APPENDIX A-5:

TURBIDITY GOAL

MEMORANDUM

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FISHERY MANAGER RECOMMENDATION FOR A UMATILLA BASIN SEDIMENT TARGET

Prepared by:
Tim Bailey, Umatilla District Fish Biologist, Oregon Department of Fish & Wildlife
Craig Contor, Fish Biologist, Confederated Tribes of the Umatilla Indian Reservation
John Sanchez, Fish Biologist, USDA Umatilla National Forest

Submitted to:
Umatilla Basin TMDL Technical Committee
Umatilla Basin TMDL Stakeholders Committee

As partners in developing plans to improve water quality in the Umatilla basin and to assist in restoring productive salmonid fish populations, Fisheries Biologists from the Oregon Department of Fish and Wildlife, Confederated Tribes of the Umatilla Indian Reservation and Umatilla National Forest collaborated to develop a water column sediment target for the purpose of developing load allocations. In early 1999, the fishery managers presented their turbidity target recommendation of 30 NTU for a period of 48 hours to the Umatilla Basin TMDL Technical Committee (for definition of terminology used in this document see the Umatilla TMDL document). The Umatilla basin TMDL Stakeholder Committee agreed to the recommendation during meetings held June through December 1999. The following discussion will frame the context in which the recommendation was developed and provide substantiation for its validity.

As determined by consensus of the Umatilla TMDL Technical Committee, salmonid spawning and rearing is the Beneficial Use within the Umatilla basin most sensitive to sedimentation. For this reason, the sediment target recommendation was developed to protect salmonid fish resources in the Umatilla Basin.

Optimally, the sediment target would be based on an understanding of the delivery of sediment to rivers and streams in the Umatilla basin prior to human-induced impacts or on an assessment of achievable desired future conditions. This would be a portrayal of conditions that salmonid fish survived under prior to the time of man's intervention in the watershed or of the optimum conditions obtainable in the present day. Unfortunately, data do not exist on sedimentation prior to settlement by Europeans nor does a methodology currently exist for determining the optimum attainable conditions in the present day (i.e. methods applicable at the scale of the Umatilla basin are not available). Therefore, we have focused on what is known about the most sensitive beneficial use, salmonid fish, and impacts of sediment on them.

The fishery managers are not aware of studies on the effects of sedimentation on salmonid fish conducted in the Umatilla basin or in adjacent basins within the same hydro-physiographic provinces. Therefore, development of the sediment target is based on the review of general literature and reference to species that are present, and endemic to, the Umatilla basin. Though not specific to the Umatilla basin, there is a wealth of literature that documents effects of sedimentation on migration, spawning and rearing of salmonid fish. The specific effects of both suspended and deposited sediment on various species is well documented and well understood. Waters (1995) provides an extensive review of the literature on the impacts of sediment on aquatic resources. Lloyd (1987) also did a thorough review of turbidity impacts on salmonid fish as means of verifying the validity of water quality standards in Alaska.

The first step in identifying a target is to determine the level of protection desired to be achieved. Should the goal of the target be to simply minimize direct mortality, or to protect the beneficial use at the level of chronic sub-lethal affects where the overall productivity of a population can be significantly impacted? Bearing on this decision is the fact that bull trout (*Salvelinus confluentus*) and summer steelhead (*Onchorhynchus mykiss*) in the Umatilla basin are currently listed by the United States Government as

"Threatened" under the Endangered Species Act. In addition, millions of dollars are invested annually by private parties and federal, state and local governments on the behalf of restoring salmon in the Umatilla basin. Given this consideration, salmonid fish should be provided protection to avoid direct mortality of the species and allow sufficient productivity of the populations to recover. Lloyd (1987) found that "An acceptable turbidity standard must do two things to protect aquatic habitats: (1) prevent a loss of aquatic productivity and (2) cause no lethal or sub-lethal effects on fish and wildlife". Newcombe and Jensen (1996) in their scale of severity of ill effects associated with suspended sediment define sub-lethal effects as: reduction in feeding rate and feeding success; physiological stress; moderate habitat degradation; and impaired homing. The same authors define lethal or paralethal effects as: reduced growth rate; delayed hatching; reduced fish density; increased predation; moderate to severe habitat degradation; and direct mortality. Umatilla basin fish managers find that protection at the level of sub-lethal effects is imperative to protect and restore indigenous salmonids in the Umatilla basin. The indigenous salmonids in the basin include: summer steelhead and resident redband trout (*Onchorhynchus mykiss*), bull trout (*Salvelinus confluentus*), fall and spring chinook salmon (*Onchorhynchus tshawytscha*), and coho salmon (*Onchorhynchus kisutch*).

To accomplish the task of recommending a suspended sediment target, the fish managers reviewed Waters (1995) and other more recent publications, selected references that pertained to the species present in the basin, and addressed the levels of impact described above. In our review of the literature we were looking for research that provided statistically significant findings with regard to the following responses: altered behavior, avoidance, displacement, reduced growth, reduced feeding, increased stress and increased mortality. All of these responses expressed at the individual level would effect productivity of the population with increasing occurrences and severity. We also focused on research conducted in the Pacific Northwestern United States.

Since authors such as Waters (1995) and Lloyd (1987) have done so, we did not attempt to conduct an exhaustive review of the literature. We focused on the findings of several papers, that in our opinion, had the best application to species in the Umatilla basin.

The first indication of the effects of sediment on salmonid fish begins at the behavior level such as alarm reactions, avoidance of sediment-laden water, etc. When given choice of clear (0 mg/l), medium (100 to 400 mg/l) or and high (1,000 to 4,000 mg/l) concentrations of sediment, juvenile coho salmon chose medium or low concentrations (Cederholm and Reid 1987). Bisson and Bilby (1982) found that juvenile coho avoided water with turbidities of 70 NTU. Sigler (1984) not only found that steelhead fry avoided turbidities of 25-50 NTU, but they also had reduced growth rates. Berg and Northcote (1985) found that dominance hierarchy's broke down, territories were not defended and gill flaring occurred more frequently when exposed to turbidities from 30 to 60 NTU. They also found that reaction distance to brine shrimp, capture success and the percentage of prey ingested decreased at the referenced turbidities.

Stress is another indicator of the ill effects of turbidity on salmonid fish. Redding and Shreck (1987) found that both juvenile steelhead and coho salmon showed signs of stress at high levels of suspended sediment (2-3 g/L) but not at low levels (0.4 to 0.6 g/L). In a summary literature reporting effects of turbidity on fish, Lloyd (1987) reports several studies that document stress at 15-27 JTU (Smith and Sykora 1976), 231 NTU (Carlson 1984), 300 mg/L (McLeay et al. 1984), and 50 Mg/L (McLeay et al. 1983).

Suspended sediment loads and/or turbidity at levels that lead to reduced feeding and growth of rearing fish strongly indicates an effect on the long-term survival of anadromous juveniles to the adult stage and of the relative productivity of a population. Cederholm and Reid (1987) found that prey capture success of juvenile coho salmon significantly declined at concentrations of 100 to 400 mg/l. Studies in Idaho on the effects of elevated turbidity showed that steelhead and coho salmon fry showed reduced growth at levels of 25-50 NTU (Sigler et al. 1984) and 22-113 NTU (Sigler 1980).

The studies reported above show responses to sediment at a fairly wide range of suspended loads and turbidities. However, the fishery managers choose to base this target recommendation on literature documenting changes in fish behavior as the most sensitive response level to sediment. Berg and

Northcote conducted experiments with naturally produced coho salmon juveniles of which the fishery managers have used to set an actual target number. The authors tested responses to both short-term bursts and short-term pulses of sediment at turbidities of 20, 30 and 60 NTU. They found that behavior did not change after a two-day exposure to 20 NTU, but an increase to 30 NTU did produce a major disruption in the social organization of the fish.

It is upon the findings of Berg and Northcote and those of Sigler et al. (1984) and Sigler (1980) regarding growth that the fishery managers recommend a target of 30 NTU for 48 hours for suspended sediment. Other aquatic species may require similar levels of protection. Because sufficient studies for the presence and needs of other species are generally unavailable and because salmonids are potentially present through much of the basin throughout the year, it is recommended that this goal be applied to waters throughout the Umatilla basin, throughout the year.

To provide a tool for fishery managers to assess the effects of both dose and duration of salmonids to elevated levels of sediment, Newcombe and Jensen (1996) did a meta-analysis of 80 published and adequately documented reports. From this analysis the authors developed matrices of ill effects to various doses and exposures to sediment. This provides an extremely useful tool for evaluating targets to protect salmonid fish. At a 48 hour exposure, the matrices results show that sub-lethal effects on adult and juvenile salmonids begin at concentrations of 3 mg/L and lethal or paralethal effects begin at approximately 1000 mg/L.

In a review of studies conducted in Alaska and elsewhere, Lloyd (1987) found that increases of 25 or 5 NTU above ambient conditions in clear coldwater habitats provide moderate and relatively high protection. Rowe et al (1998) (unpublished draft) in an effort to determine quantitative water quality standards for sediment in Idaho recommends 50 NTU instantaneous or 25 NTU for more than 10 consecutive days above background. However, they recognize that there are impacts to biota at turbidities above 10 NTU. In a review of sediment criteria Harvey (1989) suggests sediment targets for coldwater biota in this same range.

A Umatilla basin suspended sediment TMDL is being developed based on this recommendation. Through regression analysis, this 30 NTU goal has been translated to various target levels of total suspended solids (TSS). It should be noted that while this sediment TMDL is developed for TSS, many of the streams included on the 303 (d) list for the Umatilla basin were listed based on ocular estimates of substrate fines. The issue of substrate fines within spawning areas for anadromous fish is a primary concern for fish managers in the Umatilla basin. However, the substrate fines data used to place many Umatilla basin streams on the 303 (d) list are not adequate from which to develop load allocations. For this reason, and the lack of any other available data on substrate fines (and to address the mainstem turbidity listing), the Umatilla TMDL Technical Committee chose to develop the TMDL to allocate water column sediment. Undoubtedly, there are linkages between water column sediment and deposited sediment, but not likely any direct, measurable ones. Therefore, the fish managers in an additional recommendation provide Measures of Progress to address both substrate fines and habitat modification. Both are listed parameters in the Umatilla basin. The fish managers' recommendations for substrate fines and habitat modification will be incorporated into the overall TMDL document as measures of progress, documented within the sections pertaining to these parameters. Since this TMDL addresses water column sediment, the fish managers have not attempted to present a review of literature regarding the impacts of deposited sediment on salmonid fish and their habitat.

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