 15°C and 18°C bull trout were present; and at temperatures less than 12°C the highest densities of bull trout were located (Temperature Subcommittee, DEQ 1995). In the John Day Basin, bull trout occurred at temperatures less than 16°C (Temperature Subcommittee, DEQ 1995). The adult temperature preference range is 9°C to 13°C with the highest number of individuals at temperatures less that or equal to 12°C (Temperature Subcommittee, DEQ 1995). In addition, investigators found that reaches in the Metolius River system are susceptible to brook trout invasion at temperatures equal to or greater than 12°C (Administrative Record, July 21, 1997).

Based on the available information, the criterion for spawning, rearing, and resident adult bull trout adequately protects these life history stages. However, migration corridors must be adequately protected to safeguard remaining populations and to restore species distribution and integrity. Although the numeric criterion of 10°C adequately protects migrating bull trout, Oregon has not designated for protection migration corridors. The temperature technical subcommittee for the Oregon water quality standards review recommended that "no temperature increase shall be allowed due to anthropogenic activity in present bull trout habitat, or where historical cold water habitat is needed to allow a present bull trout population to remain viable and sustainable in the future" (Buchanan and Gregory 1997). In an evaluation of Oregon's bull trout, Pratt (1992) determined that elevated temperatures had reduced species distribution with populations becoming largely fragmented and isolated in the upper reaches of drainages. Population fragmentation has resulted in decreased species fitness and viability. Therefore, to adequately protect Columbia River Basin bull trout and Klamath Basin bull trout, migratory corridors should be afforded protection.

Additionally, it is clear that bull trout require temperatures less than 10°C for successful spawning, incubation, and rearing. The criterion applied as a summer maximum should be protective of life history stages occurring at other times of the year when temperatures are cooler. However, data on both annual thermal regimes and bull trout temperature preferences and effect thresholds should continue to be collected and analyzed. Collected information should serve as the basis for decision-making during the next triennial review.

As migratory corridors are omitted from the designation, the criterion is likely to adversely affect Columbia River Basin bull trout and Klamath Basin bull trout.

IX. Summary of Findings:

* The temperature criterion for spawning, incubation, and emergence is not likely to adversely affect threatened and endangered salmon:

  (A) The 12.8°C criterion is at the upper limit for successful spawning, incubation, and emergence. Therefore, a more protective strategy would be to establish the criterion as a daily maximum rather than a 7-day moving average of the daily maximum.

  (B) It is critical that all appropriate habitat and periods of spawning, incubation, and emergence be correctly identified. If designations are too narrowly or incorrectly applied then they may not be sufficiently protective of native salmon.

  (C) Owing to the limited information on steelhead temperature preferences, monitoring to detect thermal stress during spawning and incubation periods should be conducted.

  (D) Owing to the susceptibility of coho embryos to elevated temperatures, incubation temperatures and embryo viability should be monitored.

  (E) Owing to the susceptibility of chum salmon alevins to elevated temperatures, incubation and emergence temperatures and embryo/alevin viability should be monitored.

  (F) Owing to the limited availability of information on Umpqua cutthroat trout, monitoring to detect thermal stress during spawning, incubation, and emergence should be conducted.

  Collected information should serve as the basis for decision-making during the next triennial review.

* The temperature criterion for bull trout is likely to adversely affect Columbia River Basin bull trout and Klamath Basin bull trout.

  (A) Migration corridors must be adequately protected to safeguard remaining populations and to restore species distribution and integrity. Although the numeric criterion of 10°C adequately protects migrating bull trout, Oregon has not designated for protection migration corridors. Elevated temperatures have reduced species distribution with populations becoming largely fragmented and isolated in the upper reaches of drainages. Population fragmentation has resulted in decreased species fitness and viability. To adequately protect Columbia River Basin bull trout and Klamath Basin bull trout, migratory corridors should be afforded protection.

  (B) It is clear that bull trout require temperatures less than 10°C for successful spawning, incubation, and rearing. The criterion applied as a summer maximum should be protective of life history stages occurring at other times of the year when temperatures are cooler. However, data on both annual thermal regimes and bull trout temperature preferences and effect thresholds should continue to be collected and analyzed. Collected information should serve as the basis for decision-making during the next triennial review.

* The temperature criterion for rearing is likely to adversely affect threatened and endangered salmon.

Adult migration, adult holding, smoltification, juvenile emigration as well as rearing were analyzed for exposure effects at 17.8°C and where species utilized the Columbia or Willamette mainstem at 20°C.

  (A) The rearing criterion is likely to adversely affect threatened and endangered Snake River sockeye salmon, Snake River spring/summer chinook salmon, Southern Oregon and California Coastal spring chinook salmon, Lower Columbia River spring chinook salmon, Upper Willamette River spring chinook salmon, Snake River fall chinook salmon, southern Oregon and California coastal fall chinook salmon, Lower Columbia River fall chinook salmon, Southern Oregon/Northern California Coast and Oregon Coast coho salmon, Columbia River chum salmon, and Umpqua River cutthroat trout.

This criterion should be reassessed and a new temperature criterion protective of these species during migration, adult holding, residence, rearing, and smoltification be developed.

(B) If designated "spawning and rearing habitat" underestimates available habitat then the designation may not be sufficiently protective of native salmon.

* Essentially the standard establishes a de facto exception to the rearing criterion. The standard specifies criteria of 20°C for the Columbia River to river mile 309 and the Willamette River to river mile 50. This criteria is not protective of salmonid rearing, smoltification, emigration, adult migration, or adult holding.

  These large river systems have been highly altered through various land use practices. Depletion of ground water and subsurface storage, and loss of surface water/ground water/ hyporheic zone interaction, loss of sloughs and side channels, and the construction of dams have altered the natural thermal regime of large river systems. Shifts in the annual thermal regime as well as increased maximum temperatures negatively affect all salmonid life stages.

* Although research on fluctuating or intermittently elevated temperatures may not be exhaustive, the studies that have been conducted point to the risks associated with this type of exposure. Organisms respond to maximum diel fluctuation, maximum daily temperatures, mean daily temperatures, mean monthly temperatures, and cumulative thermal history with both physiological and behavioral changes. Response depends upon the setting and array of temperatures provided. These results are corroborated by previous studies that established the ability of freshwater fishes to detect temperature changes as slight as 0.05°C (Berman and Quinn 1991).

  Given this information, numeric temperature criteria should be established below demonstrated sublethal temperature ranges. Temperature measurement units that mask or allow excursions above sublethal effects thresholds or that do not adequately consider cumulative exposure history should not be used. Exposure to mean or daily maximum temperatures at or above the threshold for sublethal response may not be offset by daily minimum temperatures.

* The use of a "seven-day moving average of the daily maximum

temperature" allows for some flexibility in daily maximum temperatures that might occur over time. The daily maximum reportedly can exceed the maximum weekly average temperature by approximately 0.5 to 2°C (Buchanan and Gregory 1997). As previously discussed, "flexibility" may not adequately protect salmonids from exposure to sublethal temperatures. This type of measurement unit masks the magnitude of temperature fluctuation and the duration of exposure to daily maximum temperatures. Additionally, daily mean temperatures and cumulative exposure history are not addressed.

The ability of Oregon's temperature measurement unit to adequately protect native salmon and charr lies in (1) the protectiveness of the numeric criteria selected, (2) the ability to define unacceptable maximum diel fluctuation, and (3) the ability to track and respond to cumulative exposure history. If, as in the current case, the measurement unit in conjunction with numeric criteria masks salmonid exposure to sublethal and lethal temperatures then the measurement unit, the criteria, or both must be modified. Establishment of conservative numeric criteria would lessen concerns surrounding the magnitude of fluctuation and cumulative exposure. However, in the long-term these issues should be factored into the temperature standard.

Using a hypothetical stream reach as our example, it becomes evident that the "seven-day moving average" masks the magnitude of temperature fluctuation and the duration of exposure to daily maximum temperatures as well as neglects cumulative exposure history. From the example, we find that on five of the seven days, the daily maximum temperature is at or above the rearing criterion. Although daily mean temperatures do not exceed the criterion, they are less than 1°C from the criterion on five of the seven days. Where daily maximum temperatures are 17.8°C or greater, organisms are exposed to temperatures equal to or greater than the criterion over a potentially significant portion of the day. Finally, the "seven-day moving average of the daily maximum temperature" meets the rearing criterion of 17.8°C even though the cumulative exposure history of an organism in "Stream XYZ" is often at or above the standard and is well within the sublethal to lethal range. The assumption that "the criteria represent a "maximum" condition, given diurnal variability..." appears unfounded. Based on current numeric criteria, the temperature measurement unit does not adequately protect native salmon and charr. Establishment of conservative numeric temperature criteria would lessen concerns surrounding the magnitude of fluctuation and cumulative exposure.

As most riverine networks currently exceeding temperature standards exceed other water quality standards as well, the standard may not adequately address the synergistic effects of multiple stressors. Additionally, it is important to recognize that these systems do not contain the system diversity and resilience to provide refuge from elevated temperatures. Shifts in the thermal regime affect all life history forms to different degrees and different magnitudes. These effects are cumulative. Loss of organism integrity due to elevated temperatures weakens the ability of individuals to respond to additional stressors.

* The maintenance and restoration of spatially diverse, high quality habitats that minimizes the risk of extinction is key to beneficial use support of cold water species (Quigley 1997). Therefore, areas of historical species distribution should be identified and restored to ensure long-term species survival. Identified areas should be reflected in beneficial use designations.

  The June 22, 1998 letter clarifying application of Oregon's standards states that, "The temperature criteria of 64°F will be applied to all water bodies that support salmonid fish rearing...This would include all waters except those listed as warm water above."

  Portions of systems identified for "warm water" uses historically supported salmonids. Extinct populations include spring/summer chinook salmon in the Klamath River, Malheur River, and Owyhee River; fall chinook in the Klamath River; and steelhead from the Owyhee River and Malheur River (Nehlsen et al. 1991). In addition, systems currently supporting salmon or charr such as the Willamette River are identified for "cool water" use.

  To fully protect beneficial uses and to restore endangered and threatened species, it may not be adequate to solely address current conditions and distributions. To ensure species persistence, cold water systems and remnant patches should be protected and areas of historical distribution should be identified and thermal regimes restored.

* Shifts in the annual thermal regimes of river systems may generate a cascade of changes affecting the successful completion of life history stages. The phase shift of riverine temperatures should be evaluated in conjunction with single maxima. Species are adapted to the abiotic conditions of riverine systems. Phase shifts may negatively affect egg development and the timing of emergence, reproduction, and emigration (Naiman et al. 1992,

Holtby 1988). State standards use daily or weekly criteria to protect perceived sensitive life history stages. However, this approach may not be fully protective of poikilothermic species such as salmonids (see Section VI). Modifications to the timing of seasonal temperature shifts are as important to salmonid viability as daily maximum, minimum, and averages temperatures. This topic should be the basis of future discussions related to temperature standard development.

* Issues related to the scale of applicable designated beneficial use categories should be clarified. For example, the salmonid rearing criterion states that, "...In a basin for which rearing is a designated beneficial use, and in which surface water temperatures exceed 17.8°C." To reduce possible confusion, the hydrologic unit code or other methods to accurately depict locations should be employed.

* The standard is based on the Department's ability to accurately locate spawning, incubation, and rearing locations for native salmon, charr, and trout. Of concern in this analysis is the representativeness, completeness, and accuracy of the stream and salmonid use data as well as the accuracy of the beneficial use designations. Oregon has made much progress in data collection and information management. However, more detail is required for waterbodies where limited or no information exists.

Additionally, the extent of our knowledge concerning distribution and life history requirements of native salmon and charr should not be overestimated. For example, Washington State did not collect data in small or ephemeral streams based on the belief that salmonids did not exploit these systems. Later investigations found this assumption to be false. However, in the interim, habitat important to native species was adversely affected. Additionally, management based on perceived understanding of run timings has skewed migration timing, reducing species fitness and variability.

Finally, standards based solely on presence-absence of species and single life history stages exclude historical habitat that may be critical to population and species survival. Presence-absence data alone should not be used to define species ranges that are dynamic and vary over time according to natural disturbance regimes and habitat suitability. As with species range, within range habitat critical to single life history stages such as spawning and rearing may be "stable" in the short-term, but may vary significantly over the long-term. Therefore, beneficial use designations that do not account for the dynamic nature of ecological systems may not accurately reflect species range or spawning and rearing habitat. Designating only a portion of the overall range exposes species to additional risks. Those spawning or rearing areas inappropriately designated may be systematically degraded as a higher temperature criterion is applied. Further analysis of species distributions, current temperature profiles, and beneficial use designations is required.

* The issue of identifying and protecting cold-water refugia is complex. Several questions arise such as the scale at which refugia occur, identification criteria and methods, and the effect of system alteration on refugia abundance, distribution, and accessability.

The Standard states that, ecologically significant cold-water refugia exists "when all or a portion of a waterbody supports stenotypic cold-water species not otherwise widely supported within the subbasin...." Firstly, refugia may occur at various scales and may expand and contract depending on controlling factors. Refugia include micro-habitat features within stream reaches, as well as macro-habitat features such as stream reaches, tributaries, watersheds, subbasins, as well as basins.

Secondly, refugia are areas available to species during disturbance events - they do not necessarily "support cold-water species not otherwise widely supported within the subbasin" at all times of the year. As natural or anthropogenic disturbances affect the system, species distribution shrinks and refugia are utilized. The definition provided in the standard is more akin to a "source" area subsequent to disturbance.

Thirdly, intact stream networks may provide larger more contiguous areas of cold water during summer months than degraded systems. Therefore, refugia in intact and disturbed systems may not be comparable in abundance, distribution, or accessability. Issues related to delineation of refugia should be clarified.

Fourthly, the definition states that the refuge, "maintains cold-water temperatures throughout the year...." Refugia develop through many different mechanisms. However, often ground water or subsurface flow plays a role. In these instances, winter temperatures may actually be greater than ambient temperatures.

Finally, a protocol outlining an approach for refugia identification should be developed. Lack of standardization may lead to the loss of critical refugia.

* The statement, "In stream segments containing federally listed Threatened and Endangered species, if the increase would impair the biological integrity of the ... population" requires clarification. Again the issue of scale must be discussed. Assessment of species integrity requires analysis of scales greater than single reaches. Information related to condition across the species' range as well as risks to these areas is important to decision-making. Data and spatial and temporal scale of effective areas necessary to define impairment of biological integrity should be specified.

* The standard specifies that, "An exceedence of the numeric criteria...will not be deemed a temperature standard violation if it occurs when the air temperature during the warmest seven-day period of the year exceeds the 90th percentile of the seven-day daily maximum air temperature....." Although additional language indicates that approved surface water temperature management plans will remain in affect during these periods, this specification ignores both the complex array of underlying factors controlling ambient stream temperature as well as the differences in response to air temperature oscillation between intact and altered systems.

  There are many factors that affect ambient water temperature as well as the number, distribution, and accessibility of thermal refugia. Processes controlling air temperature, channel morphology, riparian structure, hyporheic zones and ground water, wetland complexes, and flow volume shape stream temperature. Alteration of one or more of these parameters leads to thermal alteration. Temperature may be perceived as a single water quality parameter. However, thermal regimes are established through the complex interaction of the above controlling factors. Therefore, stream segments exceeding temperature criteria during warm periods may actually be in violation of state standards if alteration affecting the controlling factors has occurred. This alteration would lead to higher maximum temperatures as well as greater magnitude of fluctuation than in an intact system. Additionally, the altered system would contain fewer cold water refugia. This statement should be rewritten to accurately reflect the ecology of the riverine system.

* The statement, "Any source may petition the Commission for exception to ...for discharge above the identified criteria if: the source provides the necessary scientific information to describe how the designated beneficial use would not be adversely impacted" requires clarification. Species integrity requires analysis of scales greater than single sources or reaches. This

should not be a "piecemeal" process. Necessary data and spatial and temporal scale of effective areas should be specified.

* The majority of discussion regarding lethal and sublethal temperature effects addresses elevated temperatures. However, the effect of sublethal low temperatures should also be reviewed in the next triennium.

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Appendix - A Summary of Temperature Preference and Effects from the Technical Literature:

Definitions (from McCullough 1997):

Optimum: The optimum temperature range provides for feeding activity, normal physiological response, and normal behavior. The optimum range is slightly wider than the growth range.

Preferred: The preferred temperature range is that which the organism most frequently inhabits when allowed to freely select temperatures in a thermal gradient. The final temperature preferendum is a preference made within 24 hours in a thermal gradient and is independent of acclimation temperature.

Lethal loading: Increased burden on metabolism that controls growth and activity. Lethal loading stress occurs over long periods (Brett 1958).

Upper incipient lethal temperature: An exposure temperature, given a previous acclimation to a constant temperature, that 50% of the fish can tolerate for 7 days. The **ultimate upper incipient lethal temperature** is the point where further increases in acclimation temperature results in no increase in temperature tolerated.

Upper lethal temperature: The temperature at which survival of a test group is 50% in a 10 minute exposure, given a prior acclimation temperatures within the tolerance zone.

I. Sockeye:

Adult migration:	7.2-15.6°C (Bell 1986, Spence et al. 1996) 10°C adult sockeye lost 7.5% body weight and had visible fat reserves, at 16.2°C they lost 12% of their body weight and visible fat reserves were essentially depleted. Females with developing eggs lost more body weight than males. Also adverse gonadal development of females (Bouck et al. 1977) 21°C migration inhibition (Beschta et al. 1987 from Major and Mighell 1967).

Above 21°C rising or stable temperatures blocked entry of fish from the Columbia River into the Okanagan River, WA; falling temperatures allowed migration to resume

Spawning:	10.6-12.2°C (Bell 1986, Spence et al. 1996)
Incubation:	4.4-13.5°C (Combs 1965) 4.4-13.3°C (Bell 1986, Spence et al. 1996) 10°C (Dept of Fisheries, Canada; International Pacific Salmon Fisheries Commission 1952) > 12.8°C severe mortality (Dept. Fisheries, Canada; Combs 1965)
Rearing:	10-12.8°C (Bell 1986) 10.6°C (Huntsman 1942, Burgner, 1991) 10.6-12.8°C (Coutant 1977) 14.5°C (Coutant 1977; Ferguson 1958; Huntsman 1942) 12-14°C (Brett 1952) 11.2-14.6°C preferred (Beschta et al. 1987) 15°C optimum (Beschta et al. 1987)
Physiological optimum:	15°C (Brett et al. 1958)
Smolt outmigration:	2-10°C (Spence et al. 1996)
Termination of smolt outmigration:	12-14°C (Brett et al. 1958)

II. Spring Chinook Salmon:

Adult migration:	3.3-13.3°C (Bell 1986, Bjornn and Reiser 1991, Spence et al. 1996) 21°C migration block (Temperature Subcommittee, DEQ 1995)
Spawning:	5.6-14.4°C (Olson and Foster 1955) 5.6-13.9°C (Bell 1986, Spence et al. 1996)

	5.6-12.8°C (Temperature Subcommittee, DEQ 1995)
Incubation:	5-14.4°C (Bell 1986, Spence et al. 1996) 4.5-12.8°C (Temperature Subcommittee, DEQ 1995)
Rearing:	11.7°C (Coutant 1977, Ferguson 1958, Huntsman 1942) 10-12.8°C (Bell 1986) 10-14.8°C (Temperature Subcommittee, DEQ 1995)
Adult holding:	8-12.5°C (Temperature Subcommittee, DEQ 1995) 13-15.5°C pronounced mortality (Temperature Subcommittee, DEQ 1995) 6-14°C - optimal pre-spawning broodstock survival, maturation, and spawning (Marine 1992)
Smoltification and Outmigration:	3.3-12.2°C (Temperature Subcommittee, DEQ 1995) 18.3°C smolt lethal loading stress (Temperature Subcommittee, DEQ 1995)
Optimum production:	10°C (Temperature Subcommittee, DEQ 1995)
Maximum growth:	14.8°C (Temperature Subcommittee, DEQ 1995)
Lethal:	18-21°C (Marine 1992) 17.5°C - upper sub-lethal to lethal range (Berman 1990)
Sublethal:	15-17°C (Marine 1992, Berman 1990)

III. <u>Summer Chinook Salmon:</u>

Adult Migration:	13.9-20°C (Bell 1986, Spence et al 1996)
Spawning:	5.6-14.4°C (Olson and Foster 1955)

6.1-18.0°C (Olson and Foster 1955)
5.6-13.9°C (Spence et al. 1996)

Incubation: 5.0-14.4°C (Spence et al. 1996)

Rearing: 11.7°C (Coutant 1977; Ferguson 1958; Huntsman 1942)
10.0-12.8°C (Bell 1986)

IV. Fall Chinook Salmon:

Adult migration: 10.6-19.4°C (Bell 1986, Spence et al. 1996)

Spawning: 10-12.8°C (Bell 1986)
10-16.7°C (Olson and Foster 1955)
5.6-13.9°C (Spence et al. 1996)

Incubation: 10-12.8°C (Bell 1986)
10-16.7°C (Olson and Foster 1955)
10-12°C (Heming 1982, Neitzel and Becker 1985, Garling and Masterson 1985)
5-14.4°C (Spence et al. 1996)
> 12°C alevins substantial reduction in survival (Ringler and Hall 1975)
> 15.6°C mortality (Smith et al.1983)

Rearing: 12-14°C (Bell 1986)

Smoltification: 4.5-15.5°C typical migration (Spence et al. 1996)
ATPase Activity - 8°C and 13°C allow increased activity over a 6 week period, at 18°C ATPase activity decreases over the same time period - inhibitory effect of water temperature on gill Na-K ATPase activity (Sauter unpublished data)

V. Chinook Salmon (general):

Final Temperature Preferendum:

adult: 17.3°C (Coutant 1977)
Yearling: 11.7°C (Ferguson 1958; Huntsman 1942)

Spawning:	5.6-13.9°C (Bjornn and Reiser) 5.6-10.6°C (Bell 1986) 5.6-12.8°C (Temperature Subcommittee, DEQ 1995) spawning inhibition 15.5°C
Incubation:	5-14.4°C (Bjornn and Reiser) 13°C (Bell 1986) > 12.5°C increases egg mortality and inhibits alevin development - produces only 50% egg survival (Calif Dept Water Res)
Rearing:	10-15.6°C maximum productivity (Brett 1952) 12-14°C preferred range (Brett 1952) 7.3°C-14.6°C preferred range (Beschta et al. 1987) 12.2°C optimum (Beschta et al. 1987) > 12.8°C first feeding fry do not develop normally > 15.5°C disease increases mortality (Temperature Subcommittee, DEQ 1995)
Smoltification:	< 12.2°C (Calif Dept Water Resources, all salmonids) 18-21°C sub-lethal and lethal loading stress (Brett 1952)

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Chinook salmon - Other salmon species are not markedly different in their requirements.

Adult migration and spawning: optimum- 10°C, with a range of about 8- 13°C; stressful->15.6°C; lethal- 21°C
Incubation: optimum-<10°C, with a range of about 8- 12°C; stressful->13.3°C; lethal->15.6°C
juvenile rearing: optimum- 15°C, with a range of about 12- 17°C; stressful->18.3°C; lethal 25°C

National Marine Fisheries Service:

Chinook habitat assessment: 10-13.9°C properly functioning; 14-15.5°C at risk for spawning; and 14-17.5°C at risk for rearing and migration.

VI. Steelhead:

Adult migration:	X 21°C migration inhibition (Beschta et al. 1987) 10-13°C general preferred (Bjornn and Reiser 1991)
Upper incipient lethal temperature:	21-22°C (Hicks 1998)
Spawning:	3.9-9.4° C (Bell 1986, Spence et al. 1996) 4.4-12.8°C (Swift 1976) Rainbow trout brood fish must be held at water temperatures below 13.3°C and preferably not above 12.2°C for a period of 2 to 6 months before spawning to produce eggs of good quality (Smith et al. 1983)
Incubation:	5.6-11.1°C (Hicks 1998)

Preferred Temperatures Rearing:

summer run	**10-12.8°C (Bell 1986)**
winter run	**10-12.8°C (Bell 1986)**
fall run	**10-14.4°C (Bell 1986)**
spring run	**10-12.8°C (Bell 1986)**
	7.3-14.6°C preferred (Beschta et al. 1987) 10°C optimum (Beschta et al. 1987)
Smoltification:	11-12.2°C from 7.2°C resulted in cessation of downstream movement (Hicks 1998) <12°C (Hicks 1998)

See: Return to the River Report: Independent Scientific Group chinook comments for migration and incubation temperatures.

VII. Coho

Adult migration:	7.2-15.6°C (Reiser and Bjornn 1973, Brett 1952)

Spawning:

4.4-9.4°C (Reiser and Bjornn 1973, Brett 1952)
10-12.8°C (Bell 1986)
7.2-12.8°C (Hicks 1998)

Incubation:

4.4-13.3°C (Reiser and Bjornn 1973, Brett 1952)
10-12.8°C (Bell 1986)
8-9°C (Sakh 1984)
4-6.5°C (Dong 1981)
Egg mortality approx. 14°C (Reiser and Bjornn 1973, Brett 1952)
>12°C increased mortality (Allen 1957 in Murray and McPhail 1988)
>11°C increased mortality (Murray and McPhail 1988)
1.3-10.9°C produced best survival rates of eggs and alevins (Tang et al. 1987)
2-8°C optimum range (Tang et al. 1987)

Lower lethal:

0.6-1.3°C (Dong 1981)

Upper lethal:

12.5-14.5°C (Dong 1981), University of Washington
10.9-12.5°C (Dong 1981), Dungeness River, WA

Rearing:

11.8-14.6°C (Reiser and Bjornn 1973, Brett 1952)
11.4°C (Coutant 1977)
12-14°C (Bell 1986)
Cessation of growth >20.3°C (Temperature Subcommittee, DEQ 1995, Reiser and Bjornn 1973, Brett 1952)
11.8-14.6°C, preferred (Beschta et al. 1987)
25.8°C, upper lethal (Beschta et al. 1987)

Smoltification:

12-15.5°C (Brett et al. 1958)
2.5-13.3°C observed migration - most fish migrate before temperatures reach 11-12°C (Spence et al. 1996)

Optimum Cruising Speed: 20°C Underyearling and yearling approach velocities above dams exceeding 1.0 foot/second creates a problem in safeguarding underyearlings. Capacity to stem such a current for greater than one hour is limited to 18.5-21.5°C (Brett et al. 1958)

Final Temperature Preferendum:

Adult: 11.4°C (Coutant 1977) Laboratory

Adult: 16.6°C (Coutant 1977) L. Michigan

Upper lethal: 26°C, incipient lethal temperature (Brett 1952)
Acclimation was 20°C, 50% mortality in 1,000 min.
25°C (Temperature Subcommittee, DEQ 1995)

Preferred temperature: 12-14°C, temperatures >15°C were avoided (Brett 1952)

VIII. Chum

Adult migration: 8.3-15.6°C (Bjornn and Reiser 1991)

Spawning: 7.2-12.8°C (Bjornn and Reiser 1991)

Incubation: 8°C (Beacham and Murray 1985)
4.4-13.3°C (Bjornn and Reiser 1991)
6-10°C, maximum efficiency for conversion of yolk to tissue (Beacham and Murray 1985)
12°C, alevin mortality occurred 1-3 days after hatch (Beacham and Murray 1985)

Rearing: 14.1°C (Coutant 1977, Ferguson 1958, Huntsman 1942)
10-12.8°C (Bell 1986)
11.2-14.6°C, preferred (Beschta et al. 1987)
12-14°C, preferred (Brett 1952)
13.5°C, optimum (Beschta et al. 1987)
25.8°C, upper lethal (Beschta et al. 1987)

Final temperature preferendum:

Underyearling:	14.1°C (Coutant 1977) Laboratory
Yearling:	14.1°C (Ferguson 1958) Laboratory
	14.1°C (Huntsman 1942) Laboratory
Smoltification:	X
Upper lethal:	25.4°C, incipient lethal temperature (Brett 1952) Acclimation was 20°C, 50% mortality in 1,000 min.

IX. Umpqua cutthroat

Jeff Dose, Forest Fisheries Biologist, Umpqua National Forest (7/13/98). Few or no cutthroat occur where thermographs are located. Temperatures may be too warm, distribution and abundance has decreased from 1937 survey data. Lance Kruzic MS thesis (NMFS, Portland) - 15.5°C to 21°C no cutthroat present, upstream approx 4.5°C cooler begin to find cutthroat, defining distribution. Loss of spatial distribution, fragmentation, upper reaches where competition and disturbance regimes are a concern.

Sea-run cutthroat

Adult migration:	X 18-22.8°C upper lethal temperature range (Kruzic 1998)
Adult Holding:	Smith, C.E., W.P. Dwyer, and R.G. Piper. 1983. Effect of water temperature on egg survival of cutthroat trout. Prog. Fish-Cult. 43:176-178. West-slope cutthroat trout: Females held in fluctuating temperatures (2-10°C) had significantly better eggs than those held at a constant 10°C. Elevated temps experienced by mature females affected subsequent viability and survival of embryos.
Spawning:	6.1-17.2°C (Beschta et al. 1987, Bell 1986)
Incubation:	X
Rearing:	10°C (Bell 1986) 9.5 12.9°C, preferred (Beschta et al. 1987)

23°C, upper lethal (Beschta et al. 1987)
22.8°C, upper lethal (Bell 1986)

Smoltification: X

X. Bull trout

Migration: 10-12°C (Administrative Record, July 21, 1997, Bull Trout -Specific Temperature Criteria for Idaho Streams: Technical Basis, Notes, and Issues, Temperature Subcommittee, DEQ 1995)

Spawning: <9-10°C, initiate spawning, MT (Temperature Subcommittee, DEQ 1995)
<9°C, initiate spawning, B.C. (Spence et al. 1996, Temperature Subcommittee, DEQ 1995, Pratt 1992)
4.5°C, Metolius River, Oregon (Spence et al. 1996, Temperature Subcommittee, DEQ 1995)
4-10°C (Temperature Subcommittee, DEQ 1995)

5-6.5°C, peak spawning activities (Administrative Record, July 21, 1997, Bull Trout -Specific Temperature Criteria for Idaho Streams: Technical Basis, Notes, and Issues)

Incubation: 8-10°C, 0-20% survived to hatch, B.C. (Temperature Subcommittee, DEQ 1995)
6°C, 60-90% survived to hatch, B.C. (Temperature Subcommittee, DEQ 1995)
2-4°C, 80-95% survived to hatch, B.C. (Temperature Subcommittee, DEQ 1995)
4-6°C, MT (Temperature Subcommittee, DEQ 1995)
1-6°C (Temperature Subcommittee, DEQ 1995)
2-6°C (Spence et al. 1996)

Rearing: 4°C optimal temperature for growth, B.C. (Temperature Subcommittee, DEQ 1995)
4.5°C, Metolius River, Oregon (Temperature Subcommittee, DEQ 1995)

4-4.5°C, optimum fry growth (Temperature Subcommittee, DEQ 1995)
4-10°C, optimum juvenile growth (Temperature Subcommittee, DEQ 1995)
<10°C, Metolius River (Administrative Record, July 21, 1997, Bull Trout -Specific Temperature Criteria for Idaho Streams: Technical Basis, Notes, and Issues)
>14°C is a thermal barrier in closely related arctic charr (Pratt 1992)

Adult resident:

19°C, no bull trout were observed, MT (Temperature Subcommittee, DEQ 1995)
15-18°C, bull trout were present, MT (Temperature Subcommittee, DEQ 1995)
<16°C, bull trout present, John Day Basin, OR (Temperature Subcommittee, DEQ 1995)
<12°C, highest densities of bull trout, MT (Temperature Subcommittee, DEQ 1995)
9-13°C, adult preference (Temperature Subcommittee, DEQ 1995)
Less than or equal to 12°C, highest adult density (Temperature Subcommittee, DEQ 1995)

4-18°C, adults present (Temperature Subcommittee, DEQ 1995)
<15°C vertical distribution in lakes (Pratt 1992)

Competition:

12°C, Metolius River, reach susceptible to brook trout invasion (Administrative Record, July 21, 1997, Bull Trout -Specific Temperature Criteria for Idaho Streams: Technical Basis, Notes, and Issues)

Additional Sources:

Upper lethal: Acclimation temperature was 20°C, 50% mortality occurred in 1,000 minutes (16.7 hours) (Spence et al. 1996):
Chinook: 26.2°C Sockeye: 25.8°C Steelhead: 23.9°C

Upper lethal temperature (chinook): 25.1°C (Brett 1952)

The Columbia River Basin Fish and Wildlife Program of the Northwest Power Planning Council recommends that habitat restoration efforts in tributaries maintain temperatures in historically useable spawning and rearing habitat at less than 60°F (15.5°C), not to exceed 68°F (20°C).pg 168 Return to the River.

National Marine Fisheries Service:

Making ESA Determinations of Effect for Individual or Grouped Actions at the Watershed Scale:

Properly functioning: 10-14C

At risk:
Spawning: 14-15.5C
Migration and rearing: 14-17.8C

Not properly functioning:
Spawning: >15.5C
Migration and rearing: >17.8C

Brett (1952) found that the range of greatest preference by all species of Pacific salmon was from 12 to 14°C for acclimation temperatures ranging from 5 to 24°C. Brett (1952) also noted a definite avoidance of water over 15°C (Beschta et al. 1987).