APPENDIX C

Kootenai River Sand Transport

Appendix C KOOTENAI RIVER SAND TRANSPORT

C.1 Introduction

A sand transport analysis was undertaken as part of the Corps' sturgeon recovery efforts on the Kootenai River. It is intended specifically to inform the NEPA evaluation (Upper Columbia Alternative Flood Control [VARQ] and Fish Flow Environmental Impact Statement, or UCEIS) being performed for a long-term decision on implementation of VARQ alternative flood control and on flows for sturgeon, bull trout, salmon and steelhead from Libby and Hungry Horse dams. This analysis focuses on flows from Libby Dam to the Kootenai River.

Sand transport and deposition are important factors in the selection and design of dam operations or river modifications that are intended to improve reproductive success of Kootenai River white sturgeon. This analysis provides an initial estimate of the effects various Libby Dam flow regulation scenarios could have on annual suspended sand transport in the Kootenai River downstream of Bonners Ferry, river mile (RM) 152[1].

C.2 Flow Regulation Scenarios

Six flow regulation scenarios were used in this analysis. Each scenario provides flood control (FC), with four also providing supplemental flows (fish flows) intended to benefit sturgeon, bull trout, and salmon. Four of the scenarios are NEPA alternatives in the UCEIS; the other two are benchmark operations that provide a basis for comparison to derive the direct effects of fish flows in the UCEIS. The flow regulation scenarios are described below and the corresponding flow duration curves are shown in Figure C-1. Compared to the benchmark Standard flood control scenario without fish flows, the other scenarios all shift water from the low flow periods to the high flow period, especially the spring freshet.

[1] The river mile locations in this report are based on the Columbia Basin Inter-Agency Committee River Mile Index for the Kootenai/Kootenay River. This system assumes that RM 0 is located at the mouth of the Kootenay River, where it joins the Columbia River near Castlegar, BC.

- The benchmark Standard flood control scenario (LS) is the flow regulation currently authorized for long-term use and was used prior to and through calendar year 2002. It is also referred to as Standard FC or "BASE-CRT63". The Standard FC storage reservation diagram is used in combination with Libby's seasonal water supply forecasts to determine how much space needs to be made available by 15 March for flood control. During refill, it is assumed that the outflow from Libby Dam will be a steady 4 kcfs. There are no flow augmentations for fish in this scenario.
- The benchmark VARQ flood control scenario (LV) is the flood control method currently being used on an interim basis at Libby Dam, and recommended for long-term implementation in both the USFWS Biological Opinion and the NMFS Biological Opinion. This interim operation began in January 2003. Similar to Standard FC, VARQ FC also requires a storage reservation diagram in conjunction with the water supply forecast to determine the flood control space needed. However, compared to the Standard FC scenario, VARQ FC requires less flood control space in years with low to moderate runoff predictions. During refill, the outflow from Libby Dam is variable and is almost always greater than 4 kcfs. There is no flow augmentation for fish in this scenario.
- The no-action alternative Standard FC with fish flows to powerhouse capacity (LS1), follows the Standard FC rules, and provides supplemental fish flows as follows: First, provide a tiered volume of water during the spring freshet for sturgeon spawning and recruitment, using only the maximum powerhouse capacity (about 25 kcfs). Next, make sure Libby outflow is greater than or equal to the minimum bull trout flow during July and August. Finally, draft the pool to elevation 2439 feet (20 feet from full) for salmon flow augmentation during July and August.
- The preferred alternative, VARQ FC with fish flows to powerhouse capacity (LV1), resembles the LS1 alternative, except the VARQ flood control procedure is followed instead of the Standard FC procedure. This alternative has been implemented on an interim basis, beginning January 2003 and pending a long term decision based on the decision from the UCEIS.
- Alternative LS2, Standard FC with fish flows up to 10 kcfs above powerhouse capacity, provides fish flows similar to alternative LS1, except sturgeon flows are provided using the powerhouse capacity plus an additional 10 kcfs of release capacity.
- Alternative LV2, VARQ FC with fish flows up to 10 kcfs above powerhouse capacity, is similar to LV1, except sturgeon flows are provided using the powerhouse capacity plus an additional 10 kcfs of release capacity.

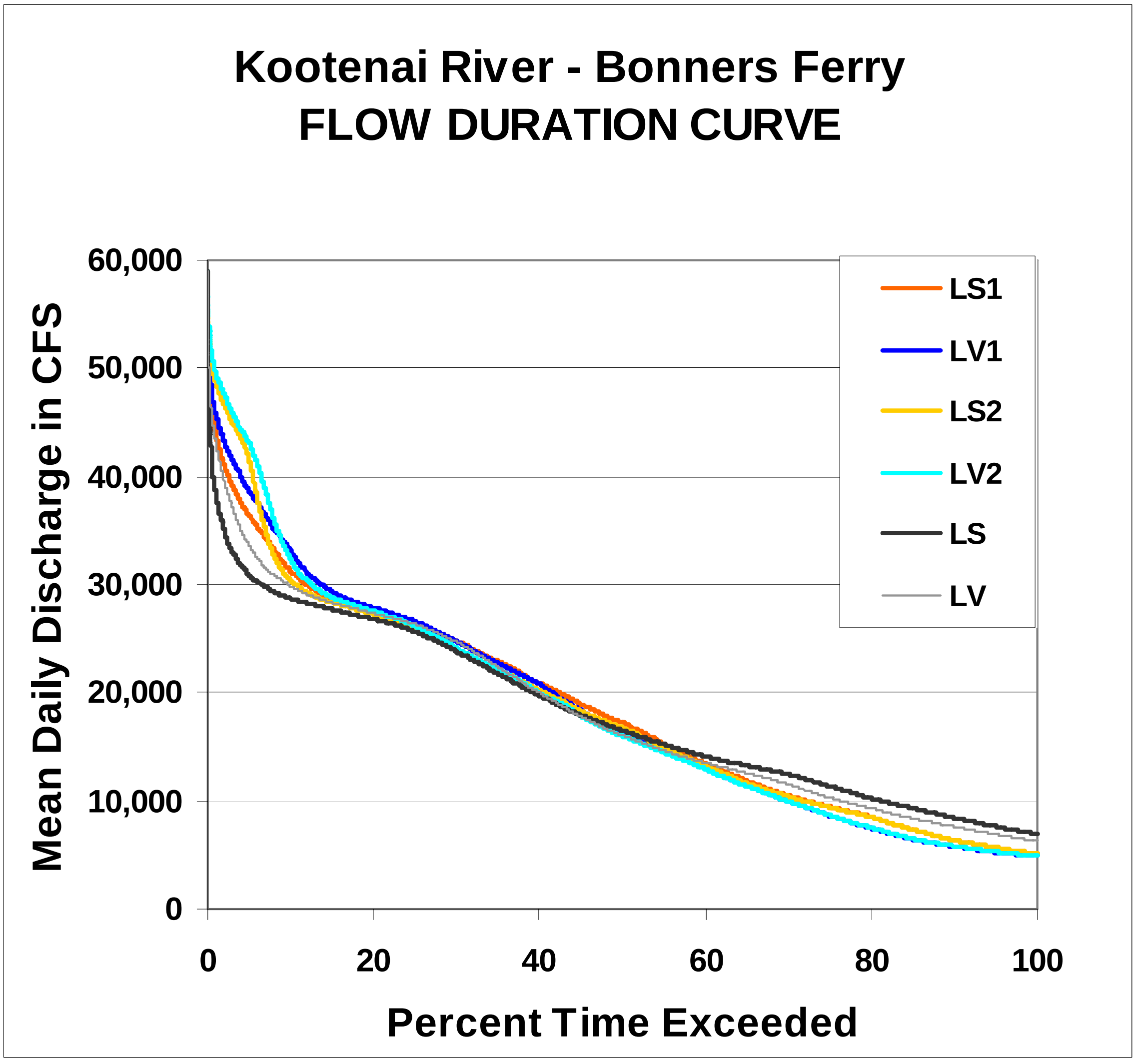

Figure C-1. Alternative flow duration curves for the Kootenai River at Bonners Ferry, RM 152.

C.3 Sand Transport Analysis

The magnitude of the average annual sand transport is an important factor in the behavior of a river. It is also important in the selection and design of dam operations or river modifications. The six flow duration curves presented above were combined with a computed suspended sand load curve to calculate average annual sand transport for each flow regulation scenario.

C.3.1 Suspended Sand Load Curve

In sand bed rivers, such as the Kootenai River between Bonners Ferry, RM 152, and the Canadian border, RM 106, suspended sand transport is directly related to the hydraulic conditions in the channel. As a result, several empirical equations have been developed that use selected hydraulic parameters to calculate suspended sand transport. These equations can be used to calculate suspended sand transport in situations where there is hydraulic information but little or no sand transport data.

On the Kootenai River there is little useful sand transport data. Over the past 40 years the USGS has collected some suspended sediment data, even publishing daily total suspended sediment (TSS) data for the Kootenai River from 1966 to 1983. However, measurements were routinely collected on a monthly schedule without concentrating on the high discharge periods when most sand transport occurs. The available suspended sand data alone is not adequate to reliably define the sand load curve, but is useful in comparing computed sand load curves. Recently, at the direction of the Kootenai Tribe of Idaho using Bonneville Power Administration funding, the USGS has collected data and is modeling sediment transport in the Kootenai for purposes of determining characteristics of existing sturgeon spawning and rearing habitat and how it may be modified. The report from that effort is unavailable at the time of this draft.

For this analysis, Yang's sand transport equation and hydraulic data for RM 142.6 [2] from the Corps' "Kootenai River Geomorphic Assessment" (TetraTech and Perkins Geosciences 2004) were used to calculate an initial suspended sand transport curve. That initial sand transport curve was then compared to the available suspended sand and total suspended sediment transport data collected by the USGS. After this comparison, a power function, best-fit curve for the initial Yang data points was selected as the most representative suspended sand load curve. The chosen sand load curve is shown on Figure C-2 as the "Power" trend line; also shown are selected total suspended sediment trend lines and individual suspended sand data points. The high ends of the 1972, 1975, and 1980-82 curves are not well defined because the maximum discharges for those years were less than 60, 40, and 45 kcfs respectively. However, the 1966-68 curve is better defined as it includes data for discharges as high as 95 kcfs. As can be seen in Figure C-2, the chosen sand load curve provides a good match to not only the initial Yang curve, but also to the available suspended sand data.

[2] RM 142.6 is designated as RM 36.97 in the TetraTech/Perkins Geosciences report, which assumes that RM 0 is located at the Canada-US border rather than at the mouth of the Kootenay River.

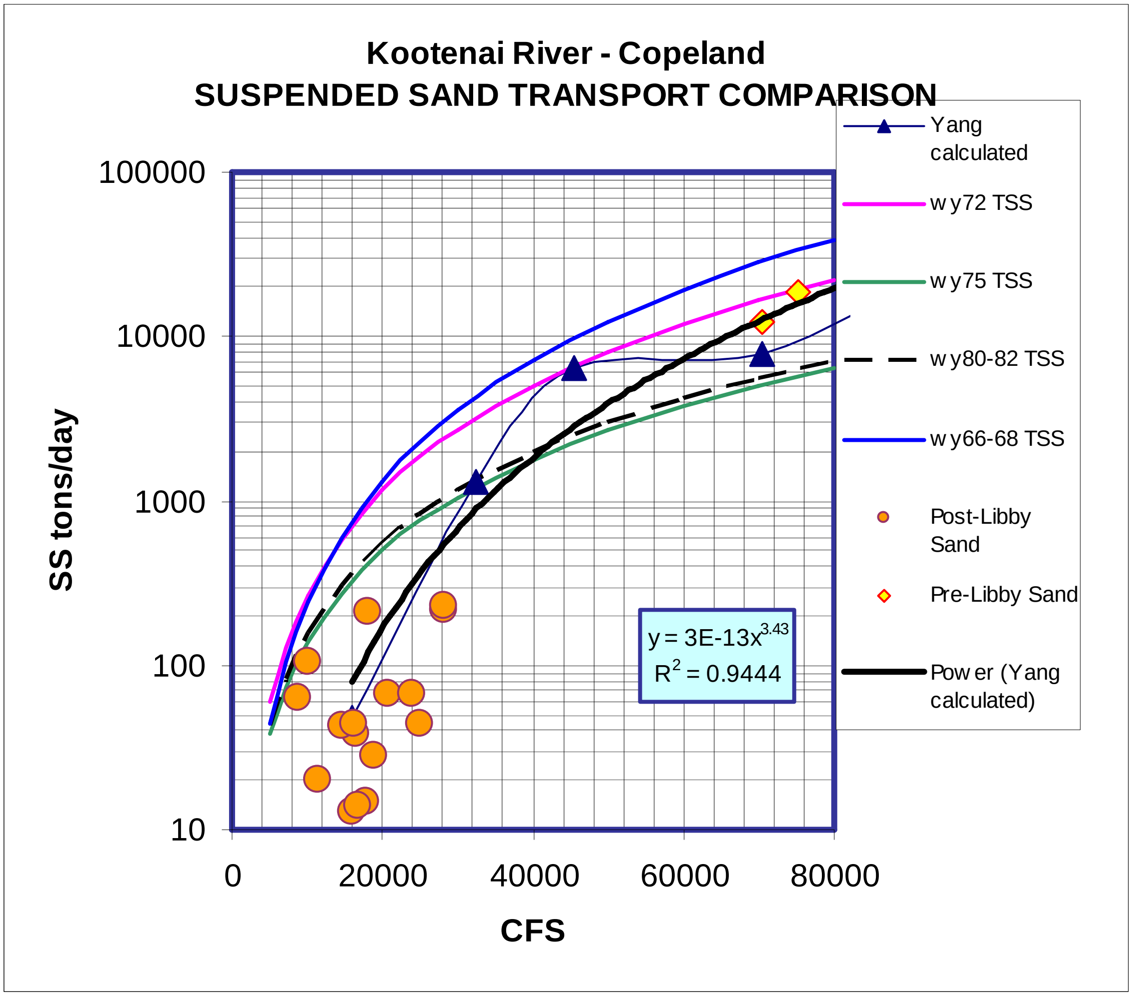

Figure C-2. Initial and chosen suspended sand load curves and measured total suspended sediment trend lines and suspended sand data points for the Kootenai River near Copeland. Trend lines have been used for clarity because of the large number of available total suspended sediment data points.

C.3.2 Average Annual Suspended Sand Transport

The flow duration curves were integrated with the chosen suspended sand load curve to calculate the average annual suspended sand transport for each alternative and benchmark scenario at Bonners Ferry. The calculated average annual suspended sand transport volumes are listed in Table C-1. As the scenarios shift more water to the high discharge period the sand transport increases, even though the annual peak discharge has been held constant at 59 kcfs in each scenario. The effects on suspended sand transport from shifting more water to the high flow period can also be seen in the sand discharge duration curve presented in Figure C-3. That figure shows that the increased sand transport occurs during the 10 to 15 percent of the year with the highest discharges and that the reductions occur during the 40 percent of the year with the lowest discharges.

An unregulated sand discharge was not calculated as part of this analysis, but is believed to be much higher than any of the scenarios because of the higher peaks and larger volumes of the natural freshets.

Table C-1. Average annual suspended sand transport in the Kootenai River near Copeland.

Alternative		Sand Transport (tons/year)
LS1		113,000
LV1		126,000
LS2		130,000
LV2		142,000
Benchmark		
LS		87,000
LV		102,000

C.4 Limitations

This analysis provides good estimates of average annual suspended sand transport for each of the six flow regulation scenarios. However, it does not present a complete description of the existing Kootenai River sand budget. Bedload transport and inflowing sand discharges would need to be analyzed to complete a sand budget. Bedload may also transport a significant volume of sand, but was not included in this analysis. Sand inflows are necessary to determine if the Kootenai River downstream of Bonners Ferry is aggrading, degrading, or in a state of dynamic equilibrium. The lack of available data would greatly limit the reliability of any attempt to calculate bedload or sand inflow volumes.

C.5 Conclusions

Altering the flow regulation patterns at Libby Dam by shifting more water to the spring freshet will result in increased sand transport in the Kootenai River downstream of Bonners Ferry (RM 152). The scenarios included in this analysis increased suspended sand transport by 17 to 63 percent above the Standard FC condition without fish flows. Given the steep, high-energy channel between Libby Dam and Bonners Ferry, the most likely source of additional sand is the riverbed downstream of Bonners Ferry. If all the increase in sand transport were to come from the first mile of river downstream of Bonners Ferry, it could equate to 0.2 to 0.7 ft/yr of channel erosion. However, if it occurred over the 10 miles of riverbed between Bonners Ferry and Shorty's Island, it would equate to an average of only between 0.02 and 0.07 ft/yr of channel erosion.

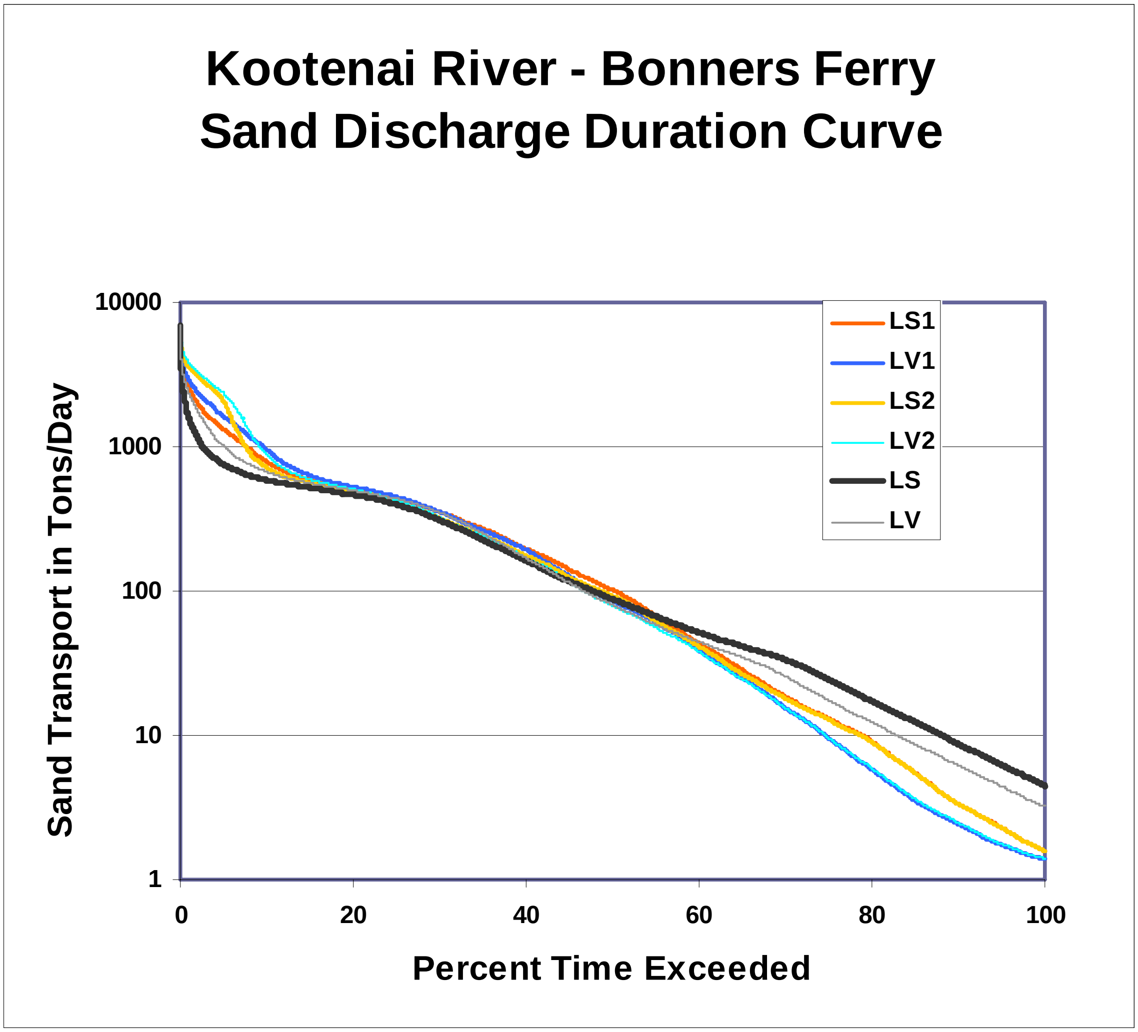

Figure C-3. Sand discharge duration curves based on the calculated daily transport rates. The effects of releasing more water during the high discharge times of the year are reflected in the higher transport rates that occur.