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Lower Granite Reservoir In-water Disposal Monitoring Strategy: Design of the Impact Hypotheses

Workshop Report
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by

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7.0 SUBSYSTEM DESCRIPTIONS

Although the interaction matrix developed at the workshop had four subsystems, it was decided that the subgroup sessions would be more fruitful if the physical/chemical and habitat discussions were held in the same subgroup. This seemed reasonable since much of the discussion dealing with physical changes would likely be oriented around how to engineer the disposal activity to create "good" fish habitat.

Each subgroup met for about six hours. The results of those discussions are presented in the next three sections. Following the subgroup meetings, each subgroup had a representative present their results to the plenary session. Comments raised at that time have been incorporated into the following summaries.

7.1 Physical and Chemical Habitat Subgroup

7.1.1 Introduction

The physical and chemical habitat subgroup discussed how information currently available could be used to predict changes in key components of habitat. The discussions focused on the prediction of changes in habitat components identified in the interaction matrix as being of concern to the subgroups considering changes in either migrating salmonid or resident fish populations. Several of the items listed in Table 3 are easily defined (for example, the proximity of the disposal site to access points) and were not discussed during the subgroup meeting.

Two sites have been designated for dredging during the first year of the in-water disposal test (Figure 1). Site number one is located at the confluence of the Snake and Clearwater rivers and has accumulated a mixture of silt, sand, and clay. Site number two is located immediately downstream of the confluence of the two rivers. The sedi-

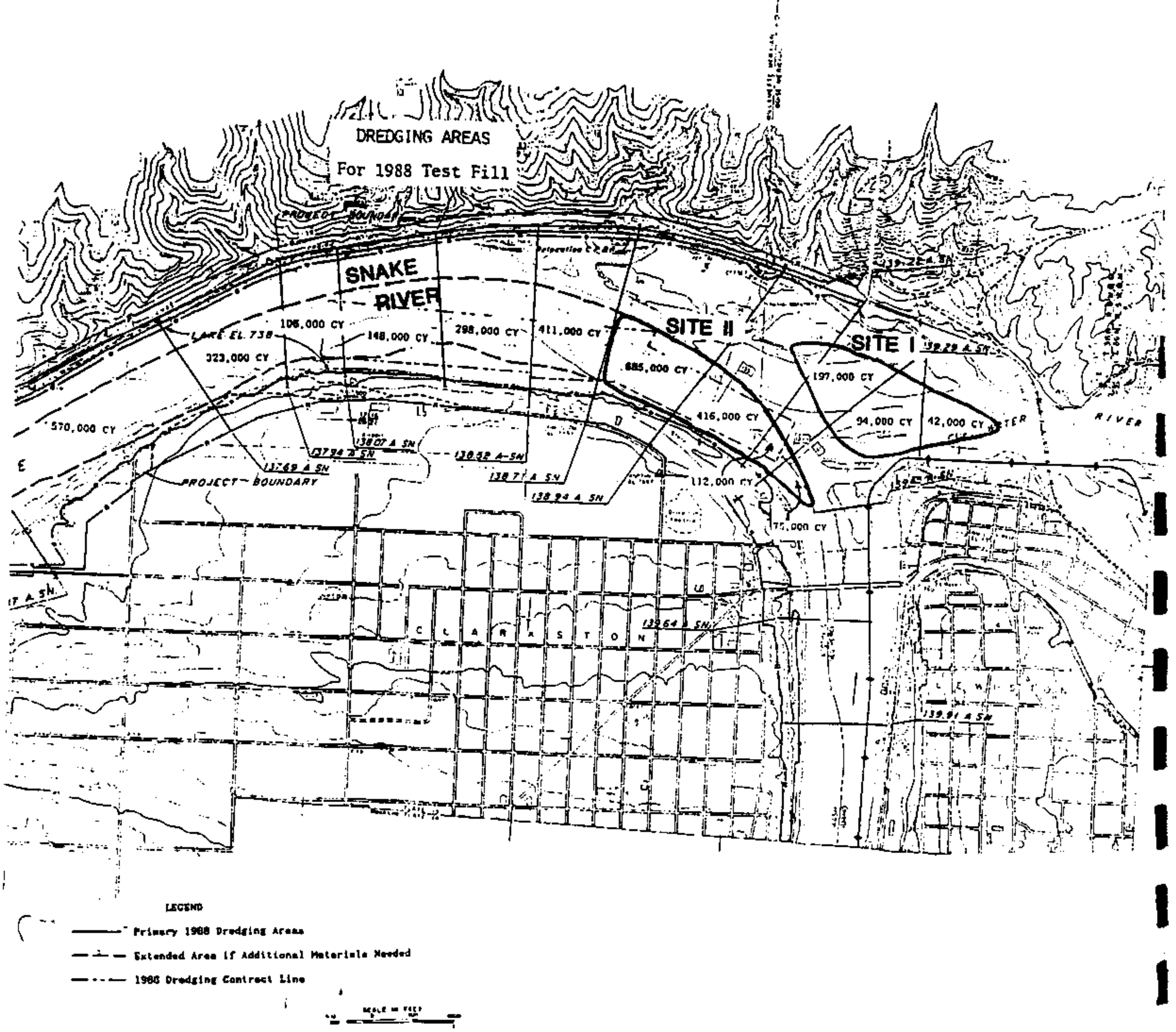

Figure 1 : Location of proposed dredging sites for test period. Adapted from: Environmental Assessment. Position Paper, July 2, 1987. Clearwater/Snake River Confluence Dredging, Winter 1987/88 Dredging Window.

ments at this site are predominantly sand.

7.1.2 Turbidity Plume

There will be a turbidity plume at both the dredging and disposal sites. The turbidity plume has been assessed at the dredging site during the past years' dredging activity downstream from the confluence of the Snake and Clearwater Rivers (site number two).

Dredging Sites

Characteristics of the observed plume and the expected background conditions are summarized in Table 3. In the table, characteristics of the plume are expressed in two systems of measurement: standard turbidity units (ntu - the light scattering property of the plume material), and concentration units (mg/l). Although there is a general correlation between these measures, factors, such as the mineralogy of different sediments, require that the relationship be calibrated for different sediments.

Latitudinal extent of the plume, as observed from the air, has typically varied from 10% to 15% of the river width. The downstream extent is estimated to be approximately 425 m, at which distance, no detectable level above ambient conditions was observed.

The plume resulting from future dredging activities will vary with four major attributes of the dredging, namely:

1) The location within the reservoir. The two areas where dredging activities are planned during the present test evaluation differ substantially with regard to their silt and clay content. In future, it is anticipated that areas further downstream will also be dredged. In general, these areas are predominantly sandy, however, some areas have a relatively high silt content, including one of the

Table 3: Relative measures of suspended sediment and turbidity at dredging site.

A) Background Conditions - Sediment Concentration *

200 mg/l - typical high flow runoff

500 mg/l - extreme runoff event

* data from the U.S. Geological Survey

B) Observed Turbidity

i) Background:

< 5 ntu - typical turbidity during winter months

54 ntu - observed during mid-February to March freshet

100 ntu - maximum turbidity during January - February

ii) No overflow dredging regime:

1 - 20 mg/l - increase over ambient conditions within mixing zone

iii) Overflow dredging regime:

11 - 40 mg/l - increase over ambient conditions within mixing zone

2 - 4 ntu - average increase at 90 m downstream from dredge location

39 ntu - maximum increase at 90 m downstream

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two sites designated for dredging in 1988.

The turbidity level arising from dredging in areas of relatively high silt content will be higher than observed to date. Due to the variations in the relationship between turbidity and suspended sediment concentrations, however, it is not possible to predict accurately. Increased turbidity from a factor of 2 to an order of magnitude are possible.

2) The mineralogy of the dredged sediment. When compared at equal concentrations, some clays produce much higher turbidity (light scattering) relative to others due to differences in their particle shape.

3) The percent moisture content (pmc) of the material also affects the turbidity caused by a given mass of suspended material.

4) Climatic events, such as extreme runoff events, will increase the background concentrations of sediment and thereby reduce the visual observation of the turbidity plume. At the same time, the additional sediment from the runoff will increase the total concentration of suspended sediment. Such events will also have several other effects from the associated increase in velocity, including more rapid mixing of the plume and increased lateral extent of the plume.

Disposal Sites

At the disposal sites, turbidity will arise from entrainment of dumped material into the water column and from bottom sediment which will be resuspended upon impact of the dumped material. The sediment at the lower portion of the reservoir is predominantly silt (based on surface grabs). Based upon an estimate of 1% entrainment of dumped material, expected flows ranging between 0.4 and 1.5 ft./sec., and an assumption of complete mixing, the extent of the plume zone is estimated to be approximately 100 m laterally and 500 m downstream. Average concentrations within the zone are estimated to be 80 mg/l above ambient.

The characteristics of the turbidity plume at the disposal sites cannot be accurately predicted and monitoring will be needed to confirm present estimates. Measurements suggested for this include concentration of sediment (mg/l), turbidity (ntu), depth of dump site, and current velocity. Since the shape and intensity of the plume will vary with depth, it was suggested that these measurements should be made near the surface, and in both mid-water and near bottom strata of the water column.

7.1.3 Chemicals

Water quality monitoring was conducted during the previous years of dredging and the results were found to be within the federal and state criteria for protecting aquatic resources. Additional compliance monitoring will be conducted during the experimental monitoring period.

During the subgroup discussions, questions were raised about whether the dredge sediments contain significant amounts of chemicals discharged by a nearby pulp mill. The primary concern was for the possible bioaccumulation of chemicals, such as acid resins, being relocated to the lower reservoir. To date, repeated tests over the last four years indicate that this is not a problem.

7.1.4 Substrate Composition

The composition of the substrate at the proposed dredging and disposal sites is summarized in Table 4. From the table it is apparent that, immediately following disposal of the dredged material, grain size at the disposal sites will

Table 4: Substrate composition at dredging and disposal sites.

Location	Substrate Composition: Sand (%)	Silt (%)	Clay (%)	Volatile Organics (%)	Oil & Grease (ppm)
Dredge Site Number 1					
(at the confluence of the Clearwater and Snake Rivers)	30 - 40	40 - 60 (50) *	< 11	6 - 7	300
Dredge Site Number 2					
(downstream of the confluence of the Clearwater and Snake Rivers)	80 - 98 (90-95)	2 - 20	0	0.7	50
Disposal Sites					
(both mid-depth and deep sites)	10 - 18	65 - 80	10 - 18	8 - 9	300 - 1,0

* Numbers in parentheses are average values.

be increased. An increase relative to the dredging sites is also expected due to the entrainment of silt into the water column. This is estimated to be approximately 1% of the total material deposited and would thus be a marginal increase in grain size relative to the source sites.

Since the formation of the Lower Granite Reservoir, approximately 24 in. of silt has been deposited in the lower reservoir. Variations in the annual rate of accrual are expected with variation in runoff, but over this ten year period, the observed accumulation represents an average deposition rate of approximately 2 in./yr. Consequently, a return to the present grain size of exposed material is expected within one year of the deposition of dredged material.

7.1.5 Topography of the Disposal Site

The final topography of the disposal site will be determined by the spatial pattern of dumping within the disposal zone, the settling characteristics of the sediment, the current velocity at the time of disposal, water depth, and long term stability of the disposed material. Large grain material such as sand will settle more rapidly and disperse over a smaller area than small grain materials disposed over the same depth of water. As water depth increases, the field over which a single dump of material will settle on the bottom increases and the corresponding relief of the dumped material decreases.

At a depth of 50 ft., a typical settling field would be approximately 100 m in diameter. Assuming downstream motion of barges while dumping, an elliptical disposal field from any single dump is likely. An initial slope of the dumped material of 25 degrees is considered likely. After a period of further settling and erosion during periods of high flow, the slope is expected to be reduced to an eventual relief of 10 degrees.

Variations in topography within the overall disposal field will arise primarily from the pattern of dumping. During the workshop there was considerable discussion of the type of pattern desired to enhance or maintain salmon habitat, and for the purposes of obtaining a good experimental design. The possible topographic characteristics of the disposal field at the proposed mid-water disposal site are illustrated in Figure 2. The mid-water disposal site is approximately 1,000,000 sq. ft.(1000 ft. x 1000 ft.), and assuming that 400,000 cy of material is deposited, the average reduction in depth over the site would be approximately 10 ft. At 2,000 cy/scow this would require a total of 200 individual scow loads. In order to achieve a uniform pattern of dumping within the area, the average separation between the center of each load's settling field would have to be 50 to 60 ft.

7.1.6 Change in Flow

Estimates of change in flow have been made for the reservoir as a whole but not on a local basis. These estimates are for the expected condition after the completion of an extended period of in-water disposal (117 years) and do not reflect the likely increase during the two year test period. The estimated increase in average cross-sectional flow velocity is 20%. Discussions during the meeting indicated that, in shallow areas toward the sides of the reservoir, reducing the depth of the substrate would be expected to reduce local flow velocity. Consequently, for the net cross-sectional velocity to be increased, flow in the main channel is expected to increase more than the average estimate.

7.1.7 Change in Temperature

During periods of the year in which the temperatures within the reservoir are homogeneous, no change in temperature over the new habitat is expected. Only during the summer period are differences likely to occur and only over

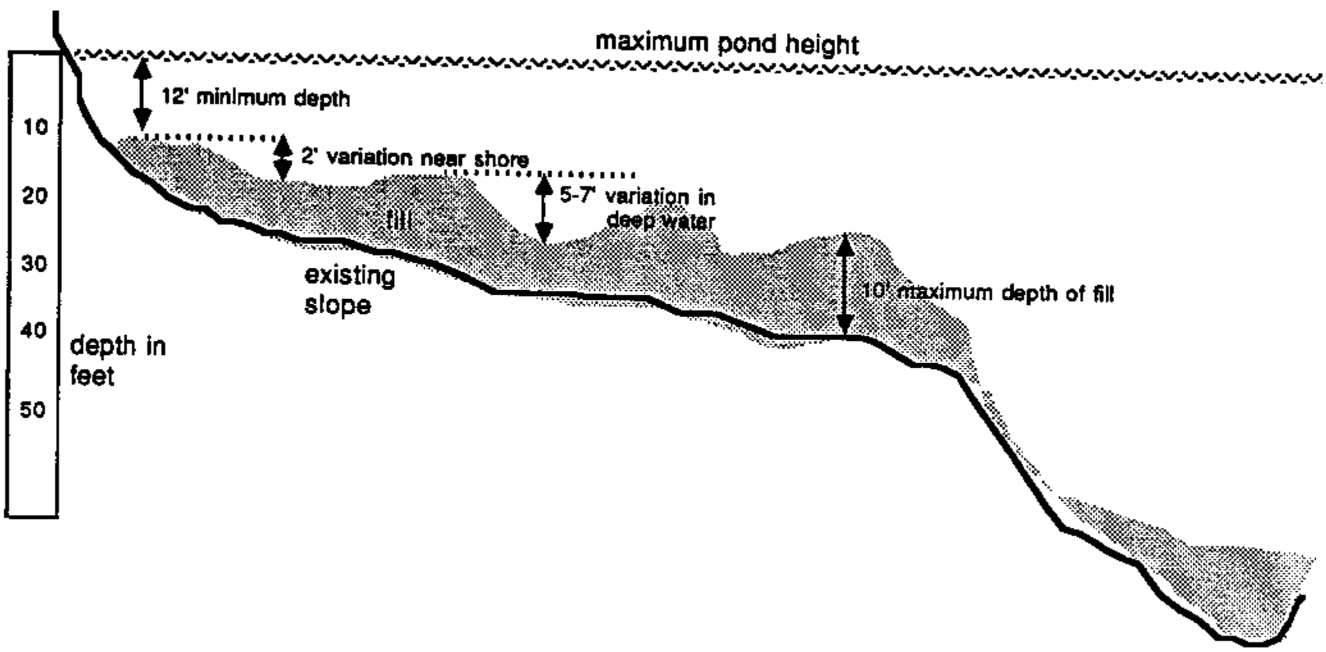

Figure 2: Possible topographic characteristics of the disposal field at the proposed mid-water disposal site.

long-term disposal.

Temperature profiles in the Lower Granite Reservoir are available from the recent studies by Bennett and Shrier (1987). These studies did not find a strong thermocline within the reservoir. It was agreed that these profiles should provide a reasonable estimation of temperature over the newly created habitat.

7.1.8 Change in Dissolved Oxygen

Due to the relatively low organic content of the dredge sediments, no significant reduction in dissolved oxygen is expected at either the time of disposal or in the long term. A slight reduction in dissolved oxygen concentrations may occur in the immediate disposal and dredging plumes. Due to the periodic nature of the disposal process, this should be more transient at the disposal site than at the dredging site. During the dredging activity in 1986, the mixing zone specified for dissolved oxygen by the Washington State Department of Ecology extended 425 m downstream from the dredge and disposal site. At this distance, there was no significant difference in dissolved oxygen concentrations relative to ambient conditions.

7.1.9 Change in Macrophytes

Macrophytes in the lower reservoir are usually limited to areas between 5 and 12 ft. below maximum pond elevation. Consequently, in the short term, no additional areas of macrophytes are predicted if the in-water disposal does not raise the substrate to within 12 ft. of maximum pond elevation.

In the long term, the total area of macrophyte habitat should increase as the natural accrual of sediments in the lower basin raises substrate elevations into this zone. As noted previously in the discussion of substrate composition a relatively rapid rate of sedimentation has been observed within the Lower Granite Reservoir and averages approximately 2 in./yr.

Therefore, it is expected that increases in the distribution of macrophytes could occur regardless of the in-water disposal program. By reducing the mean depth in the lower reservoir, in-water disposal will, however, accelerate the rate at which this will occur. Limitation of the long term rate of development of macrophytes should be feasible through limitation of the maximum elevation of newly created habitat. This will vary between sites due to variations in the local rate of sediment accrual.

7.1.10 Change in Benthos

Recent studies by Bennett and Shrier (1986) indicate that the primary components of the benthic community with respect to their importance for forage are oligochaetes and dipterans. Recolonization, due to downstream drift, of benthic communities in riverine environments after substrate disturbance is typically rapid. This is consistent with the observations of Bennett and Shrier at sites dredged during 1985 and 1986 where they found recolonization of both taxa began within 3 months.

Benthic production and standing crops are usually greater in sediments with higher organic contents. Given the relatively high sand content of the dredge materials, recolonization by benthic organisms is expected to depend upon the rate of siltation at disposal sites and the rate of invasion of organisms from surrounding areas. As noted above with regard to macrophytes, this does vary among shallow sites.

Assuming an average accrual of 2 in./yr., recolonization of dipterans is expected to occur with the first year. Furthermore, the rate of recolonization is expected to be maximized by disposal during the winter months since sediment deposition from spring runoff and recolonization by first instar larvae will occur shortly after disposal. Since dipterans inhabit the upper layers of the substrate, initial recolonization could be as high as 60% of the original biomass and productivity after one year, and should be fully recovered within two to three years.

Similarly, recolonization of oligochaetes is also expected to begin in the first year. Since oligochaetes use deeper strata within the sediment, up to about 8 in. of depth, their recovery should be slower than that of the diptera. Recovery on the order of 30% - 40% by the end of the first year is likely. Subsequent increases in standing crop and productivity are expected to be a linear function of the rate of accrual of new sediment and could be considered complete when the depth of silt over the disposal sediment reached a depth of 8 in. Alternatively, for areas which currently have less than 8 in. of silt, recovery could be considered complete upon reaching the current silt depth.

7.1.11 Crayfish

The effects of in-water disposal on local crayfish populations are uncertain. A possible increase in these populations would provide additional forage, primarily for bass, and could therefore lead to an increase in the abundance of this predator. The crayfish inhabiting the reservoir are not a burrowing species and, while they may be found throughout the shallow water habitats, they are expected to be most abundant in shallow rocky areas.

7.2 Resident Fish

7.2.1 Introduction

The resident fish group discussed the potential effects of dredging and disposal operations on a number of native and non-native fish species found in the Lower Granite reservoir. All the major resident fish species found in the reservoir were considered (Table 5), with the exception of suckers. The absence of any expected interaction between

Table 5: List of fish species discussed by the resident fish subgroup.

Native fishes that prey on salmonids

- northern squawfish
- sculpins

Native fishes that do not prey on salmonids

- sturgeon
- other cyprinids
    - redside shiner
    - chiselmouth chub
    - peamouth chub

Non-native fishes that prey on salmonids

- centrarchids and percids
    - smallmouth bass
    - crappies
    - yellow perch
- channel catfish

Non-native fishes that do not prey on salmonids

- carp

suckers and other species in the system provided the rationale for excluding this group. In addition, we concluded that our ignorance of the distribution, abundance, and habitat preferences of sculpins in the Lower Granite reservoir made it impossible to judge the impact of dredging and disposal on this group of fishes.

To provide a focus for the discussion of effects, we identified five key processes that might be influenced by dredging and disposal for some or all of the selected species (Table 6). We then examined the potential influence of each physical or habitat change identified in the interaction matrix (Table 7) on each process, for each species. In the following text, we summarize the results of our discussions for each potential effect. The overall results are presented in Tables 8-13.

7.2.2 Dredging Operations

None of the resident species spawn during the time period in which dredging is intended to take place, with the possible exception of yellow perch. Perch, however, do not spawn in the areas where dredging will take place. Therefore, dredging operations are not expected to influence the reproductive success of the resident fish species discussed. Similarly, the timing and location of the dredging operations are such that impacts on the other life history stages and processes are not expected for any of the resident fish species. It should be stressed that this conclusion is largely a consequence of the timing of the dredging operation. Were dredging to occur at a time when larval fish or salmonid smolts were present in the vicinity of the operations, the potential for entrainment and other impacts would have to be considered.

7.2.3 Disposal Operations

The changes in water chemistry and turbidity expected to result from the disposal operations were not considered

Table 6: List of life history processes discussed by the resident fish subgroup.

- Reproduction (spawning)
- Rearing (young-of-year) success
- Immature and adult success (growth and survival)
- Predation on salmonid juveniles
- Predation by salmonid juveniles

Table 7: Physical, chemical, and habitat changes potentially resulting from dredging and disposal operations whose impacts were considered by the resident fish subgroup.

- Dredging operations:
  - timing
  - method (hydraulic, mechanical)
  - location
- Disposal operations:
  - barge traffic
  - physical plume characteristics (turbidity)
  - chemical plume characteristics
- Physical characteristics of new habitat created from disposal:
  - depth
  - substrate composition (particle size)
  - topography
  - cover
  - proximity to other habitats
  - proximity to access points
- Abundance and composition of benthos in new habitats:
  - oligochaetes
  - dipterans
  - crayfish
- Area and composition of new macrophytes
- Abundance and distribution of juvenile salmonids

Table 8: Summary of the physical/habitat changes that influence squawfish.

	Reproduction	Rearing	Immature/Adult	Predation on Salmonids	Predation by Salmonids
Dredging	no effect expected due to location and timing of operations				
Disposal	no effect expected due to location and timing of operations			turbidity plume would affect feeding on and by salmonids, but timing of disposal minimizes effect	
Physical habitat - depth - grain size - topography - cover - other habitat - access points	squawfish do not spawn in areas where physical or biological habitat changes are expected to occur therefore no effect is expected	increased shallow water habitat and less habitat structure will enhance rearing success	no strong preference for particular physical habitat features - pelagic distribution implies little or no effect	simplifying habitat (less cover and topographic relief) will favor predation both on and by salmonids	
Benthos		increased dipteran abundance will enhance rearing	increased benthos will have positive effect	increased benthos will decrease predation both on and by salmonids	
Macrophytes		macrophytes may provide cover but less important than for other resident fish	not important	increased macrophyte cover will reduce predation both on and by salmonids	
Juvenile salmonids		some feeding on squawfish by smolts	salmonids are not a major part of squawfish annual energy intake		

Table 9: Summary of the physical/habitat changes that influence sturgeon.

	Reproduction	Rearing	Immature/Adult
Dredging	no effect expected due to location and timing of operations		
Disposal	no effect expected due to location and timing of operations		
Physical habitat - depth - grain size - topography - cover - other habitat - access points	sturgeon do not spawn in areas where physical or biological habitat changes are expected to occur therefore no effect is expected	appear to use all physical habitat types for rearing; thus rearing success effects are not expected	losses of deep water habitat may reduce success juxtaposition of deep and shallow waters may be important
Benthos		increased benthos abundance will enhance rearing	increased benthos will have positive effect
Macrophytes		not important	not important
Juvenile salmonids		not important	not important

Table 10: Summary of the physical/habitat changes that influence other cyprinids.

	Reproduction	Rearing	Immature/Adult
Dredging	no effect expected due to location and timing of operations		
Disposal	no effect expected due to location and timing of operations		
Physical habitat - depth - grain size - topography - cover - other habitat - access points	no effect expected from physical habitat changes	increased shallow water habitat and less habitat structure will enhance rearing success	no strong preference for particular physical habita features
Benthos	not important	some positive effect of increased benthos in later stages of rearing	increased benthos will have positive effect
Macrophytes	increased macrophytes may benefit redside shiner spawning	macrophytes provide cover	macrophytes provide cover
Juvenile salmonids		some feeding on other cyprinids by salmonid smolts	

Table 11: Summary of the physical/habitat changes that influence centrarchids and percids.

	Reproduction	Rearing	Immature/Adult	Predation on Salmonids	Predation by Salmonids
Dredging	no effect expected due to location and timing of operations				
Disposal	waves caused by disposal barges may reduce perch spawning success	no effect expected due to location and timing of operations		turbidity plume would affect feeding on and by salmonids, but timing of disposal minimizes effect	
Physical habitat - depth - grain size - topography	newly created habitat will not be good centrarchid or percid spawning habitat	increased area of very shallow water (< 2') may enhance rearing	require a mixture of shallow and mid-water habitat	decreased cover will decrease impact of bass predation on salmonids	
- cover - other habitat			reduced habitat diversity would have a negative impact		
- access points			proximity of new habitat to access points will influence sport fishing success		
Benthos		increased benthos abundance will enhance rearing	increased benthos will have positive effect	increased benthos decrease impact on salmonids	
Macrophytes		increased area of macrophytes will enhance rearing	increased area of macrophytes will have positive effect	increased area of macrophytes will increase impact on salmonids	
Juvenile salmonids		not important	not important		

Table 12: Summary of the physical/habitat changes that influence catfish.

	Reproduction	Rearing	Immature/Adult	Predation on Salmonids	Predation by Salmonids
Dredging	no effect expected due to location and timing of operations				
Disposal	no effect expected due to location and timing of operations			turbidity plume would affect feeding on and by salmonids, but timing of disposal minimizes effect	
Physical habitat - depth - grain size - topography - cover - other habitat - access points	newly created habitat will not be good catfish spawning habitat	rearing habitat in Lower Granite reservoir unknown; therefore cannot evaluate potential habitat change effects	reductions in mid- and deep-water habitats would have adverse effect reduced habitat diversity would have a negative impact	decreased cover is expected to decrease the impact of catfish predation on salmonids, although prey are captured in absence of cover	
Benthos			increased benthos will have positive effect	increased benthos decrease impact on salmonids	
Macrophytes			not important	increased area of macrophytes will increase impact on salmonids	
Juvenile salmonids			not important		

Table 13: Summary of the physical/habitat changes that influence carp.

	Reproduction	Rearing	Immature/Adult
Dredging	no effect expected due to location and timing of operations		
Disposal	no effect expected due to location and timing of operations		
Physical habitat - depth - grain size - topography - cover - other habitat - access points	no effect expected from physical habitat changes	increased shallow water habitat and less habitat structure may enhance rearing success	increased shallow waters should benefit carp
Benthos	not important	increased benthos should have positive impact	increased benthos will have positive effect
Macrophytes	increased macrophytes may benefit spawning		macrophytes may provide source of food
Juvenile salmonids			

to be of sufficient magnitude, spatial extent, or duration to have a significant impact on any of the resident fish species. Once again, this conclusion is, in part, a consequence of the timing and location of the disposal operations. While increased turbidity is known to influence the feeding success of fishes, the disposal plume will be present at a time when turbidity is either already high, or when migrating salmonids are not present. Thus, significant effects on salmonid predation are unlikely. In addition, the timing (winter) and location (mid- or deep-water) of disposal is such that relatively little feeding by resident fish will be occurring, so effects on rearing and adult success are not expected.

A potential impact of disposal operations identified, however, involves the wave action created by the dredge disposal barges moving down the reservoir to the disposal sites. As mentioned above, yellow perch begin spawning near the end of the dredging period. Perch typically spawn in shallow waters near the shoreline and are, thus, susceptible to having their eggs washed onto land as a result of the wave action generated by moving barges. Thus, barge traffic during March may have a negative influence on perch reproductive success.

7.2.4 Changes in Physical Habitat Characteristics

Changes in the amount of habitat at different depths in the reservoir are expected to have a number of impacts on the resident fish community. It is not completely clear, however, which of these impacts will be the direct result of changes in physical habitat, and which will be a consequence of the biological changes (e.g., benthos, macrophytes) that result from these physical changes.

Changes in physical habitat are not expected to affect the reproductive success of any of the species considered by the resident fish subgroup. Either spawning does not take place in the areas to be affected (as is the case for sturgeon and squawfish), or the newly created habitat will not provide additional spawning areas. Spawning habitat is not considered limiting for the non-native species, so losses of such habitat are not expected to be significant.

Increases in the amount of shallow water habitat are expected to increase the rearing success of cyprinids, centrarchids, and percids. Rearing success of sturgeon is unlikely to be affected, while the rearing requirements of catfish in this reservoir are unknown. Cyprinid rearing may also benefit from reduced structure (e.g., cover, topographic relief), while the converse is expected for centrarchids and percids.

Increases in shallow and mid-water habitat will tend to favor the older age classes of non-native species except catfish, which generally prefer deeper waters. Immature and adult sturgeon apparently benefit from a mixture of deep and shallow water habitat, so that changes in the relative amounts of these two habitats may be significant. Reductions in habitat structure through losses of topographic relief or cover are expected to adversely affect catfish, centrarchids, and percids. Finally, the creation of good adult centrarchid, percid, or catfish habitat in the vicinity of access points may adversely affect the survival of these species while providing a beneficial effect for sport fishermen.

Changes in physical habitat may also affect the predator-prey interaction between juvenile salmonids and resident fishes. Squawfish predation, as well as salmonid predation on resident fish, will tend to benefit from decreases in cover. Conversely, predation by bass and catfish is expected to benefit from increases in cover. Thus, changes in this habitat characteristic will tend to alter the relative importance of native and non-native predators on juvenile salmonids.

7.2.5 Benthos

Increases in the overall abundance of benthic invertebrates are expected to benefit both young-of-year and older age classes of all the resident fish species. Different species have different food preferences, however, so that changes in the composition of the benthic community would benefit some species more than others. For example, catfish and bass would respond more than the other species to increases in the abundance of crayfish.

Increases in benthos will also tend to reduce predation on and by juvenile salmonids. For the species that prey upon salmonids, benthic invertebrates provide a source of alternative prey. Similarly, juvenile salmonids prey upon invertebrates as well as fish, and, thus, stand to reduce their feeding pressures on cyprinids and other fish prey when invertebrates are abundant.

7.2.6 Macrophytes

Increases in the area of shallow water habitat occupied by macrophytes may enhance the spawning success of some cyprinids (redside shiner, carp). In addition, all age classes of cyprinids, centrarchids, and percids are expected to derive some benefits from increases in macrophytes. It is likely that the latter two species groups will be more strongly influenced than the cyprinids. Macrophytes may also supply a source of cover for both the predators and prey of salmonids, and a source of food for carp. Substantial increases in carp abundance may, in fact, lead to reductions in macrophytes.

7.2.7 Juvenile Salmonid Abundance and Distribution

Changes in the abundance and distribution of juvenile salmonids that might result from dredging and disposal operations are not expected to have significant impacts on the resident fish community. The salmonids are not present in the reservoir for a large enough proportion of the growing season to supply a major source of energy intake for their predators. Similarly, it is considered unlikely that salmonid consumption of resident fish in the reservoir is critical to salmonid growth and survival.

7.2.8 Other Issues

At the conclusion of our discussions, the subgroup considered the interactions among the resident fish species that might significantly influence the effects of habitat changes on individual species. These interactions are reflected in the conceptual model, presented in Chapter 8. To summarize, they include predation by bass and squawfish on other cyprinids, and the potential negative impacts on percids and centrarchids due to consumption of macrophytes by carp.

It is important to stress that while it is possible to identify in qualitative terms the differences among the resident fish species in their response to changes in habitat, there remains substantial uncertainty concerning the relative magnitude of these responses. Even if it is possible to describe precisely the changes in habitat expected to occur, predictions of the consequences of these changes for the resident fish community will be largely speculative. Therefore, it may be informative to consider how strong the resident fish species' responses have to be before changes in community structure (or salmonid predation) will be detectable over a reasonable time frame for monitoring. This could be examined using a simple community interaction model coupled to a set of predictions about the changes in habitat that might result from dredging and disposal.

7.3 Salmonids

7.3.1 Introduction

The salmonid subgroup discussed the potential direct and indirect effects of dredging and disposal operations on the adult and juvenile salmonids that spend a portion of their lives in the Lower Granite reservoir. Three groups of fish were considered:

1) spring and summer chinook;

2) fall chinook; and

3) steelhead.

Each of these groups consists of a number of separate stocks derived from both natural and hatchery reproduction. For the purposes of this discussion, these finer distinctions were not considered to be important. Since all hatchery steelhead are marked with some type of fin clip, it would be useful to keep track of the differences between hatchery and natural fish in survey work.

Two other species of anadromous salmonids are found in the Upper Snake River. A small number of sockeye migrate through the reservoir, but these are of little importance. Coho have historically spawned above the Lower Granite, but current runs are marginal and there are, at present, no plans to rebuild these stocks. Neither of these species was considered in the subgroup discussions.

Salmonids use the reservoir during two phases of their life history: as juveniles, they migrate downstream during the spring and summer, and as adults, they migrate upstream through the reservoir to their spawning sites. A proportion of spring/summer chinook, fall chinook, steelhead juveniles, and adult steelhead overwinter in the reservoir. The numbers and location of overwintering fish and their habitat requirements are currently poorly understood.

The potential effects of dredging and disposal on salmonids fall into three categories:

1) direct effects of the dredging and disposal activities including the effects of the turbidity plumes, noise, and entrainment into the dredging equipment;

2) effects of alterations in habitat caused by the placement of sediments at the disposal sites; and

3) effects mediated through interactions with other fish species in the reservoir, predominantly through predation.

7.3.2 Direct Effects of Dredging and Disposal

The subgroup discussions of the direct effects of dredging and disposal on salmonids were restricted to those which would occur in the winter dredging window from January 1 to March 1 with possible extensions back into December or further into March. This choice of dredging window removes many of the potential impacts since the majority of salmonids are not present during that period. There are four potential areas of impact:

1) entrainment of overwintering juveniles and early downstream migrants;

2) turbidity and chemical effects from dredging and disposal plumes on overwintering and early migrant juveniles;

3) disruption of the upstream migration of steelhead adults due to the noise and turbidity plumes from dredging and disposal operations; and

4) direct and indirect effects of dredging and disposal operations on the steelhead fishery.

Juvenile Entrainment

The subgroup did not consider juvenile entrainment to be a significant problem for downstream migrants since the major portion of the juvenile migration does not start until early April. The effects on overwintering juveniles cannot be predicted at this point since their location is not known. Juvenile entrainment, however, has not been detected in previous dredging operations in this area.

Interactions with Plumes

Turbidity plumes could have two effects on juvenile salmonids:

1) a reduction in survival due to either physical effects or the disruption of migration patterns; and

2) an alteration in the effects of predation by visual predators due to the reduction in visibility.

The group felt the increase in turbidity during the time of smolt migration (mid March and on) would not be significant as the reservoir is already very turbid with the spring freshet. In January and early February when the reservoir is relatively clear, the water is also cold and predation pressure on any overwintering juvenile salmonids is low. The group did not, therefore, consider the turbidity plumes would result in a significant impact.

At present, there is no reason to suspect there will be problems from chemical contaminants in the dredging or disposal plumes. Therefore, the group did not consider these potential impacts further.

Interactions with Adult Steelhead Migration

Adult steelhead that had overwintered in the reservoir could be present and migrating upstream during dredging operations in mid to late March. The potential for impact on this migration is unknown but the group felt it was unlikely to be significant.

Interactions with Steelhead Fishery

The choice of the January/February operations window removes the possibility of major interactions with the steelhead fishery, although there is some potential for interaction in late December. The group felt the major potential for impacts is through the aesthetic effects of turbidity plumes and barge traffic and the safety effects of the large washes created by the barges and tugs.

There does not appear to be any objective evidence for an effect of turbidity on catch per hour, although this is widely perceived to be an important relationship.

7.3.3 Effects of Habitat Alterations

Four different sets of habitat requirements might be expected to be associated with the different uses of the reservoir by salmonids: juvenile use in the spring and summer, and for overwintering, and adult use in the spring, summer, and fall, and for overwintering.

Juvenile Summer Habitat

Spring/summer chinook and steelhead juveniles are normally smolting as they move through the reservoir and tend to have relatively brief passage times on the order of 3 days to a week. During this time, they would normally be feeding on material derived from both benthic and terrestrial sources. Fall chinook juveniles are not normally as advanced and may spend several weeks feeding as they move down through the reservoir; they tend to prefer lower velocity sites.

Juvenile salmonids are only associated with the substrate in the shallow water areas (15 ft. and less). During the peak migration, they are found throughout the reservoir but only in the top 10 to 15 ft. of the water column.

Apart from depth, velocity, and food supply, the other determinant of habitat which may be important is the amount of cover in the form of macrophytes and the relief of the substrate. Generally, the subgroup felt that habitat with little cover was preferred by salmonid juveniles due to the decreased potential for predation.

The only alteration of habitat through sediment disposal, which the subgroup felt would have a significant impact on summer juveniles, was the creation of new shallow water habitat since this is the major habitat they utilize. The magnitude of the increases in juvenile survival through the reservoir, resulting from increasing the amount of this habitat, is unknown.

Juvenile Overwintering Habitat

Overwintering juvenile spring/summer chinook and steelhead have only recently been discovered in the Lower Granite reservoir. The total numbers of overwintering juveniles, their habitat requirements and their importance to particular fish stocks is unknown.

The subgroup proposed that overwintering juveniles might tend to prefer substrate with more relief and would tend to be found in deeper water. There is little evidence to support or refute this in the Lower Granite reservoir, however.

Adult Summer Habitat

Adult salmonids are generally moving through the reservoir fairly rapidly toward their spawning streams. Chinook salmon do not feed during their time in the reservoir, while steelhead will feed to a minimal extent.

The subgroup did not feel that changes in habitat caused by the in-water disposal of sediment would affect this upstream migration in either survival rates or timing.

Adult Overwintering Habitat

Some proportion of adult steelhead which pass the Lower Granite dam in September and October overwinter in the reservoir prior to spawning the following spring. The proportion of these fish which remain in the reservoir and their habitat requirements are unknown.

Summary

In summary, the main interaction between habitat alterations caused by sediment disposal and salmonids would seem to be in the creation or destruction of shallow water habitat. Alterations to the deep and mid-water habitat seem to be of relatively small importance. It should be stressed, however, that the overwintering requirements of both adults and juveniles is not well understood.

7.3.4 Effects of Alterations in Predation

The subgroup felt the major effect of the dredging and disposal operations was liable to be mediated through changes in predation pressure from resident fish. At present, the magnitude of salmonid mortality due to predation in the Lower Granite reservoir is uncertain. Estimates proposed by the subgroup ranged from 5 to 15%.

APPENDIX 1 - ISSUES RAISED AT WORKSHOP

During the bounding activity the participants were asked to identify what they felt were the key biophysical issues related to the potential impacts of in-water disposal. These are repeated here without any editing or evaluation. Although they are recorded here, this should not be interpreted as agreement on the part of the workshop participants that these issues will remain intact and ultimately be dealt with in the monitoring program. They rather serve as one aspect of the bounding activity designed to initiate development of the conceptual model and hypotheses. Ultimately many of these issues will be dropped from further consideration or will be recorded as requiring future attention as part of another initiative.

- Physical changes to the habitat, including: grain size, organic content, depth, slope, velocity, configurationa, and bathymetry. These will drive changes in fish populations.

- Direct impacts of dredging on fish; for example, entrainment.

- Maintenance of the riparian and littoral zone.

- Effect of changes in habitat on anadromous and resident fish production, including predator production.

- Other actions which could enhance habitat; for example, introduction of large grain material such as gravel, boulders, or logs. This would provide additional cover for fish.

- Cumulative impacts of long term, in-water disposal.

- What is the present functional value of deep and mid-water habitats?

- Manipulation of habitat to enhance "native" species and limit introduced species of fish; for example, bass, crappies, bullheads, and catfish.

- Sediment quality: chemicals in the dredge sediments from the nearby pulp mill. What are the concentrations and significance, if any, for pollution of the lower reservoir?

- Water quality changes (e.g., temperature, dissolved oxygen, suspended solids)

- Effects of habitat change on predator-prey interactions, especially with regard to predation on salmonids.

- Importance of shallow water habitat to salmonids.

- Potential to enhance the sport fishery in the reservoir.

- Importance of the turbidity plume to overwintering steelhead and the sport fishery.

- Change in the hydraulic regime of the reservoir and the effect, if any, on the residence period of migrating salmonids.

- Can dredging be both environmentally sound and economically effective?

- Cost of the dredging program, and how it is affected by constraints placed on the contractor.

- Effects of the dredging and in-water disposal program on the quality fishing in terms of effort and success.

- What is the linkage between habitat and productivity of the various fish populations? Will the change in habitat be reflected in changes in the fish populations? If so, then by how much?

- Effects on fish using deep water habitat; e.g., sturgeon.

- What is the relative value of shallow, mid-depth, and deep habitats? Should we be creating shallow habitat from mid-water habitat or mid-water habitat from deep water habitat or moving existing shallow water into riparian?

- Stability of the new habitat. How will it change over time especially due to "large" events (e.g., storm surges)?

- What effects will there be on fish from the turbidity plume?

- The pattern of dredging: it is expected that there will be extreme flood events which will lead to periodic, large introductions of sediment. This could necessitate more dredging effort in some years. Concern is for the feasibility of completing the necessary dredging within the allotted time window.

- What is the combined impact on benthos production within the reservoir from reductions in populations at both the dredging and disposal sites? What is the significance of this for changes in fish populations?

- The dredging window: which end of the window is the most sensitive time with respect to potential effects on fish populations or the fishery? If it became necessary to extend it, which end would have the least impact on the fish populations and the recreational fishery?

- What is the potential for an increase in either the magnitude (strength, duration) or frequency of summer algal blooms arising from a change to the mean depth of the reservoir?

- Will there be an increase in the production of macrophytes within the reservoir?

- Other actions besides dredging; e.g., channel restrictions to increase velocity and reduce sedimentation in the present problem area.

- What effect will there be on the survival of fish, either migrating salmonids or resident species? Will the project increase or decrease their survival or fitness?

- What effect will there be on the upstream migration of salmonids?

- What is the production value of the created habitat in relation to naturally created habitat areas?

- Can we even measure changes in fish populations or their habitat usage?

- Value of habitat for specific fish life functions (e.g., forage, cover, overwintering, migration, reproduction) versus conditions affecting the populations indirectly (e.g., predation, competition).

- How do we connect the possible short term effects to the more longer term considerations.

- What constitutes overwintering habitat.

- What are the potential changes caused by disposal on the littoral and riparian areas? How might these affect wildlife (e.g., ducks, geese)?