Addendum 1

Daybreak Ponds Avulsion Mitigation

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Geomorphic Analysis of the
East Fork Lewis River in the Vicinity
of the Daybreak Mine
Expansion and Habitat Enhancement Project

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Prepared for:

J. L. Storedahl & Sons, Inc.
2233 Talley Way
Kelso, WA 98626

WEST CONSULTANTS, INC.

Prepared by:

WEST Consultants, Inc.
12509 Bel-Red Road, Suite 100
Bellevue, WA 98005

Table of Contents

1 Introduction

Avulsions may be triggered by unpredictable random events. Although the possibility of a future avulsion along the East Fork Lewis River can be qualitatively described, the potentially random nature of such events prevents quantitative assessment of the probability (risk) that a future avulsion will occur at any specific location. Consequently, mitigation for an avulsion in areas with a reasonable possibility of occurrence is prudent. A detailed geomorphic investigation of the East Fork Lewis River has identified that an avulsion into the existing Daybreak Ponds has a significant potential for occurrence within several decades (WEST, 2001). Accordingly, an avulsion mitigation plan has been developed.

In the following sections a proposed avulsion mitigation plan for the existing Daybreak Ponds is presented. In Section 2 the objectives and scope of the avulsion mitigation plan are described. Section 3 describes the alternative measures that could be incorporated into an avulsion mitigation plan. Section 4 describes the details of the proposed mitigation plan. Potential impacts of the proposed avulsion mitigation plan are described and evaluated in Section 5. A summary of the proposed avulsion mitigation plan is presented in Section 6.

2 Objectives and Scope

In the following sections the objectives and scope of the Daybreak Ponds Avulsion Mitigation Plan are described.

2.1 Objectives

An avulsion into a floodplain gravel pit can result in both short-term and long-term environmental impacts. These impacts can affect the hydrology, hydraulics, sediment transport, and morphology of the river. A detailed description of avulsion related impacts relevant to the East Fork Lewis River was presented by WEST (2001). A summary of specific types of impacts associated with an avulsion is shown in Table 2-1. An effective avulsion mitigation plan must include measures to avoid, reduce, and minimize these potential impacts.

2.1.1 Prevention of Avulsion

The primary objective of an avulsion mitigation plan is prevention. Prevention of an avulsion would avoid all associated environmental impacts. Since the specific location and characteristics of an avulsion cannot be quantitatively ascertained, the effectiveness of measures to prevent an avulsion cannot be guaranteed. However, implementation of an avulsion mitigation plan is undoubtedly more effective and beneficial than a "Do Nothing" approach to managing a defined avulsion threat. Mitigation measures to prevent an avulsion can be implemented at the most likely avulsion locations identified from qualitative geomorphic evaluations.

2.1.2 Resistance to Avulsion

Assuming that unforeseen circumstances will occur that promote an avulsion, the second objective of an avulsion mitigation plan is to resist the formation of a flow path along which an avulsion may progress into a floodplain gravel pit. Resistance to an avulsion can be achieved by placing physical and hydraulic controls along the potential avulsion path. By controlling the energy gradient between the gravel pit and the river, the energy and quantity of flow along the potential avulsion path can be regulated and channel formation processes required for an avulsion can be prevented.

2.1.3 Control of Avulsion

A third objective for the mitigation plan is to control the magnitude and extent of the avulsion. By defining a preferential flow path for a potential avulsion, the magnitude, extent, and duration of environmental impacts can be minimized. Further, the time necessary for the fluvial system to recover from the disturbance associated with an avulsion will be minimized. Appropriate planning for an avulsion into a floodplain gravel pit can also restore valuable floodplain functions and aquatic habitat that were lost due to previous land uses both prior to the avulsion and after it occurs.

Table 2-1. Summary of the possible effects of a river avulsing into a gravel pit (from WEST, 2001).

<table>
<tr><th rowspan="2">Element of Avulsion</th><th colspan="3">Nature of Impact</th></tr>
<tr><th>Upstream</th><th>Local</th><th>Downstream</th></tr>
<tr><td>Geomorphic Characteristics</td><td>• Incision of channel
• Increased gradient
• Coarsening of bed
• Undercutting and erosion of banks
• +/- lateral migration rates</td><td>• Alluvial fan development
• Reshaping of pits
• Abandonment of former channel
• Loss of natural channel geometry</td><td>• Increased lateral migration
• Increased channel width</td></tr>
<tr><td>Sediment Transport</td><td>• Increased sediment transport capacity
• Reduction in bed load deposition</td><td>• Deposition of sediment in pits
• Short-term increase in turbidity
• Erosion of gravel pit banks</td><td>• Reduced sediment supply
• Erosion of bed
• Coarsening of bed
• Increased bank erosion
• Short-term increase in turbidity</td></tr>
<tr><td>Hydraulics</td><td>• Increased slope
• Increased velocities
• Decreased normal depth
• Increased bed roughness</td><td>• Decreased slope
• Increased channel depth
• Increased channel width
• Reduced bed roughness</td><td>• Increased bed roughness</td></tr>
<tr><td>Hydrology</td><td></td><td>• Increased flood storage
• Increased evaporation</td><td>• Reduction of flood levels
• Attenuation of flood peaks
• Changes of summer low-flows</td></tr>
</table>

2.2 Scope

At a minimum, the scope of avulsion mitigation must consider all areas contained within the Channel Migration Zone (CMZ). The CMZ in the vicinity of the Daybreak Processing Site and Daybreak Ponds has been defined to follow along the access road to the Daybreak Processing Site (WEST, 2001). At a maximum, requirements for avulsion mitigation must consider the floodplain area affected by historic channel migration. An analysis of historic plan form characteristics along the East Fork Lewis River (WEST, 2001) showed that the East Fork Lewis River channel was in the location of the existing Daybreak Ponds in the mid-1800s. Accordingly, the scope of the proposed avulsion mitigation plan encompasses the existing Daybreak Pond system.

3 Alternative Avulsion Mitigation Measures

Potential measures to prevent, resist, and control avulsion impacts include: monitoring, biotechnical techniques, hydraulic techniques, structural techniques, and channel restoration. General descriptions of potential engineered solutions are summarized below. Many of these techniques are suggested by WDFW and DNR (WDFW, 1998 and DNR, 1998).

3.1 Monitoring

Monitoring of bank stability at locations identified to have a significant avulsion potential can be used to define when engineered solutions to prevent an avulsion should be implemented. Monitoring criteria can be based on observed bank erosion or changes in flow distribution between the main and secondary channels in the vicinity of likely avulsion points. Monitoring can also be used to evaluate the effectiveness of implemented avulsion mitigation measures and to provide information for adaptive management responses to changed conditions.

3.2 Biotechnical Techniques

Biotechnical techniques use vegetation, wood, and riparian buffers that mimic or reproduce the natural system to provide physical structure that influence flow magnitude, direction, velocity, and sediment transport conditions. Biotechnical measures are routinely used to provide surface erosion protection. Vegetation and wood debris offer hydraulic resistance that reduces flow velocities and dissipates energy, promotes sediment deposition in overbank areas, and concentrates flow in the main channel. Applicable biotechnical techniques would include:

- ***Live Stakes*** Live staking involves the installation of live, rootable woody vegetative cuttings into the ground.

- ***Live Trees*** Lives trees planted along the bankline and in the floodplain provide long-term vegetative structure to cover and stabilize the floodplain and streambanks.

- ***Large Woody Debris*** Large woody debris (particularly if placed in rows) helps dissipate energy and distribute overland flow across the floodplain. They also promote deposition of sediment in the overbank areas and concentrate flow in the main channel.

- ***Debris Jam*** A debris jam is a collection of large woody debris that can train the distribution and direction of flow, create hydraulic roughness, dissipate energy, and reduce flow velocity.

- ***Riparian Buffer*** The channel migration zone (CMZ) in the vicinity of a floodplain gravel pit should be left undisturbed or planted as a riparian buffer. Vegetation along potential avulsion paths should be planted as soon as possible to allow sufficient time for growth. Establishment of mature riparian forests in areas surrounding potential avulsion sites should help slow channel migration into these areas.

3.3 Hydraulic Techniques

Hydraulic techniques can be used to influence flow direction, control energy gradients, and reduce shear stress along channels banks. Hydraulic controls can be used to redistribute flow in the channel, limit flow velocities, and control erosion and sedimentation patterns. Potential hydraulic techniques include:

- ***Fill*** Placement of fill along potential avulsion flow paths can be used to block flow conveyance area, redistribute flow, reduce hydraulic energy gradient, flow depth, and shear stresses on erodible sediments. Further, the elevation difference between the main channel and the floodplain gravel pit can be reduced by the addition of fill. Accordingly, the magnitude and potential significance of impacts associated with a headcut along the upstream channel or reduced sediment supplies to the downstream channel caused by trapping of sediment within the pit are avoided or reduced. Placement of fill in a manner that creates a defined flow path for overbank flood flows eliminates uncertainty about potential avulsion paths and impacts. Furthermore the creation of a defined flow path prior to an avulsion allows the establishment of a riparian forest buffer area that would help minimize impacts and recovery time.

- ***Groins*** The primary function of groins are to provide roughness, dissipate energy, and reduce velocities near the bank. Groins may be oriented upstream, perpendicular, or downstream to the flow. The top elevation is typically about bankfull.

- ***Barbs*** Barbs are small weirs near the toe of a bank angled upstream to turn the flow away from the bank. Barbs create roughness, which dissipate energy and reduce velocity near the bank. They are typically overtopped by moderate stream flows.

- ***Drop Structure*** A drop structure is a solid cross channel weir that redirects flow away from the bank to the center of the channel. Drop structures concentrate energy dissipation and reduce erosion along the bank.

- ***Porous Weir*** A porous weir is a low profile structure consisting of loosely consolidated boulders that span the entire width of the channel. The structure concentrates energy dissipation and reduces erosion along the bank.

3.4 Structural Techniques

Since flood events far in excess of the standard regulatory criteria may occur along the East Fork Lewis River, structural measures to prevent or control the development of potential avulsion flow paths could be instituted. A limitation for applying standard structural techniques for avulsion mitigation is the lost opportunity for the river to access and create diverse riparian and aquatic habitat within the protected areas. Furthermore, long-term maintenance responsibilities may be required for proper function of structural mitigation techniques.

Structural techniques that can be used would include:

- ***Overtopping Erosion Protection*** Non-erodible surfaces can be used to protect remnant ground between floodplain gravel pits and the main river channel from erosion caused by overtopping flows.

- ***Designated spillways*** Designated spillways composed of non-erodible materials can be located along levees separating the river from the gravel pit. Spillways can be used to control hydraulic energy gradients, flow velocities, and erosion potential for flow both entering or exiting a floodplain gravel pit.

- **Fuse Plug Embankment Section** This is a modification to a designated spillway. A designated section of the levee separating the gravel pit from the river can be replaced with easily erodible material. If flow elevations exceed the crest of the levee, the fuse plug embankment section is eroded, allowing a controlled overflow into or out of the pit.

- ***Avulsion Sill*** A sill composed of large rock or other non-erodible material could be placed at key locations to effectively prevent downcutting and shifting of the thalweg of the river or avulsion path.

- ***Rock Toe or Rock Revetment*** Rock revetment can be used to provide bank erosion protection

4 Recommended Daybreak Ponds Avulsion Mitigation Plan

An avulsion mitigation plan to minimize the potential for avulsion into the existing Daybreak Ponds and avoid/minimize associated environmental impacts was developed. The elements of the avulsion mitigation plan were selected in consideration of their associated environmental benefits and impacts. In the following sections, the major components of the mitigation plan are described.

4.1 Fill Existing Ponds

The primary feature of the avulsion mitigation plan is the substantial filling of the existing Daybreak Ponds Nos. 1, 2, 3, and 4. The fill will consist of approximately 571,000 cubic yards of materials imported from off-site sources. A plan view of the proposed fill in the Daybreak Ponds is shown in Figure 4-1.

Approximately 300,000 cubic yards of the fill to be placed in the ponds will be soils that are imported from regional excavation projects. The soils will include a range of silt, clay, sand, gravel, and cobble sized materials. The material will be used to fill the edges of the ponds as shown in Figure 4-1. The slope of the final in-pond fill of imported soils will vary from 3:1 to 5:1.

The remainder of the fill will consist of approximately 271,000 cubic yards of fine-grained sediments derived from processing gravels imported from the Tebo Gravel Mine. These sediments consist primarily of clay, silt and fine sand sized materials. They will be placed in the middle portion of the ponds to a depth that is approximately equal to the thalweg elevation of the main East Fork Lewis River channel. That elevation will be at or slightly below the high water level for the ponds (groundwater level).

The fill placement and revegetation plan has been designed to be consistent with the extent and characteristics of the channel migration zone indicated by historic mapping and aerial photography for the area. It does not reduce the opportunity for the river to create diverse aquatic and riparian habitats that may be restricted by structural methods of bank hardening and revetment. The fill placement and revegetation plan mimics the path and characteristics of the pre-development East Fork Lewis River channel identified from cadastral surveys made in 1853 and 1858. The topography to be created in the ponds will be similar to historic channel characteristics and will provide a preferential flow path for the river should an avulsion occur. The fill in the existing ponds will restore floodplain function more similar to predevelopment conditions.

The fill will reduce the potential for adverse environmental impacts that may be associated with an avulsion into a floodplain gravel pit. The reduced elevation gradient between the bottom of the filled ponds and the river thalweg will reduce the potential for the formation of a headcut and the magnitude of its effects on the upstream river channel. The reduced cross sectional area and volume of the ponds will limit the sediment trapping capability of the ponds and potential impacts to downstream channel reaches. Further, the decreased volume of the ponds will reduce the time for geomorphic recovery of the channel system.

Figure 4-1. Planview of Daybreak Ponds Showing Cross Section Locations

Placement of fill in the Daybreak Ponds will involve placement of fill under water, over sediments previously accumulated in the ponds. Sediment grain size and consistency is variable, grading from a fine silty sand near the point of the process water discharge into the pond, to silty clay and clay within the ponds.

Existing sediments in the ponds likely range from normally consolidated to lightly under consolidated depending on the deposition rates and gradation of the soil. For the purposes of this discussion, normally consolidated soils are those that have expelled any excess pore water between the individual soil particles, resulting from applied external load or subsequent sediment deposition. Under consolidated soils are those that are continuing to compress and expel pore water from the void spaces between individual soil particles.

Shallow normally consolidated soils in an alluvial environment are typically weak and sensitive to rapid changes in load, such as fill placement. If loaded slowly, sediments can be consolidated and strengthened. If loaded quickly, in excess of the material strength, normally consolidated soils will shear and displace.

Fill around the perimeter of the ponds will consist of a top down fill placement process intended to displace existing fine grained sediment towards the center of the pond. Fill will be deposited along the edge of the ponds and graded toward the pond center using a dozer or similar equipment. Lifts of fill will be placed with the intent of displacing existing weaker sediment on the pond slopes toward the pond center, where it will be confined and compressed.

Soil compaction cannot be completed under water using conventional means, as soil compaction consists of squeezing air out of the soil matrix. Once soil is saturated, as is the case for underwater placement, water will fill the void spaces in the soil matrix. Since water is effectively incompressible, any attempt to rapidly compress the soil will result in the water being pressurized, but the volume of soil matrix and water will remain the same, making "compaction," or compression of the void spaces impossible with out expelling the water.

Fill placed underwater can be consolidated however by placement of a surcharge load of excess fill over the top of the planned fill. In this case a surcharge of approximately 10 to 20-feet of soil will be utilized to consolidate the underwater fill. The surcharge will be left in place for several months or a year depending on the soil characteristics, to allow time for the excess pore water to be squeezed out, consolidating the fill.

Stable inclination of the fill slopes will be variable with the variation in material to be placed. Stable slopes will however be established by the material placement in the ponds. Because the fill placement conditions are essentially a worst case for slope stability, slopes that are stable in the short term during soil placement should become stronger in the long term as the fill soil consolidates, and forested wetland as well as emergent wetland plantings mature along the fill-open water interface. In addition, removal of the surcharge will also reduce driving forces on the fill slopes, further increasing slope stability.

Land surrounding the ponds will be disturbed during placement of fill. Minor amounts of sediment may erode from the disturbed areas. The eroded sediments will drain to the ponds. The ponds are connected to each other by a series of gated culverts. Ponds receiving eroded sediments can be isolated; preventing any migration of suspended sediments and will not flow off-site.

4.2 Riparian Buffer

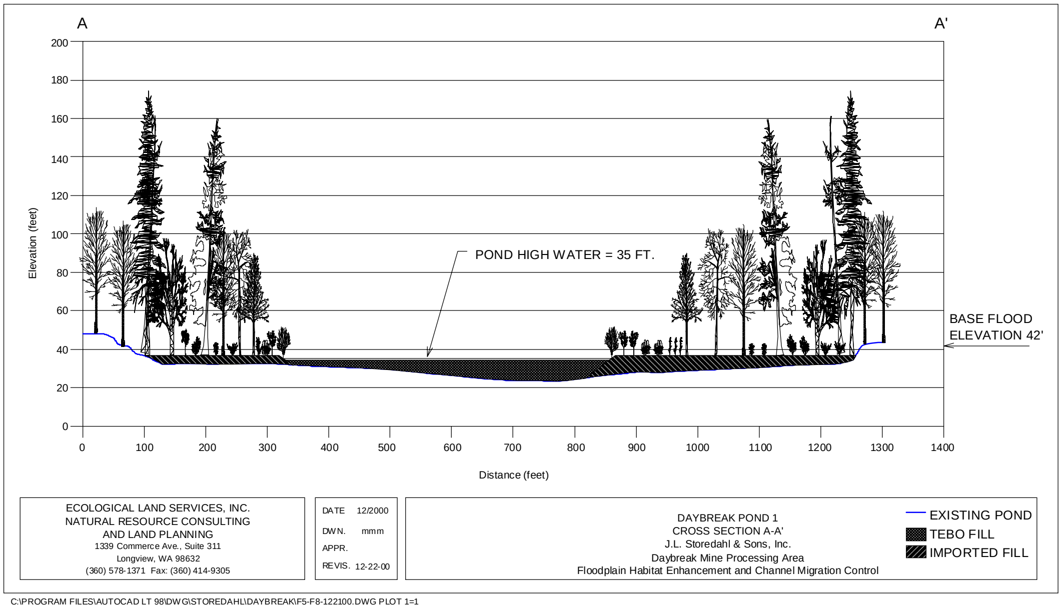
At present there is a limited amount of valley-bottom forest at the Daybreak site and in the surrounding area, as most has been removed due to agricultural and residential land-use and timber harvest. Agricultural fields used for pasture and hay production surrounds most of the site, with only remnant patches of cottonwood-alder and mixed forest remaining. Much of the existing cottonwood-alder forest near the East Fork Lewis River has been disturbed by human activity and subsequently invaded by exotic species, such as Himalayan blackberry and reed canary grass. Other portions of the East Fork Lewis River above and below the Daybreak site also have substantially reduced amounts of valley-bottom forest, resulting in a very fragmented and diminished distribution of this important ecosystem component.

The placement of fill along the borders of the pond will substantially increase the riparian buffer between the active East Fork Lewis River channel and the open water areas of the Daybreak Ponds. The increased riparian buffer is located adjacent to the Storedahl Access Road, which is the boundary of the CMZ as previously defined for the East Fork Lewis River (WEST, 2001). Enlargement of the riparian buffer will allow restoration of riparian forest.

4.3 Vegetation Plantings

Topsoil will be placed over any fill materials extending above the pond high water level to provide a viable medium for vegetation plantings. The plantings are intended to create an early-successional mixed conifer and hardwood valley bottom and riparian forest typical of the East Fork Lewis River valley. The plantings will allow the establishment of a floodplain forest in areas most susceptible to avulsion. The placement of fill in the ponds will increase the riparian buffer distance between the existing river channel location and the ponds and reduce the elevation difference between the bottom of the ponds and the thalweg of the East Fork Lewis River.

Vegetation will be planted within the riparian buffer to allow development of a mature riparian forest that will slow channel migration and resist possible avulsion. Revegetation of the fill as a floodplain forest will provide long-term resistance to erosion and channel formation processes associated with an avulsion. As the trees and understory vegetation becomes established and matures, they will provide dense root mats that bind the soil and resist erosion. In the long-term, the riparian forest will naturally supply large woody debris to the floodplain/channel system. Woody vegetation and debris will increase hydraulic roughness, slow overbank flow velocity, help to dissipate the energy of flood flows across the floodplain and through the ponds, and reduce potential for erosion of the sediments in the pond. Conceptual section views of the proposed fill plan are shown in Figure 4-2.



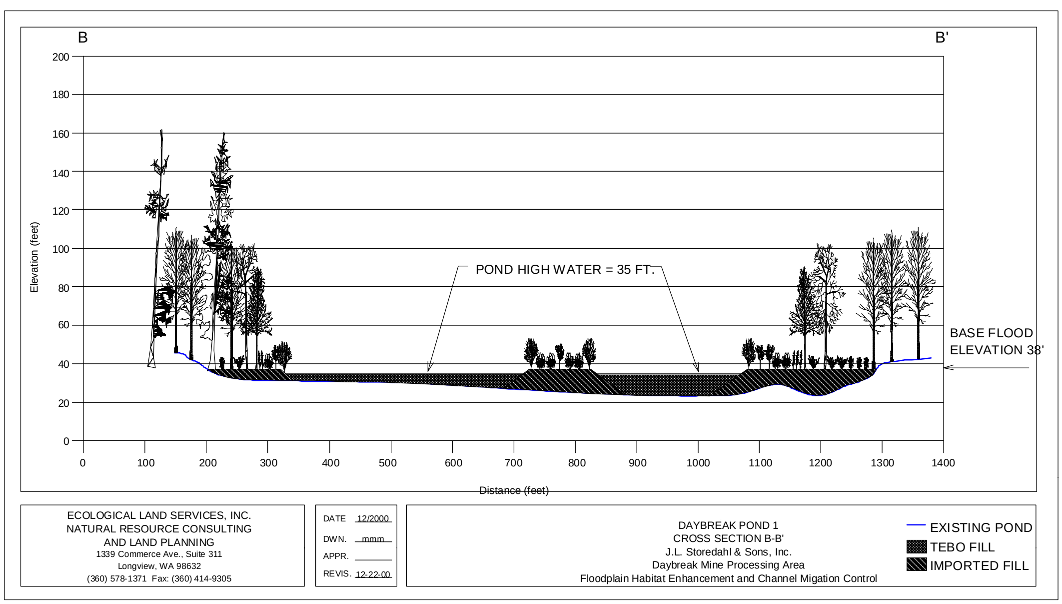
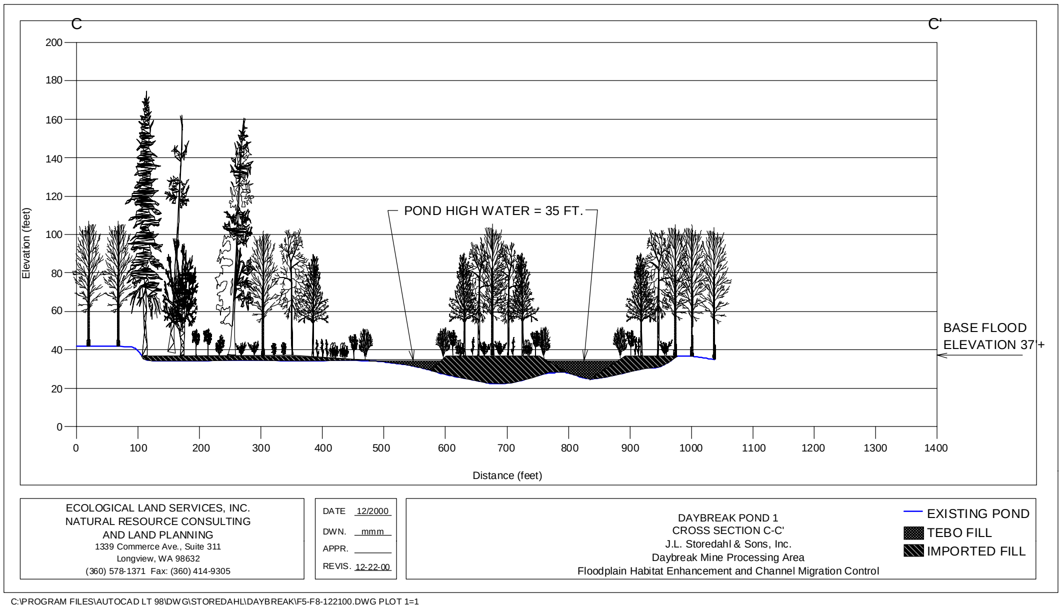


Figure 4-2. Conceptual section view of proposed fill plan for Daybreak Ponds.



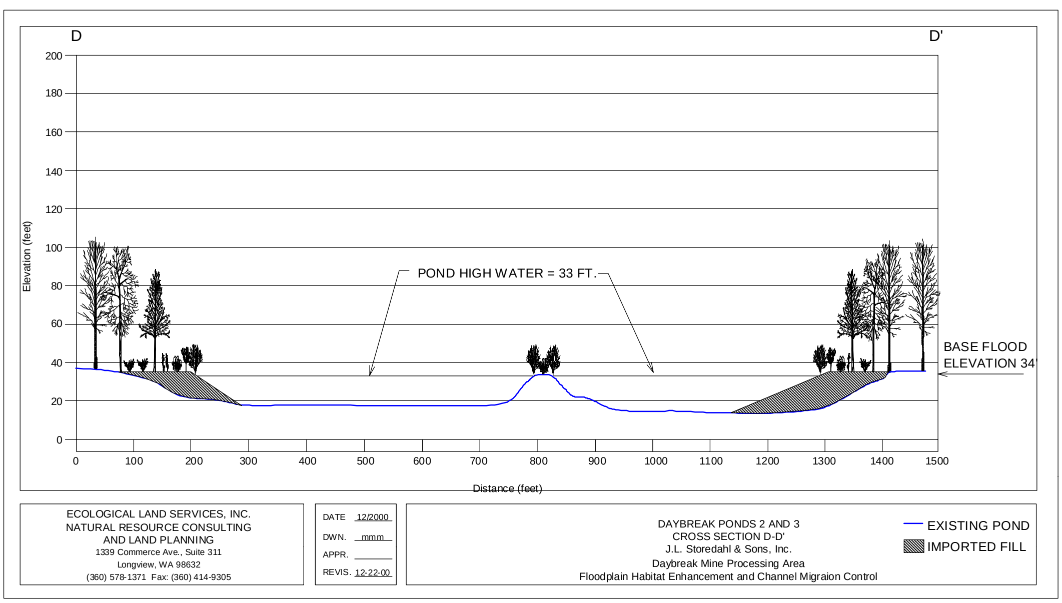


Figure 4-2 (continued). Conceptual section view of proposed fill plan for Daybreak Ponds.

An inherent difficulty in restoring any vegetation type is the desire to achieve late-successional, "climax" communities in a much shorter time frame than natural successional processes would require. Life history, physiological, and morphological characteristics of late seral species are often not suited to establishment, rapid growth, and perhaps even survival in open early seral conditions. For example, conifers such as western hemlock (*Tsuga heterophylla*) and western red cedar (*Thuja plicata*) are usually slower growing than hardwood trees such as black cottonwood (*Populus trichocarpa*) and red alder (*Alnus rubra*). Conversely, weedy, herbaceous species are highly adapted to invading open areas and often outcompete late successional species that are planted or seeded. In addition, previous restoration efforts on the Daybreak Site have found that small mammals, such as voles and rabbits, which use the herbaceous vegetation for cover, browse on woody plants causing high mortality.

With these considerations in mind, a restoration design emphasizing rapid development of a forest canopy is likely to be most successful. Douglas-fir (*Pseudotsuga menziesii*) and red alder will be used in establishing an initial tree canopy on most of the upland areas around the existing ponds. These species grow relatively rapidly and can tolerate some late summer drought, which is expected on the well-drained soils of the site. Along the pond bank slopes and the most outward portions of the proposed fill, western red cedar, Oregon ash (*Fraxinus latifolia*), and black cottonwood will be emphasized. These species are characteristic of wetter areas and can be expected to survive and grow only where sufficient moisture is available through the growing season.

In upland and swale areas, a shrub understory subsequently will be incorporated into the planting scheme to initiate understory development. Timing of understory plantings will be delayed in upland and swale sites until the initial stand of saplings is well established and canopy closure has occurred. Until canopy closure occurs, herbaceous competition and herbivory by small mammals are likely to greatly reduce the establishment of planted shrubs. The shrub understory will consist of species with a range of moisture requirements. In lower spots where the water table is near the surface, salmonberry (*Rubus spectabilis*) and vine maple (*Acer circinatum*) will be planted. In higher elevation areas hazelnut (*Croylus cornuta*), snowberry (*Symphoricarpos albus*) and Nootka rose (*Rosa nutkana*) will be planted. Shrubs will be planted in dispersed patches that will provide heterogeneity and a closer matching of species and moisture conditions.

Along pond margins, a straw mulch will be applied at a rate of 2 tons/acre to exposed soil surfaces immediately following bank contour reclamation. Establishment of a grass ground cover by seeding would be an alternative erosion control, but the grasses would likely result in severe competition to the shrub and tree plantings planned for the pond margins. Grasses also provide cover for herbivores, such as voles and rabbits.

Dense shoreline shrub communities will be established on the margins of the banks of the ponds. The planting scheme uses species characteristic of wetter areas near the shoreline (Hooker's or Sitka willow [*Salix hookeriana = S. piperi, S. sitchensis*], species of intermediate tolerance in transition zones (red-osier dogwood [*Cornus sericea*], spiraea [S*piraea douglasii*]), and species characteristic of somewhat drier conditions at slightly higher elevations but still within the riparian zone (Pacific ninebark [*Physocarpus capitatus*]). In order to utilize locally adapted plant stocks, cuttings and rooted plants from the site will be used for plantings to the extent possible. *Willow (S. hookeriana = S. piperi*) and Pacific ninebark occur along existing pond shorelines at the Daybreak Site, indicating their suitability to local conditions and providing a potential source of cuttings for restoration plantings.

The plantings will be grouped to create patches oriented parallel to the shoreline and dominated by a single species, with patches interspersed among one another. This kind of pattern is more representative of natural communities than a mixing of species on a finer scale. All of these species have been observed at the site, indicating that they are likely to be well suited to site conditions. Tree densities along pond margins will be lower, as a dense shrub community is intended to be the dominant vegetation in those areas. If necessary, Himalayan blackberry (*Rubus discolor*) and other invasive non-native weeds will be controlled. As the shrubs mature and the canopy closes in, these herbaceous weeds will tend to be shaded out.

In addition to plantings, there may be some natural recruitment of tree and shrub species from nearby seed sources. Black cottonwood and willow are the woody species most likely to become established from natural seed fall, as they have light, wind-borne seeds that can travel relatively long distances. Areas having bare mineral soil with a water table at or near the surface during spring and early summer (e.g., pond margins) are where these species are most likely to colonize. Red alder is also likely to colonize from abundant seed sources immediately to the south of the site. Such natural colonization will be monitored and steps taken to encourage the survival and spread of these plants. Once established, naturally colonizing plants are likely to grow more vigorously and have a higher chance of survival than planted stock.

The existing Daybreak ponds consist of approximately 58 acres of open water habitat and small amounts of emergent wetland habitat along shorelines. It is expected that the fine-grained sediments that will be placed in the open-water areas of the ponds will have a final surface elevation that is close to the typical high water elevation in the ponds. Water levels in the ponds are being monitored to provide a more accurate measure of the annual fluctuation. The annual fluctuation is currently estimated to be 1 to 2 feet. Natural recruitment of aquatic vegetation is expected to occur over this surface, as has been observed in shallow areas along the margins of the existing ponds.

The fill and vegetation is expected to create complex wetland habitat, consistent with the historic predevelopment channel conditions in the lower reaches of the East Fork Lewis River. Channel migrations and natural avulsions result in the creation of new channels and the abandonment of old channels. The old channels often become ox-bow ponds that remain connected to the current main channel and have extensive wetlands along their margins. Analysis of historic channel planform information indicates that, prior to alterations following Euro-American settlement, there was considerable channel complexity in the reach of the East Fork Lewis River adjacent to the Daybreak site (Collins 1997). The river was braided and associated with a substantial amount of wetland habitat, in contrast to the present condition, which is described by a single channel and valley bottom that is dominated by pasture of primarily upland plant communities. Immediately downstream of the Daybreak site, the river becomes wider and more meandering as the gradient of the river decreases; numerous natural oxbow ponds also remain along this section of the river.

The creation of wetland habitat in the existing ponds will be a substantial contribution to the restoration of this important habitat type in the East Fork Lewis River valley. The created wetlands will be more resistant to avulsion compared to the existing ponds. In the long term, as the sediments on which they are based settle and consolidate, it is expected that the created wetlands will be similar to other existing overflow paths for extreme flood events in the East Fork Lewis River floodplain. It is noted that during the approximate 500-year flood that occurred in 1996, no evidence of channel formation or avulsion was observed along the overflow path that drains to the existing Daybreak Ponds.

4.4 Pond 5 Outlet Modifications

Currently, Daybreak Pond 5 has three discharge outfalls. The outfalls, denoted as Locations A, B, and C on Figure 4-1, allow water to exit the pond under low flow conditions along the East Fork Lewis River and Dean Creek. The amount and primary location of discharge are dependent primarily on beaver activity and pond elevations. Outlet C is connected directly to Dean Creek. Outlets A and B flow into a defined channel and shallow wetland, respectively, eventually draining to a recently excavated ditch on the adjacent property and bypassing most of Dean Creek. The outfalls allow water to enter the pond during high flow conditions along both the East Fork Lewis River and Dean Creek. Backwater from the East Fork Lewis River enters Pond 5 for flood events with return period of about 5 years.

It is proposed that all surface outflows from Pond 5 will be restricted to a single location at the northeast corner of the Pond (Location C in Figure 4-1). The western berm of Pond 5 will be reconstructed to block outlets A and B, and surface water will be discharged during fall, winter, and spring months (October through April) only from the northernmost outlet (Outlet C) into Dean Creek. The restriction of possible outlets from Pond 5 will allow better management of water discharges to the East Fork Lewis River and Dean Creek.

A non-erodible sill will be installed at Location C to control the outlet conditions. The sill will create a barrier to salmonid species for frequently occurring flow conditions. If salmonids enter the ponds during high flow conditions, the uncontrolled sill will allow out migration to occur. The non-erodible sill will have provisions for temporary flashboards or removable gate that could be used to provide temporary control of discharges from Pond 5. This feature would provide capabilities for spill containment and control and water quality management. During placement of fill material in the ponds it may be necessary to briefly control pond outflows to manage turbidity impacts to receiving waters.

The existing outlets at Locations A and B will be filled with erodible sandy soil as a fuse plug spillway. In the event that flood waters enter the Daybreak Ponds at an upstream point, the fuse plug spillways at the existing Location A and B outfalls will allow floodwaters to exit Pond 5 without restriction. The crest of the fuse plugs will be set so that floodwaters first overtop those sections of the western embankment surrounding Pond 5.

4.5 Monitoring

All revegetated areas will be monitored to evaluate the success of plant establishment and seeding and planting. Monitoring will evaluate plant cover, canopy closure, vigor, species composition, and levels of herbivory. Soil moisture and nutrient status and pond water level fluctuations will also be monitored to aid in identifying any physical factors that might be retarding successful establishment and growth of desired plants. Monitoring of vegetation characteristics and soil nutrients will take place annually during the growing season for three years following revegetation.   Soil moisture will be monitored monthly during the growing season (April to September) for three years following revegetation.

After final grading, placement of fill in the Daybreak Ponds does not require long-term monitoring. The fill in the ponds will require no maintenance. This avulsion control measure is best suited for long-term sustainability since no long-term management actions are required to ensure its success. Final grading and revegetation of the pond system will establish a floodplain environment that mimics historic conditions, does not preclude development of complex habitat due to channel migration or avulsion, but reduces and minimizes the existing potential for avulsion.

5 Impact Assessment

An assessment of the potential hydrologic, hydraulic and sediment transport impacts associated with the proposed avulsion mitigation plan for the Daybreak Ponds was conducted.

5.1 Surface Water Elevations

An analysis was conducted to evaluate the potential impacts of the proposed plan to fill the existing Daybreak Ponds on flood elevations along the East Fork Lewis River. The Daybreak Ponds are located in the 100-year floodplain of the East Fork Lewis River, but outside of the FEMA designated regulatory floodway (FEMA, 2000). Therefore, fill within the Ponds will not result in a cumulative water surface elevation increase along the East Fork Lewis River greater than one foot.

The ponds are subject to overflows from the main channel during the 100-year flood event. A hydraulic analysis was performed to define the specific impacts to flooding that would be caused as a result of backfilling a portion of the Daybreak Ponds. Two hydraulic models were developed, one for existing conditions and the other for the proposed condition. The models begin at the downstream (west) end of Daybreak Pond 5 and end approximately 2,000 feet upstream (east) of Daybreak Pond 1 (see Figure 5-1). The 10-, 20-, 50- and 100-year recurrence interval discharges were evaluated. Unless otherwise noted, all elevations are referenced to NGVD 1929.

The Corps of Engineers River Analysis System standard-step backwater computer program (HEC-RAS) was used to compute channel hydraulics (U.S. Army Corps of Engineers, 1998). Cross-sections extracted from a digital elevation model developed from survey data (WEST, 1997) (Figure 5-1) and supplemented with bathymetric survey elevations of the ponds (Chase Jones, 1999) were used to develop hydraulic models of the reach. Cross section locations were chosen to provide sufficient detail of flow contraction and expansion. Water surface elevations from FEMA (2000) were used for the downstream boundary of the models. Floodwaters may enter the Daybreak Ponds by flow split from the main channel upstream of the ponds and by backwater from the main channel downstream (west) of Daybreak Pond 5. The magnitudes of the flow splits were determined previously (WEST, 2000) and are summarized in Table 5-1.

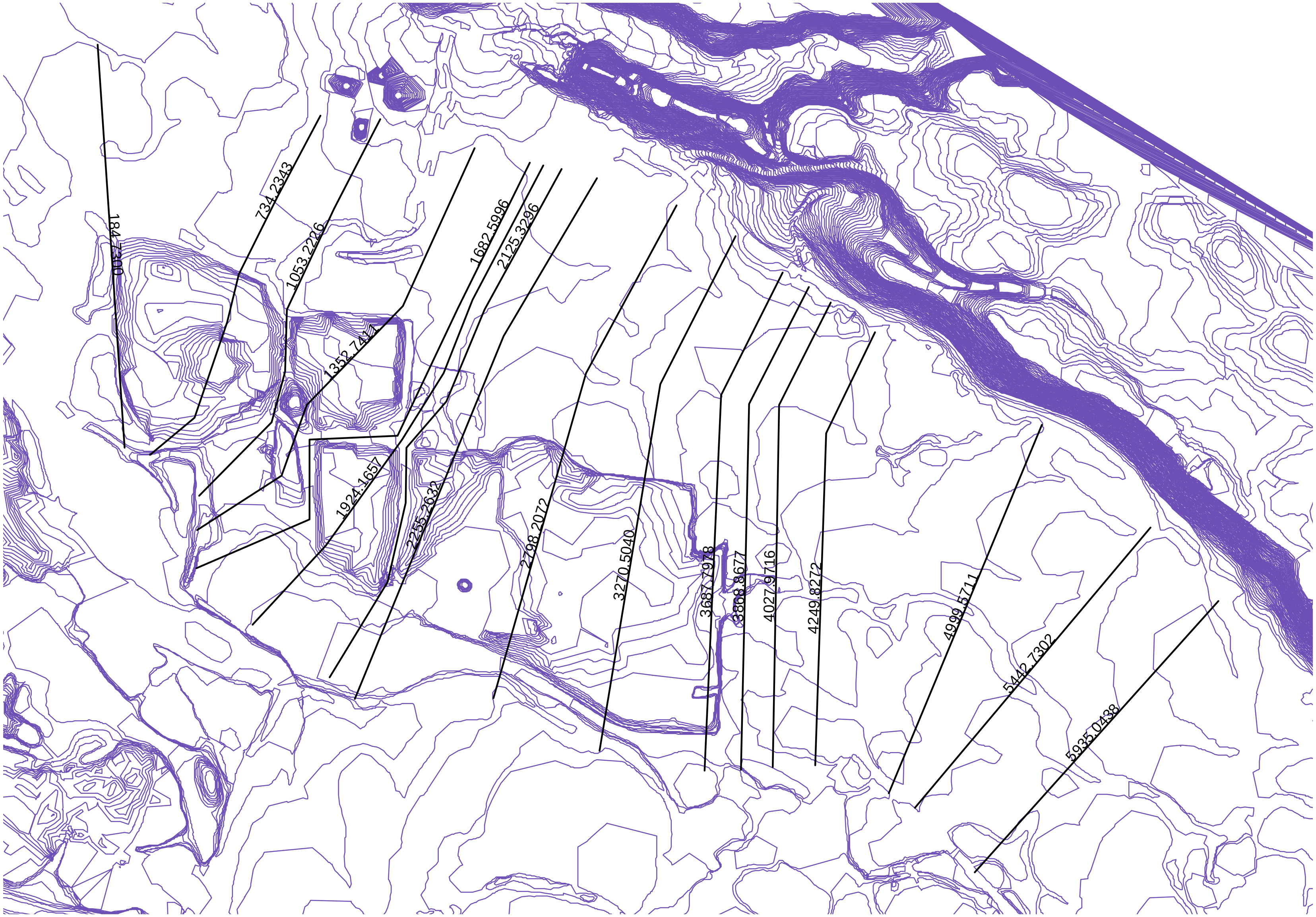


Figure 5-1. Plan view of the Daybreak Ponds showing locations of cross sections used in the hydraulic analysis.

Table 5-1. Summary of split flow magnitudes.

Recurrence Interval (Years)	Discharge (cfs)
10	100
20	285
50	475
100	650

Results of the hydraulic models for the 100-year recurrence interval flood are summarized in Table 5-2 As seen in the table, the water surface elevations for the existing and proposed models are nearly identical. At cross section 3687.8, which is located at the upstream (east) end of Daybreak Pond 1, the water surface elevation decreases by 0.02 ft as a result of the reduced channel width. A reduction in channel width that causes the water surface elevation to decrease would typically cause a backwater effect that would raise the water surface elevation upstream for some distance. However, in this case the profile of the channel is sufficiently steep upstream of this cross section that no backwater effect is created. The only other location where a change in the water surface elevation is observed is at cross section 2798.2, which is located in the middle of Daybreak Pond 1. At this location the water surface elevation increases by 0.01 ft. This is caused by a reduction in channel width downstream that causes a minor backwater effect.

Table 5-2. Modeled water surface elevation for the 100-year flood.

Cross Section No.	Existing W.S. El. (ft)	Proposed W.S. El. (ft)	Difference (ft)
5935.0	55.75	55.75	0.0
5442.7	54.33	54.33	0.0
4999.6	53.06	53.06	0.0
4249.8	50.11	50.11	0.0
4028.0	46.99	46.99	0.0
3868.9	41.40	41.40	0.0
3687.8	33.34	33.32	-0.02
3270.5	33.35	33.35	0.0
2798.2	33.34	33.35	+0.01
2255.3	33.34	33.34	0.0
2125.3	32.22	32.22	0.0
1924.2	32.35	32.35	0.0
1682.6	32.34	32.34	0.0
1352.7	32.34	32.34	0.0
1053.2	32.34	32.34	0.0
734.2	32.34	32.34	0.0
184.7	32.34	32.34	0.0

The water surface elevations in the Daybreak Ponds are controlled by the remnant ground that separates the ponds from one another. The remnant ground acts as a series of weirs that control the water surface elevations in the ponds. Because each pond is controlled by the hydraulics associated with weir flow, the proposed fill in the ponds does not impact the water surface elevation.

The existing Daybreak Ponds are located outside of the FEMA-designated regulatory floodway. The proposed improvements will have no significant impact on the water surface elevations associated with the flow split from the main channel of the East Fork Lewis River. No significant change in water surface elevation was calculated between the existing and proposed conditions models.

5.2 Surface Water Quantity

The placement of fill in the Daybreak Ponds will significantly reduce the open water area and volume of the ponds. The reduced open water area resulting from placement of the fill would be expected to reduce direct evaporation losses that are associated with the existing pond system. However, revegetation of the site will increase evapotranspiration demands for water. Overall, the proposed actions will return evapotranspiration demands to a condition similar to pre-development conditions for the site.

5.3 Surface Water Quality

The proposed action involves the placement of fill in existing floodplain gravel pits. Fill extending above the annual high groundwater level will be covered with topsoil and revegetated. The intent of the fill and revegetation is to increase the riparian buffer between the main channel of the East Fork Lewis River and the existing ponds. The fill material imported from off-site will be certified as free from deleterious materials and chemical contamination prior to placement.

Currently, high water temperature is one of the most important water quality issues in the lower East Fork Lewis River, and the river is listed as water quality impaired by the State of Washington due to water temperatures that exceed 18°C. Relatively recent historical water quality exceedances in the river at the Daybreak Bridge upstream of the project site include 20.2°C on 7/28/97; 19.0°C on 8/28/96; 22.5°C on 7/31/96; 18.6°C on 8/30/95; 18.8°C on 7/26/95; 19.6°C on 6/28/95; 21.3°C on 7/28/92; and 22.0°C on 6/23/92. Spot recordings of monthly water temperatures in the past year collected by Ecology in the East Fork Lewis River at the Daybreak Bridge are listed below:

May 2, 2000	12.6°C
June 2, 2000	18.8°C
July 2, 2000	17.5°C
August 2, 2000	19.3°C
September 2, 2000	15.0°C

Concerns have been raised about increased water temperatures in the East Fork Lewis River, specifically from releases of warm surface water, warm groundwater, and an increased riverine surface area in the event of an avulsion through the project site.

Releases of surface water from the existing ponds have the potential to input water with higher temperatures than already in Dean Creek or the East Fork Lewis River. This existing potential condition will be mitigated by the reduction in water surface area by narrowing and reconfiguring the ponds, and by increased shading provided from trees planted along the pond edges. A riparian forest is to be established on the riparian buffer. The riparian forest would be expected to resist channel migration and avulsion and provide shade to aquatic areas. The shade provided by the riparian forest will help in moderating temperatures in the East Fork Lewis River during summer months.

The potential effect of an avulsion on water temperature in the East Fork Lewis River is relatively unknown. Currently, the East Fork Lewis River flows through the Ridgefield Pits, which were former gravel ponds, and the effect on water temperatures through this reach can be presumed to be similar to the effect if the river avulsed out of this reach and into the Daybreak Ponds. In August of 1998 and 1999, a limited number of water temperature measurements were recorded above and below the reach that flows through the Ridgefield Pits. Storedahl is continuing to monitor water temperatures in the river and in the groundwater to provide further information on the existing conditions. Although water temperatures were observed to be higher downstream of the Ridgefield Pit reach is it unknown how these observations would relate to upstream/downstream measurements in other reaches on the river. Additionally, because these measurements were taken over the course of several hours, the influence of daily water temperature fluctuations is unknown. Nonetheless, a river flowing through an area of greater surface area has the potential to increase in water temperature. To reduce the potential of this phenomenon to occur if the river avulses through the Daybreak Ponds, the width of the existing ponds is proposed to be narrowed and the shoreline revegetated with shrubs and trees. This narrowing of the ponds will direct a potential avulsed flow into a channel that is narrower than the existing ponds and will mimic historic channel shape and location. This narrowed channel would reduce the surface area of open water, and thereby reduce the input of solar radiation and the potential for increased water temperatures with respect to existing conditions. In addition, the revegetated shoreline would provide shade along the expected avulsion flow path.

The fine-grained sediments resulting from gravel processing will be placed to an elevation at or slightly below the annual high water level in the ponds. As the pond water levels are expressions of the local groundwater level, it is expected that the shallow open water areas remaining after reclamation of the ponds will result in complex wetland habitat, consistent with the historic predevelopment channel conditions in the lower reaches of the East Fork Lewis River. Wetlands provide a wide range of water quality benefits including detention of stormwater runoff, moderation of flood peaks, biofiltration of contaminants, and settling of suspended sediment.

5.4 Groundwater

A site water table map (Figure 5-2) shows that the Daybreak Ponds act as a local groundwater sink, and that groundwater locally flows into the up-gradient side of the ponds. Site water table maps have been developed for both wet and dry periods that show a similar condition throughout the year. Under the current configuration of the ponds, surface water discharge from the ponds results in local suppression of the water surface and a net groundwater inflow to the ponds (i.e., groundwater inflow to the ponds is greater than groundwater outflow from the ponds). During the winter, the hydraulic gradient to the ponds is high, groundwater inflow is high, and most water drains from the pond system by surface flow. During the summer, the hydraulic gradient to the ponds is reduced, surface discharge from the ponds is low, and most water leaves the ponds as either groundwater seepage or evaporation.

The fill proposed to be placed in the Daybreak Ponds will reduce the available open water area of the ponds and the influence of the ponds on the local ground water surface. The proposed fill material is expected to have a significantly lower hydraulic conductivity than the coarse sands and gravels naturally occurring at the site. Since the local groundwater gradient is in the same direction as the river flow, fill in the ponds would not be expected to create a significant barrier to groundwater flow.

The project ponds are not believed to increase the temperature of groundwater released to the river. Recent groundwater temperature data collected from a piezometer immediately west of Pond 5 during late summer was 16°C compared to 19°C in both Pond 5 and the East Fork Lewis River, indicating that the ponds do not contribute to higher water temperatures in the river via groundwater input.

Groundwater flow at the project site during the summer was determined to flow from the ponds parallel to the river and then into the river a considerable distance downstream of the ponds, after attenuation of any temperature increase. In addition, seepage from the ponds is estimated to be only 0.9 cfs in the summer, which would have minimal effect on the East Fork Lewis River, even if subsurface water temperatures were higher as a result of the ponds.

5.5 Hyporheic Zone

The extent of the hyporheic zone of the East Fork Lewis River near the Daybreak Ponds is not known. However, the hydrogeomorphic setting of the river and its valley suggest that hyporheic flow on the scale of the fluvial plain (hundreds of meters) is possible. Groundwater contours and flow lines shown in Figure 5-2 indicate that hyporheic flow could intersect the existing Daybreak Ponds.

The effect of the existing Daybreak Ponds on the characteristics of the hyporheic flow are also unknown, but they would be expected to be similar in principle to those of a flow-through reach where hyporheic water enters the channel on the upstream side and goes subsurface on the downstream side. The ponds might have different effects than a river on the biological and chemical properties of water as it is exchange with surface water.

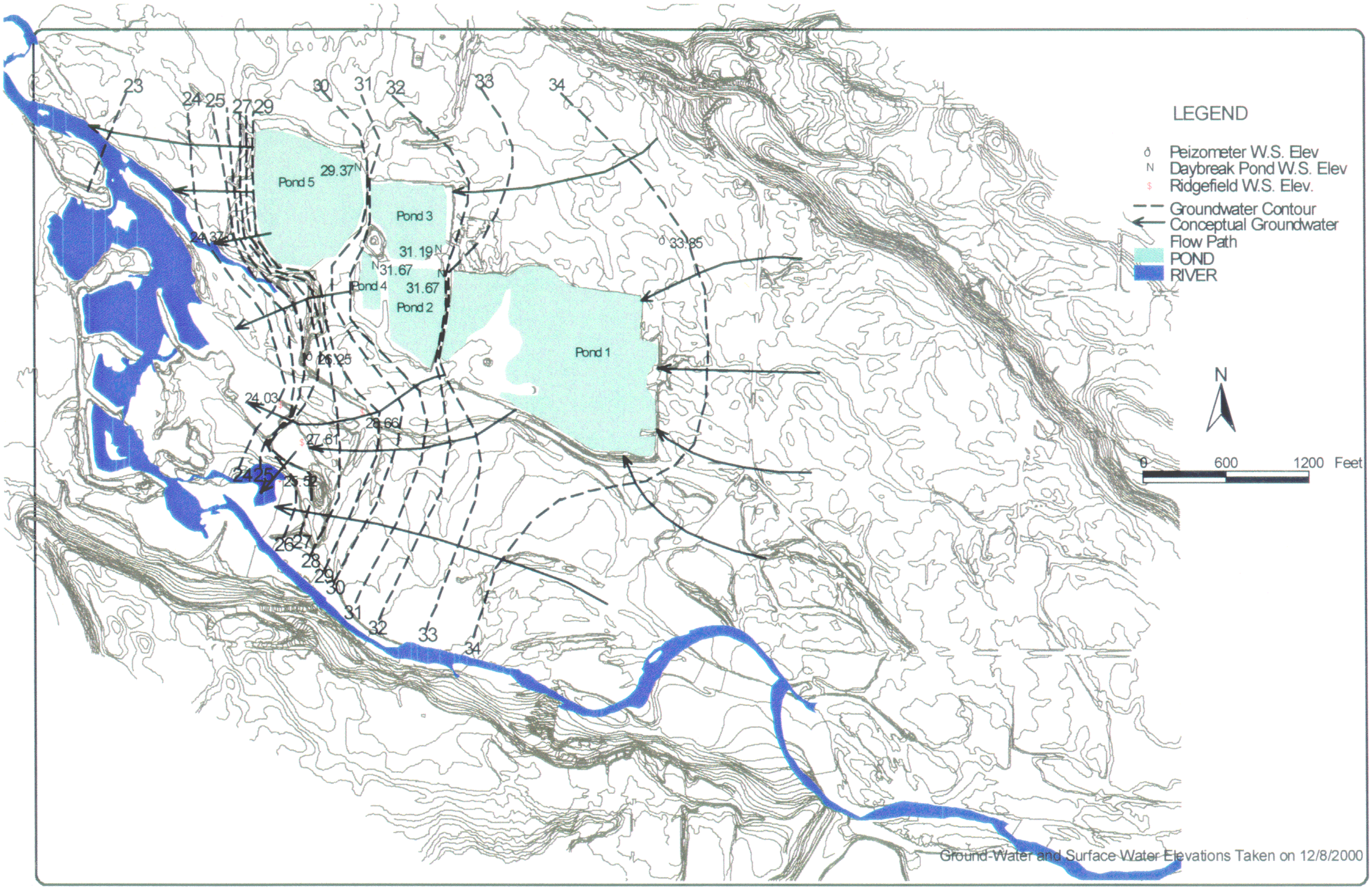


Figure 5-2. December 2000 groundwater contours.

Both past and proposed placement of fine grained sediments in the pond would be expected to retard exchange of hyporheic and surface water in the ponds, if it occurs. Such an impact would be consistent with other natural geomorphic processes in the area, such as, oxbow channel cutoffs or abandoned channel reaches, typical in the lower East Fork River valley, which would be expected to also have similar fine grained sediments in them. The existing ponds effectively replaced hyporheic volume that was present before the ponds were excavated. The proposed fill reestablishes a portion, albeit altered, of the hyporheic volume of the existing ponds.

The Daybreak Ponds are not considered to be a significant impact to the hyporheic zone. Mixing of stream water and groundwater in near-channel sediments below and lateral to the channel is typically limited to a few meters from the channel (D'Angelo et al. 1993; Wroblicky et al. 1998; Woessner 2000). Near channel sediments are inferred to be those within the bounds of a bankfull river. Consequently, exchange of surface and hyporheic water in near channel areas is unlikely to be affected by the existing Daybreak Ponds.

5.6 Sediment Transport Impacts

A detailed analysis of sediment transport conditions along the East Fork Lewis River has been conducted (WEST, 2001). The WEST study defines the hydrology, hydraulics, sediment transport, and geomorphic conditions of the project site. The following sections supplement the previous study by addressing specific issues relevant to the proposed avulsion mitigation plan for the Daybreak Ponds.

5.6.1 Increased supply of fine sediments to the river downstream of Daybreak

The supply of fine sediments to the East Fork Lewis River comes from many sources within the watershed. Sediment is supplied to the river by processes that include such things as hillslope erosion, rill and gully erosion, river bank erosion, mass wasting, and the failure of natural hydraulic controls such as beaver dams and log jams. These processes can supply large-scale short-term introductions of sediment into the channel as well as long-term chronic supplies of sediment in the case of bank erosion. Deposition of fine sediments in the floodplain of the East Fork Lewis River is a natural and ongoing process that is considered to be a primary floodplain function. Natural deposits of fine sediments exist throughout the East Fork Lewis River floodplain including naturally occurring oxbows, abandoned channels that convey flow during floods, backwater areas and locations upstream of beaver dams such as at the mouth of Dean Creek. This also includes large areas of agricultural fields in the lower East Fork Lewis River basin on which the soils were developed from natural deposition of fine sediments on the floodplain. Similar to the Daybreak Ponds, these features can become sources of fine sediment if the river migrates or avulses into their location.

The annual yield of sediment from the East Fork Lewis River basin was estimated to be between 32,000 to 64,000 tons per year (PNRBC, 1970). However, the river is considered to be supply limited, having the capacity to transport much greater amounts of sediment than is supplied to it. In fact, the capacity of the river to transport bed material in the vicinity of the Daybreak Site was estimated to be approximately 145,000 tons per year (see Section 5.7 from WEST 2001). The capacity of the river to transport material finer than that found in the gravel bed portions of the river is considered to be virtually unlimited except where it is tidally influenced in the lower 6 miles of the river.

Material hauled in from the Tebo Pit is proposed to be processed at the Daybreak Site. Approximately 4 percent of this material will be waste product that will be deposited in the existing Daybreak Ponds as part of the washing process and proposed pond reclamation. The total volume of the fine grained sediment material to be placed in the Daybreak Ponds is approximately 271,000 cubic yards or 325,200 tons. Particle size distributions for the individual samples and a composite size distribution for this material are shown in Figure 5-3. Approximately 37 percent of this material is composed of sand sized material and larger, while the remaining 63 percent is silt sized and smaller.

Various concerns exist over whether this material may at some point in the future be eroded and transported downstream by the East Fork Lewis River. Of greatest concern is whether all or a portion of this material will deposit within the 1.25 miles of spawning gravels that exist downstream of the Daybreak Site. Two scenarios were considered in the evaluation of the potential impacts to the downstream channel. The first was to estimate the potential for the river to transport sediment out of the existing ponds during a 100-year flood in which a flow split from the main channel enters the upstream end of Daybreak Pond 1. The second was to estimate the potential for the river to transport sediment downstream of the Daybreak Ponds if an avulsion where to occur.

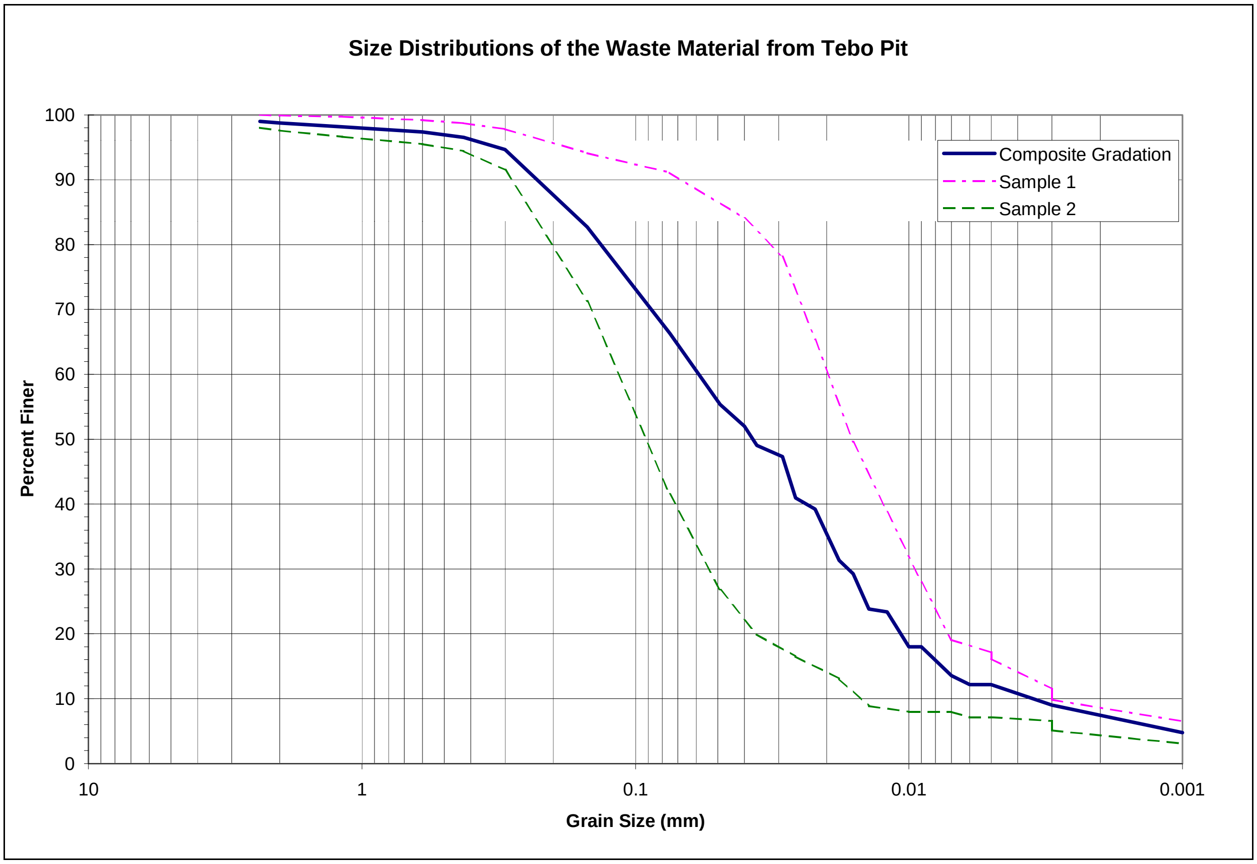


Figure 5-3. Sediment gradations for samples taken from waste material derived from the Tebo pit.

5.6.2 Potential for Sediment to be Transported Out of the Daybreak Ponds during a 100-year Flood

The water surface elevations in the Daybreak Ponds are controlled by the remnant ground that separates the ponds from one another. The remnant ground acts as a series of weirs that control the water surface elevations in the ponds. Because each pond is controlled by the hydraulics associated with weir flow, the proposed fill in the ponds does not impact the water surface elevation. The potential for erosion of materials filled in the ponds was also evaluated. Comparison of the output for existing and proposed conditions demonstrates no significant change in the expected shear stress. Within the ponds, where filling is proposed, the shear stress against the pond boundary is calculated to be zero during a 100-year flood due to the low energy gradient through the ponds. This is due to the hydraulic control provided by remnant ground between the ponds. At the upstream boundary of Daybreak Pond No. 1 (Section 3687.798) and at sections that overflow the remnant ground between ponds (Sections 1682.6 and 2125.330) the shear stress was calculated to range between 0.13 and 2.12 lb/ft^2 during the 100-year return period flood. The only increase in shear stress (erosion potential) between existing and proposed conditions occurs at Section 3687.798, the overflow inlet to Daybreak Pond No. 1. The shear stress at that location increases slightly from 0.02 to 0.13 lb/ft^2 for the 100-year flood. The identified range of shear stresses, and associated erosion potential, is not significant since it is well within the range of permissible shear stresses (0.35 to 3.70 lb/ft$^{2)}$ for vegetative linings (FWHA, 1985). A wetland marsh and riparian forest are to be established on the proposed fill.

5.6.3 Sediment Transport Associated with an Avulsion

As previously described, there is a potential for the East Fork Lewis River to avulse into the existing Daybreak Ponds. An avulsion could cause a portion of the fines deposited with in the ponds to be transported downstream. An evaluation of the rivers ability to transport this material downstream was conducted using three methods. The first was to determine the fall velocity of the particles that comprise the fill material to estimate the downstream extent of expected transport and deposition. The second was to estimate the transport capacity of the river to understand the ability of the river to transport material shown to not remain in suspension by the fall velocity calculations. The third was to estimate the incipient motion particle size.

5.6.3.1 Fall Velocity Calculations

The fall velocities for individual particle sizes were determined using the Corps of Engineers computer program H0910 “Determination of Particle Fall Velocity by Shape Factor” that is included in the SAM Hydraulic Design Package for Channels (USACE, 1998). The fall velocity that a particle attains in a quiescent column of water is directly related to the relative flow conditions between the sediment particle and the water during conditions of sediment entrainment, transportation, and deposition. The fall velocity reflects the integrated result of size, shape, surface roughness, specific gravity, and the viscosity of the fluid. The fall velocity is calculated as the difference between the particles buoyant weight and the resisting forces resulting from fluid drag.

Because fall velocity calculations are considered appropriate for conditions of quiescent water conditions, the effects of turbulence associated with flow in a river channel would tend to keep a particle in suspension for much longer than the fall velocity would indicate. Therefore, estimates of downstream travel distance based on the particle fall velocity are considered to be smaller and therefore conservative for estimation of particle deposition location in the East Fork Lewis River. The travel distance of individual particles was calculated using the average channel velocities and depths for the 10- and 100-year flood calculated from the 1992 FEMA hydraulic model for the East Fork Lewis River. Results of the fall velocity calculations showed that particle sizes finer than medium silt (0.031 mm) would be transported through the entire length of the river. Coarse silt sized particles (0.0625 mm to 0.031 mm) where shown to drop out of suspension below river mile 6.24 and 5.61 for the 100- and 10- year floods, respectively. The sand sized particles where shown to drop out below river mile 7.29 for both the 100- and 10-year floods. Particle travel distances tended to be lower for the 100-year flood vs. the 10-year flood due to higher backwater effects from the downstream Lewis and Columbia Rivers during the 100-year event.

In order to understand the magnitude of the greatest possible impact to downstream locations from fine sediments transported out of the Daybreak Ponds, the total volume of material proposed to be deposited in the ponds was considered in the evaluation. Of the total amount of fine sediments proposed to be deposited in the Daybreak Ponds, approximately 48 percent (156,100 tons) is medium silt or smaller and would be expected to be transported out of the East Fork Lewis River. Approximately 15 percent (48,800 tons) is coarse silt that could potentially deposit in the river below river mile 6.24. The remaining 37 percent (120,300 tons) of material is very fine sand sized and larger. This material is indicated by the calculation to potentially deposit within the 1.25 mile spawning gravel reach located below the Daybreak Ponds. However, given the extremely conservative nature of the travel distances estimated from fall velocity calculations, it should be expected that some portion of this material would be transported beyond this reach. Additionally, it should be recognized that although fall velocity calculations indicate the time necessary for a characteristic particle to settle in a water column, it does not address the potential for the sediment particle to be transported by the flow of the water. Further, it must also be recognized that it is also unlikely that the entire amount of fine sediments would be transported out of the ponds during an avulsion. It is more likely that the majority of the sand-sized material would deposit within the downstream Daybreak Ponds 3 and 5, as these ponds are not proposed to be filled with sediment from Tebo. The trapping of fines would likely be similar to that observed to have occurred in the downstream-most Ridgefield Ponds after the avulsion in 1996.

5.6.3.2 Sediment Transport Capacity Estimates

Estimates of sediment transport capacity in the East Fork Lewis River were made for the channel at river mile 6.43, which is near the downstream end of the spawning gravel reach. Sediment transport capacity was estimated for the 2-year flood and the 5-, 10-, 25-, and 50-percent exceedance flows for the very fine sand sized material and larger (see Table 5-3) that was shown to by fall velocity calculations to deposit within the spawning gravel reach during both the 10- and 100-year flood. These estimates were made using the sediment transport formula of Toffaleti (1968). Values shown in Table 5-3 are the capacity of the river to carry the very fine sand sized and larger material in suspension. The ability of the river channels to transport particles that are silt sized and finer is considered to be unlimited (Simons and Senturk, 1976), therefore the amount of silt sized and finer material in suspension is only limited by the supply. However, in locations such as the lower reach of the East Fork Lewis that are affected by tidal backwater, conditions may exist during tidal cycles that would allow these particles to settle out of suspension.

Table 5-3. Sediment transport capacity estimates at RM 6.43 of the East Fork Lewis River.

Flow	Discharge (cfs)	Transport Capacity (tons/day)	Time to Transport Material (days)
50% exceedance	579	37,600	3.2
25% exceedance	1,249	64,700	1.9
10% exceedance	2,282	80,000	1.5
5% exceedance	3,221	90,000	1.3
2-year flood	11,200	112,500	1.1

As seen in Table 5-3, the sediment transport capacity of the channel for the very fine sand sized material and larger is fairly large, even for relatively low flows. For 50 percent of the time, the river has a flow of 579 cfs or greater. Given this flow, the river would be able to transport the entire volume of very fine sand sized material and larger in approximately 3.2 days. If the entire volume of very fine sand and large material were to be transported out of the ponds in less that 3.2 days for this flow, then deposition within the spawning gravel could occur. Alternately, if the material were removed from the ponds over a period of time exceeding approximately 3.2 days, then no deposition would occur. For a large event, such as the 2-year flood, the river has the capacity to transport the entire volume in approximately 1.1 days. Flood events on the East Fork Lewis River typically last 4 or 5 days. Therefore, it is expected that the entire volume of very fine sand sized material and larger would be transported in suspension to locations downstream of the spawning gravel reach during a 2-year flood.

If the very fine sand sized and larger material where to deposit within the spawning gravel reach, it is possible that some of this material may infiltrate into the interstitial spaces of the gravel bed, potentially leading to suffocation of salmon eggs or entrapment of fry. This would only occur if an avulsion and sediment deposition where to occur while reds are in the river. If no reds are present in the river at the time of an avulsion, the fine material in the interstitial spaces of the gravel is expected to be flushed out by the spawning adults during the construction of the red or during the next high flow event that has the ability to disrupt the armor layer. Disruption of the armor layer typically occurs during floods equal to or in excess of the bank full event. Bank full events typically have a recurrence interval of 1.5 to 2 years.

It is recognized that the ability of the river to transport the very fine sand sized and larger material derived from the Daybreak Ponds would be reduced by the amount of that sized material already in suspension that was derived from upstream sources. However, it is expected that the majority of this material would settle out in Daybreak Ponds 3 and 5, allowing nearly the entire transport capacity of the channel to be utilized for the downstream transport of the Daybreak Pond fill material. Additionally, it is expected that a large portion of any Daybreak Pond fill material that was eroded during an avulsion would also deposit in the downstream Ponds 3 and 5, therefore reducing the supply of very fine sand sized material and larger to the downstream 1.25 mile spawning gravel reach.

5.6.3.3 Incipient Motion Analysis

An analysis of incipient motion particle size was conducted to determine the size of material in the bed that is considered to be stable for given flows. The Shields (1936) method was used to estimate stable particle size for the 50-, 25-, 10-, 5-percent exceedance flows and the 2-year flood. Table 5-4 summarizes the results of the analysis.

Table 5-4. Summary of incipient motion particle sizes at RM 6.43 of the East Fork Lewis River.

Flow	Critical Particle Size (mm)	Classification
50% exceedance	18	Coarse Gravel
25% exceedance	19	Coarse Gravel
10% exceedance	24	Coarse Gravel
5% exceedance	27	Coarse Gravel
2-year flood	41	Very Coarse Gravel

As seen in Table 5-4, for 50 percent exceedance flows the critical particle size at incipient motion is 18 mm. Therefore, particles smaller than 18 mm, which includes the proposed fill material, would tend to remain in transport and are unlikely to deposit on the bed.

5.6.4 Qualitative Assessment of Sediment Transport

An historical account of fish use in the East Fork Lewis River noted that "spawning habitat is poor in the lower six miles of stream where the bottom is largely mud and sand" (Washington Department of Fisheries 1951). The lower six miles is tidally influenced, and the twice-daily backwatering that occurs in this reach results in fine sediments being deposited along the banks and within the channel. This limit on spawning habitat is generally believed to begin near the mouth of Mason Creek based on visual observations of the bank and substrates and from conversations with Dan Rawding of WDFW. Visual observations included deposition of sands on the cobbles and muddy banks that delimit the typical river height fluctuations. The substrate in the riffle areas upstream of RM 6 to the Daybreak Bridge at RM 10 is generally cobble and gravel. In this four mile reach, substrates are coarser (large cobble and boulders) in the swiftly flowing portions of the river (outer bends and confined runs) and are finer substrates along the inner bends and in the bottom of pools. Specifically, the substrates in the pools that comprise the Ridgefield Pit reach are predominantly sand. The areal extent of cobble and gravel in this reach is limited to the upstream most section where the first pool (Ridgefield Pond 1) is now filled in and the river flows over deposited gravels and short gravel/cobble sections in the shallows between each of the pools.

The existing bed material observed in the East Fork Lewis River channel would suggest that fine sand, silt and clay sized particles are typically transported downstream of the spawning gravel reach as wash load into the tidally influenced lower portion of the river. Within the tidal portion of the channel fine sands and silts are seen to form the channel bed, suggesting that the transport capacity of the channel is sufficiently reduced by the backwater to deposit this material. The lack of fine sands and silts in the spawning gravel reach would suggest that the transport capacity is large enough to prevent this material from depositing on the bed. Further, the Ridgefield Ponds have likely trapped a large portion of the fine sands and silts reducing the supply to downstream areas.

If an avulsion into the Daybreak Ponds occurred, it is likely that an additional amount of fine sands and silts would temporally be added to the wash load of the river. Although an avulsion could occur during frequent occurring flows, the potential for an avulsion to occur during a high flow event is much more likely. Therefore, it is more likely that the concentration of fines in the wash load would already be large as a result of natural erosional processes in the watershed. Additionally, it is expected that a portion of the sediments in the natural wash load of the river may settle out within Daybreak Ponds 3 and 5, thereby reducing the concentration of fines remaining in suspension.

5.6.5 Suspended Sediment Concentration Estimates

Erosion and transport of fine sediments out of the Daybreak Ponds during an avulsion would likely increase the concentration of suspended sediment in the river. In order to understand the potential magnitude of impacts to sediment concentrations in the river from such an event, estimates were made of the potential suspended sediment concentrations associated with an avulsion. The majority of the time sediment concentrations in the East Fork Lewis River are relatively low, on the order of a few milligrams per liter. However, during high flow events, concentrations can be quite large on the order of thousands of milligrams per liter. On average, Western Cascade streams have an average annual concentration of approximately 50 mg/L (Majors et al., 2000).

An estimate of the average suspended sediment concentration was made for 100-year flood assuming the entire volume of fill was entrained in the flow. A simulated 5-day hydrograph with a peak of 32,200 cfs was used to calculate the involved volume of water. The resulting average concentration is approximately 1,500 mg/L. For comparison, a flood in December 1977 on Wildhorse Creek, a tributary to the nearby Kalama River, had an average concentration of approximately 1,460 mg/L (Wooldridge, 1978)

An additional analysis was performed to understand the potential magnitude of impacts of the fine sediments on downstream locations such as the Columbia River. Sediment concentrations in the Columbia River at Vancouver, WA were measured between 1964 and 1969. The average annual discharge during the period of record was approximately 240,000 cfs with an average sediment concentration of approximately 34 mg/L. Concentrations as high as 2,700 mg/L have been measured. The addition of the proposed Daybreak fill material to the Columbia River would yield an average annual sediment concentration of about 1.4 mg/L.

5.6.6 Bedload Trapping

If an avulsion into the existing Daybreak Ponds occurred, the majority of bed material would likely be trapped within Ponds 3 and 5. This would cause the supply of bed material to the downstream spawning reach to be reduced. This could potentially lead to coarser bed material in that reach. However, given the reduction in the rivers ability to transport coarse bed material out of the reach to locations below river mile 6, it is expected that the bed would remain fairly stable in the spawning reach below Daybreak. This is further supported by the lack of observed impacts to the bed of the river in this reach since the bed material supply was reduced by the avulsion into the Ridgefield Ponds in November 1996.

6 Summary

The proposed mitigation plan will reduce the risk of avulsion into the existing man-made ponds, enhance the long-term stability of the East Fork Lewis River, minimize the potential avulsion impacts, and restore important valley-bottom forest. This proposal will enhance the ecological function of the site and support Clark County's planned expansion of restored habitat along the East Fork Lewis River. The ecological functions of the site and the East Fork Lewis River will be enhanced from this project, because it will:

- Provide terrestrial wildlife habitat for nesting, dispersal, and foraging
- Provide shade to help minimize water temperatures
- Help control erosion from surface runoff
- Provide a future source of roots and woody debris for habitat complexity
- Improve habitat for amphibians, birds, and aquatic organisms
- Increase availability of terrestrial invertebrate prey items for fish
- Enhance linkages among upland and aquatic ecosystems

No significant adverse impacts to the hydrology, hydraulics, sediment transport conditions, or geomorphic characteristics will occur as a result of the proposed Daybreak Pond avulsion mitigation plan.

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