

Geotechnical  
Environmental and  
Water Resources  
Engineering

Final Letter Report

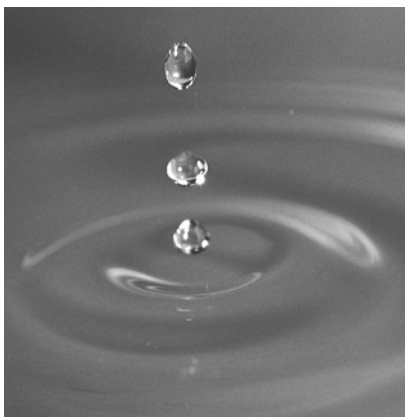
## Thompson Falls Upstream Fishway Site Selection

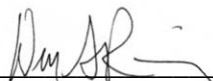
### Thompson Falls Hydroelectric Project

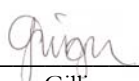
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# Introduction

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PPL Montana owns and operates Thompson Falls Dam, a 92.6 MW hydroelectric project built on the Clark Fork River in 1917. The Federal Energy Regulatory Commission (FERC) granted a new license for the project to Montana Power (now PPL Montana) in 1979, and amended the license to include a new powerhouse in 1990. Bull trout (*Salvelinus confluentus*) was listed as a threatened species in 1998, under the federal Endangered Species Act (ESA). The U.S. Fish and Wildlife Service is consulting with FERC regarding the impact of continued project operations on listed species. The biological evaluation concluded that the Thompson Falls Project was likely to adversely affect bull trout. One of the project adverse effects identified was the lack of upstream fish passage. PPL Montana agreed to assess feasibility of upstream passage improvements, and develop an implementation plan.

GEI Consultants, Inc. was retained by PPL Montana to develop a long-term Fish Passage Plan. One of the early identified needs was to conduct studies to better describe behavior of target species downstream of the dam during migration periods, so that the optimum site for a new upstream passage facility (fishway) could be determined. This would be the basis for proceeding into the fishway design development process.

The primary purpose of this letter report is to identify appropriate Thompson Falls Dam upstream passage sites for the fishway feasibility study, based on observed fish behavioral trends from 2004 and 2005 radio-telemetry studies.

# Thompson Falls Fish Passage Plan

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The primary components of the multi-year Thompson Falls Fish Passage Plan (Plan), which will result in satisfactory upstream passage at the dam, are listed below. The intent is for all stakeholders to participate fully during each Plan phase. The optimum fishway design is intended to build on cumulative input from all parties, field research, and fish passage facilities experience at other locations throughout the West. Plan phases (with brief descriptions) include:

## **Radio-Telemetry Studies (2004-06)**

Since behavior of local migratory fish populations was not well defined, and this hydroelectric project has four different discharge locations that could attract fish (two powerhouses and two spillways), telemetry studies are the only means of identifying the most appropriate fishway location. Site-selection is the most fundamental and important aspect of the fishway design. The optimum location for a new fishway is adjacent to where migrating fish hold during the height of their migration, when they are actively attempting to pass upstream. Telemetry studies were designed to identify behavior of bull trout, westslope cutthroat, and rainbow trout, and to determine the optimum location for the new fishway.

## **Fishway Site-Selection Letter Report**

The draft letter report (January 17, 2006) combined fish behavioral conclusions from 2004 and 2005 telemetry studies with other factors, then recommended the optimum fishway location, as the basis for the feasibility study. Additional and expanded fish behavioral information from the 2005 draft telemetry report was requested by the fisheries agencies representatives at the January 27, 2006 meeting. A final GEI report, with additionally requested information, is titled “Fish Behavior in the Tailrace of Thompson Falls Dam – Results of 2005 Radio Telemetry”, dated May 30, 2006. Since the final telemetry report included additional fish behavior insights, it was appropriate to delay finalizing this letter report until the additional behavioral information could be reviewed and factored into conclusions of this report.

## **Feasibility Study**

The fishway feasibility study was initiated early in 2006 to develop multiple fishway alternatives for the Main Dam right abutment (as recommended in the draft letter report). However, it was decided that, based on feedback from the resource agencies, a Main Dam left bank option should also be included. The feasibility study now includes a left bank full-height ladder, a right bank full-height ladder, and a right bank lock-type trap and haul

facility. The end-product will be the Preferred Fishway Alternative, which will be the basis for advancing into the preliminary design phase.

### **Preliminary Design Development**

This design development phase entails additional site investigations, and further development of the Preferred Fishway Alternative (from the Feasibility Study). Since this design phase results in the 20-25%-complete fishway design, an improved site layout and cost estimate will be provided. The fishway layout from this phase will remain essentially unchanged through completion of plans and specifications. It will identify location and size/capacity of most features of the recommended fishway.

### **Preparation of Plans and Specifications**

Once the resource agencies feedback is received on the preliminary design, completion of the final fishway design and preparation of plans and specifications will be initiated in 2007. Depending on timing of feedback, this phase could extend into 2008.

### **Permitting**

The biological assessment will be completed so that the U.S. Fish and Wildlife Service can issue a biological opinion on the project. In addition, PPL Montana will need to file an application to amend the FERC license and must receive a license amendment from FERC. Other state and federal permits will likely be needed, such as a Section 404 Water Quality Permit. These permitting activities are scheduled for 2008.

### **Bid and Procure Construction Services**

A bid solicitation will be prepared for competitive bidding in 2008. A construction contract will be awarded early in 2009, leaving adequate time for pre-construction preparation activities.

### **Fishway Construction**

Construction will probably take two years, and will be influenced by design, review, and approval schedules. The construction window is expected to begin with the end of the spring peak runoff period in 2009, and extend to the start of winter inclement weather. Completion of construction is expected in 2010.

## Existing Thompson Falls Facilities and Site Description

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While fishway site selection is relatively easy at many hydroelectric sites (where the powerhouse and spillway are often adjacent to each other), Thompson Falls features (old powerhouse, new powerhouse, dry channel spillway, and the main dam spillway) are separated by islands (See Figures 1 and 2). The distance from the downstream end of the old powerhouse upstream to the main dam (spillway) is approximately one-half mile. All four primary features discharge simultaneously during upstream migration periods of some years. This project layout would have made the selection of the optimum fishway site impossible, without radio-telemetry studies. The following is a brief description of primary project features:

### Old Powerhouse

The original, downstream-most right bank powerhouse is composed of six Francis turbines rated at 5 MW each, each with hydraulic capacities of 1700 cfs. Total turbine capacity is 10,200 cfs. Powerhouse maximum operating head is 62 ft at both powerhouses. Two of these old units provide station service. A large wingwall (located parallel to the river centerline) protects the powerhouse structure from high river discharges, and routes turbine discharge directly down river and along the shoreline immediately downstream of the powerhouse.

### New Powerhouse

The new powerhouse is immediately upstream of the old powerhouse, and has one large Kaplan turbine with a capacity of approximately 13,000 cfs. As the newest and most efficient turbine, it logs the most hours during normal years.

### Main Dam Spillway

Once powerhouse capacity is exceeded, spill is initiated at the Main Dam. This spillway has 36 spill bays, with 34 bays having six manually-operated spill panels (lift panels) each. Two large center-dam radial gates (Figure 3) compose spill bays 16 and 17. The Main Dam is the most upstream project feature, and is located in the original river channel (immediately upstream of the original falls). Lift panels are 4 ft wide and 8 ft high, and are manually raised and lowered by a tracked lift. Each panel passes 233 cfs. The 10-12 panels to the right of the two radial gates are near the forebay trash boom tied to the dam, and are rarely opened. Normal (pre-2001, non fish-trapping) operation generally consisted of opening left spill panels first, then progressively opening panels to the right, approaching the right abutment (with exceptions noted above). Left-to-right spill panel operation facilitates debris-handling, which is especially important during the rising hydrograph. Project operators try to balance

lift panel openings on each side of the trash shear boom, which minimizes excessive lateral hydraulic loading and limits boom problems.

The two radial gates are 41 ft wide, and each have a capacity of approximately 10,000 cfs. Their primary functions are to keep the forebay at a constant elevation at night during the spring (on the rising hydrograph), until operators can adjust the required lift panel numbers the next day; and, to maintain load-rejection capacity.

Capacity of 192 spill panels is approximately 44,736 cfs. Flow from each lift panel spreads laterally as it passes down the spillway face, and over a concrete apron before passing into the bedrock-lined tailrace channel.

Underneath the lift panels are eight, 1-ft high bulkheads. In years when total river discharge is expected to exceed 100,000 cfs during the spring freshet, a special operation removes bulkheads before the spill season. Otherwise, these bulkheads are not opened. Total capacity, without bulkheads and including the two radial gates, is approximately 65,000 cfs. Currently, uncontrolled leakage of bulkheads (below spill panels) totals approximately 200 cfs.

### **Dry Channel Spillway**

This smaller spillway is between the new powerhouse and main dam spillway, and is separated from each by islands. It is only operated when additional spill capacity, above that of the main dam spillway, is exceeded. The Dry Channel has 72 total lift panels (similar to those at the Main Dam), and a capacity of 16,776 cfs. Total spill capacity of the two spillways, without removing Main Dam bulkheads, is approximately 82,000 cfs.

## 2006 Spill Operations

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Although primary spillway operations have traditionally been for the purpose of passing project discharges above total powerhouse capacity, and enabling passage of coarse debris, experience at other locations suggests that spillway operational flexibility may allow development of a spillway protocol that will induce fish holding near the new fishway, thereby improving upstream passage. While past spill operations have generally entailed initial opening of left spill panels at the Main Dam, then progressively opening spill panels to the right, there was a moderate level of flexibility in how to satisfy project operating needs. This included whether to open primarily left spillway lift panels (vs right lift panels), and when to initiate opening of dry channel lift panels.

In 2001, with installation of a temporary fish trap (for collection and radio-tagging fish for telemetry studies), the lift panel sequence was modified and generally followed so to protect the fish trap from high flows. The spill panel opening-closing guidelines called for gates to initially be opened from the right. This allowed the trap (composed of a length of pre-fabricated steepass, baffled-chute ladder lowered into slots in bedrock outcrops near the left abutment) to operate during low spill periods (See Figure 5).

However, 2004 and 2005 telemetry studies results suggested there was operational flexibility to develop a more regimented spill schedule that would control Main Dam tailwater hydraulic conditions (and potentially control fish holding locations). The 2006 spill operating schedule was coordinated with operators at the project, revised to address both fish behavior and operations concerns, and implemented during the 2006 telemetry study. (The final revised spill schedule, dated May 2, 2006, appears in the Appendix.) The hypotheses, and basis for the 2006 telemetry study, are that spill gate manipulation will (1) change tailrace holding behavior of tagged fish, and (2) enhance fish attraction to a specific tailwater location (such as a future fishway site).



## Hydrology

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An important consideration in selection of an optimum upstream passage fishway location at Thompson Falls is hydrology. Migrating bull trout, westslope cutthroat, and other species appear to move upstream most aggressively before, and during, the rising limb of the hydrograph each spring. Tailwater conditions at each project location vary appreciably, dependent on project discharge levels and whether there is spill. Figure 9 shows total powerhouse discharge, spill, and total project discharges for spring 2005. Figure 10 shows project discharges during 2004 and 2005. Figure 11 shows mean daily streamflows for 1965 – 2004 at the Plains, MT (USGS) stream gage site. During peak flows of many years, high discharges will increase turbulence and turbidity to the extent that fish attraction to the new Main Dam fishway may be temporarily negated. Design high and low project discharges, for which the fishway will be expected to operate and pass fish, will be identified in the next design phase. The basis will be hydrology, localized hydraulic conditions near the fishway, and observed fish behavior.

## **Basis for Fishway Site Selection: 2004 and 2005 Radio-Telemetry Study Results**

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Little was known about behavior of local species in the project area prior to initiation of telemetry studies. It was necessary to investigate and characterize fish behavior, so the optimum fishway site could be selected for fishway design development. Although the target species are bull trout and westslope cutthroat trout, the tentative goal is to pass as many native and game fish as possible. Important issues to be determined were the timing of different species at the site (designated by total “hits”, in 15-minute increments for each antenna coverage zones) and how each fish responds to tailrace hydraulic conditions. The initial draft report did not include tracking summaries of each tagged fish, which Resource Agencies requested at the January 27, 2006 meeting. The following are conclusions from the final report (dated May 30, 2006):

Observations from the draft 2004 and 2005 radio-telemetry results, as they relate to selection of the optimum upstream passage fishway, included:

- 1) Bull trout, westslope cutthroat trout, and rainbow trout were radio-tagged during 2004 and 2005 studies. All but one tagged fish that entered the Thompson Falls project area in 2005 made their way to the Main Dam at least once, including six tagged bull trout.
- 2) They appeared at the Main Dam during the early spring, prior to spill, and were detected at the Main Dam from April into June. Later, they fell back to downstream locations or left the project area entirely. Some tagged fish may have been headed to Prospect Creek.
  - a) Most of the six bull trout that were tracked in 2005 were tagged by Avista, released near the Vermillion River mouth, and arrived at the project in late May. They made short forays to the Main Dam (when spill ranged from 5,000-30,000 cfs), then fell back to the Prospect Creek area for the remainder of their time at the project site (before leaving in mid-summer).
  - b) Westslope cutthroat approached the Main Dam prior to the end of May, and all left the project area prior to July 19.
  - c) Rainbows were abundant at the project prior to spill, but detections dropped quickly after the start of spill. These fish had mostly left the project area after May 24.
- 3) Fish holding in 2005 was primarily at the center and left side of the Main Dam. This correlated with the 2005 spill operation that spilled more at the right half of the Main Dam – which increased tailrace turbulence and holding difficulty for fish.
- 4) Fish appeared to follow the main channel, well upstream from both powerhouses, before ascending the steep-gradient zone to the Main Dam tailwater. Although counter-intuitive,

fish even left the bulk of project discharge at powerhouses during non-spill periods, and moved nearly a half-mile upstream (in the quiescent, original river channel) searching for an upstream fish passage route. Behavior was the same during spill operations.

- 5) Leakage (from the hinged bulkheads below spill panels) was enough to allow many fish to pass the steep-gradient zone to the immediate Main Dam tailwater prior to spill operations.
- 6) Without Main Dam leakage lower break-away bulkheads, discharge through the steep-gradient reach would drop to zero, and passage into the immediate Main Dam tailrace (and through the steep gradient reach extending from approximately 150 ft to 400 ft downstream of the Main Dam spillway apron) would be confined to periods of spill.
- 7) If spill leakage is negated at some future time, and discharge from the new fishway is the only flow down the mid-channel thalweg, it is unknown whether fish would be able to ascend during non-spill periods. In this case, some provision for increasing flow at the Main Dam (near the fishway) may be required.
- 8) While ascent through the steep-gradient reach during non-spill (leakage-only) periods was at mid-channel (Figure 6), high discharge and more formidable hydraulic conditions occurred at mid-channel during periods of spill (Figure 7). During moderate spill periods, tagged fish either stayed immediately below the spillway, or ascended the steep gradient reach along both shorelines.
- 9) Tagged fish “hits” during spill periods may have been from fish that ascended the steep gradient reach during spill operations, or were from fish that previously approached the dam, and were able to stay in the immediate tailrace during spill operations.
- 10) Fish appear to gravitate to more quiescent zones directly adjacent to highly turbulent zones downstream from open spillway lift panels. Telemetry data, experience at other sites, and 2004/2005 spill operations, suggest it may be possible to attract fish to desired tailwater zones downstream of the Main Dam by manipulating spill gates. This is expected to be an important means of optimizing fish passage at the proposed fishway.

Based on the perceived optimum Main Dam fishway location, it is hypothesized that a spill operating schedule listing which Main Dam and Dry Channel lift panels to open/close on the ascending/descending hydrograph can be developed that will control and enhance tailrace hydraulic conditions, while satisfying operational needs. Since fish behavior is “rheotactic” (directly influenced by hydraulic conditions), it is expected that fish can be attracted to a holding zone near the perceived optimum fishway location. This hypothesis was addressed in the 2006 telemetry study plan. (The final revised 2006 spill schedule appears in the Appendix.)

A 2006 telemetry study objective is to address whether tailrace fish behavior will change if more spill occurs at the left and center of the Main Dam, forcing more fish to the right abutment. If so, both left and right abutment fishways could be investigated in the feasibility study, with the expectation that fish could be passed on either side.

## Discussion

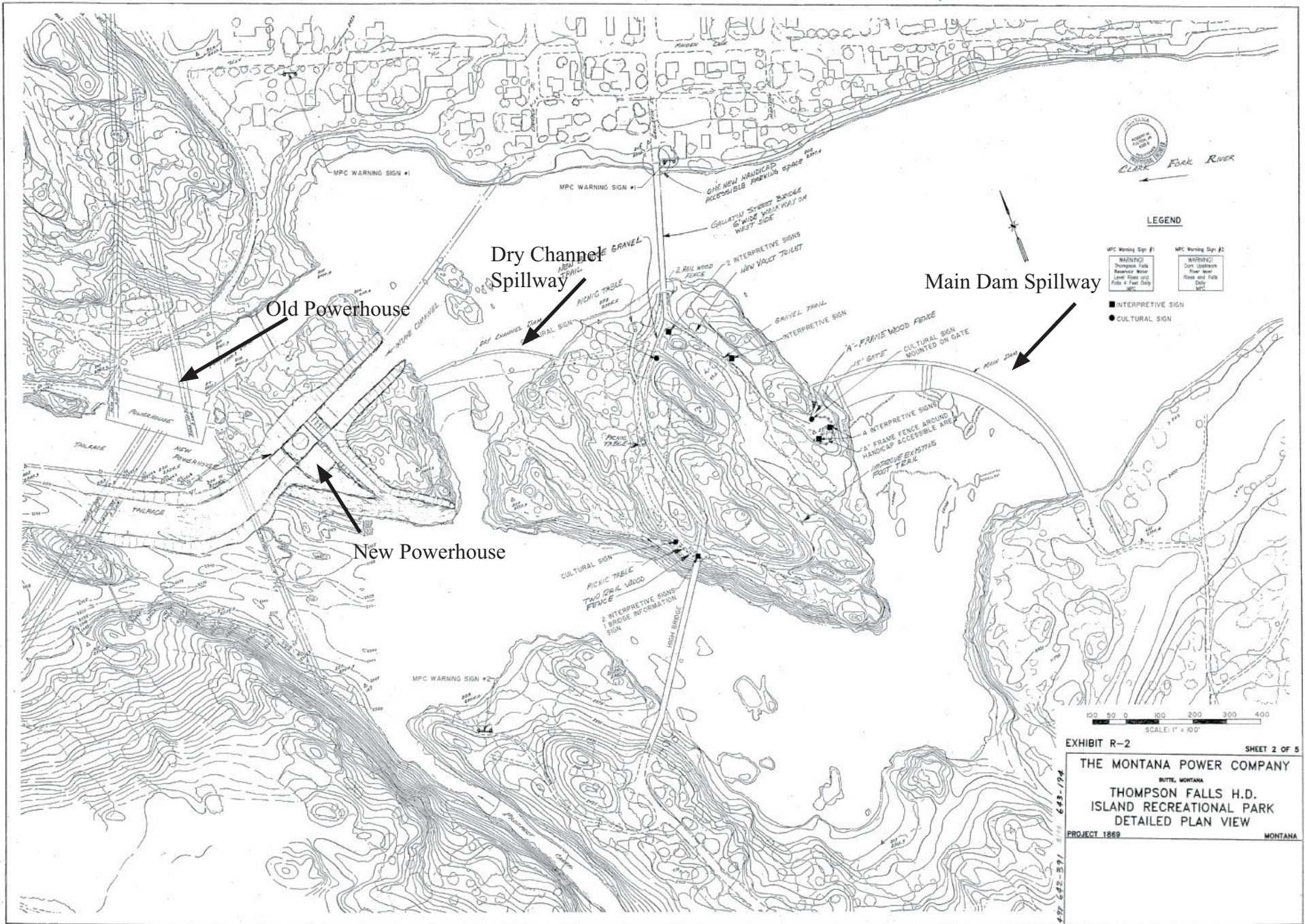
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The optimum fishway location is adjacent to where fish tend to accumulate during the height of their upstream migration, through the fullest possible range of river discharges. The 2004 and 2005 telemetry studies report suggests that tagged fish moved upstream of total powerhouse discharges in excess of 20,000 cfs before and during spill, and migrated to the upstream-most point of the original channel (Main Dam). The conclusion was that the Main Dam was the optimum location for a new fishway.

It is apparent from 2005 cumulative data that fish appear to be more aggressively seeking upstream passage at the furthest upstream terminus of the original channel before spill and during the rising hydrograph. This behavior could be termed “*primary*”, in contrast with “*secondary*” behavior after peak spill. There was general agreement at the January 29, 2006 meeting with the resource agencies that the new fishway site should be selected to conform with the shorter window of *primary* upstream migration behavior, rather than *secondary* behavior (when net fish movement is primarily downstream).

The 2006 study plan was developed to identify whether a protocol (spill schedule) could be developed that would control tailrace hydraulic conditions below the Main Dam spill gates, and thus where tagged fish would aggregate. The final revised 2006 spill schedule, which was developed to see if tagged fish approaching the Main Dam would pass near the right abutment, appears in the Appendix.





MPC #43391-D24 SHT 2 FERC #1869-50

Figure 1

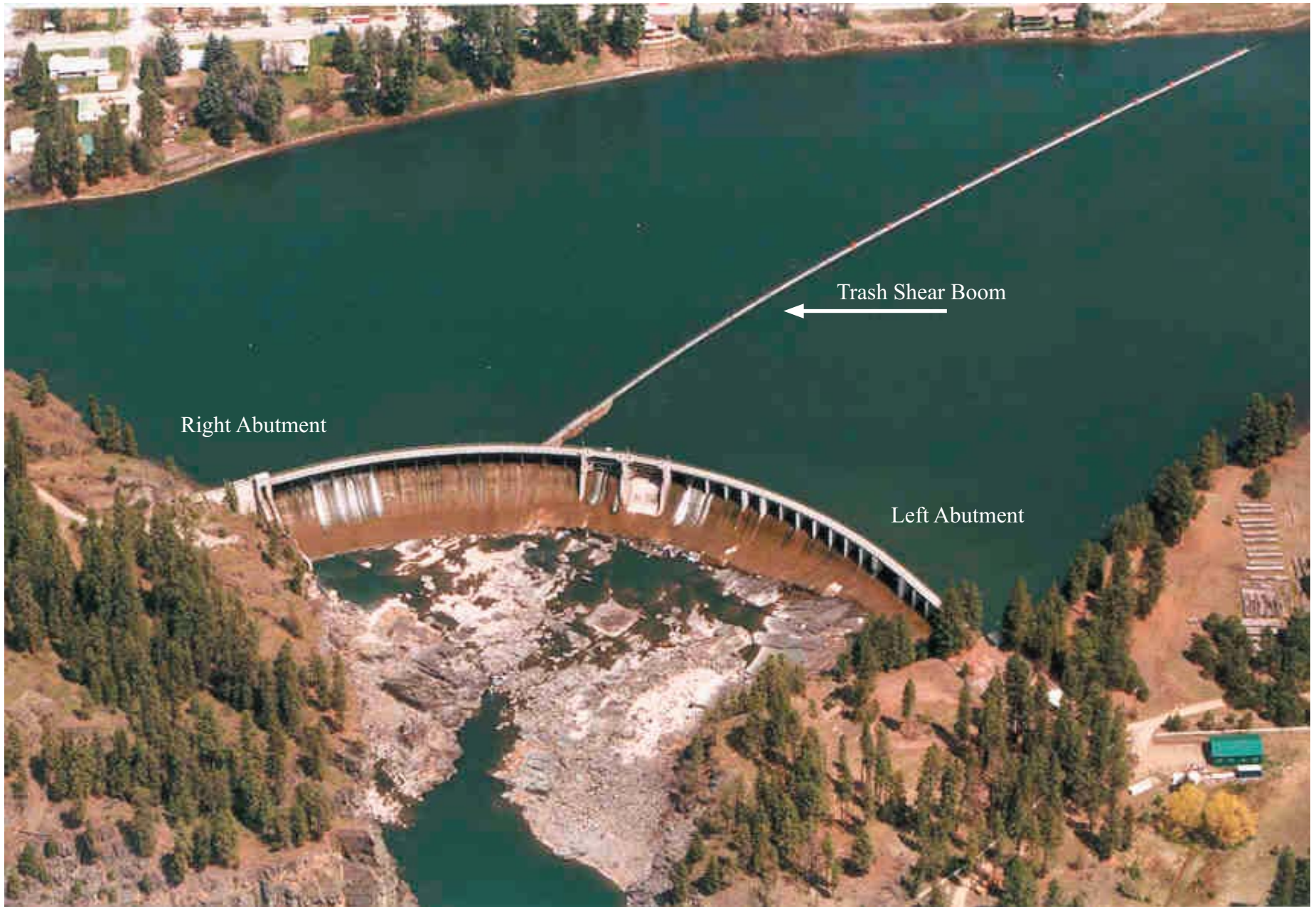




Thompson Falls Aerial Photo

Figure 2





Main Dam Spillway

Figure 3





Main Dam Spillway - Right Abutment

Figure 4





Main Dam Spillway - Left Abutment

Figure 5





Main Dam Spillway - Spillgate Leakage Only

Figure 6





Main Dam Spillway with 6,000 CFS Spill

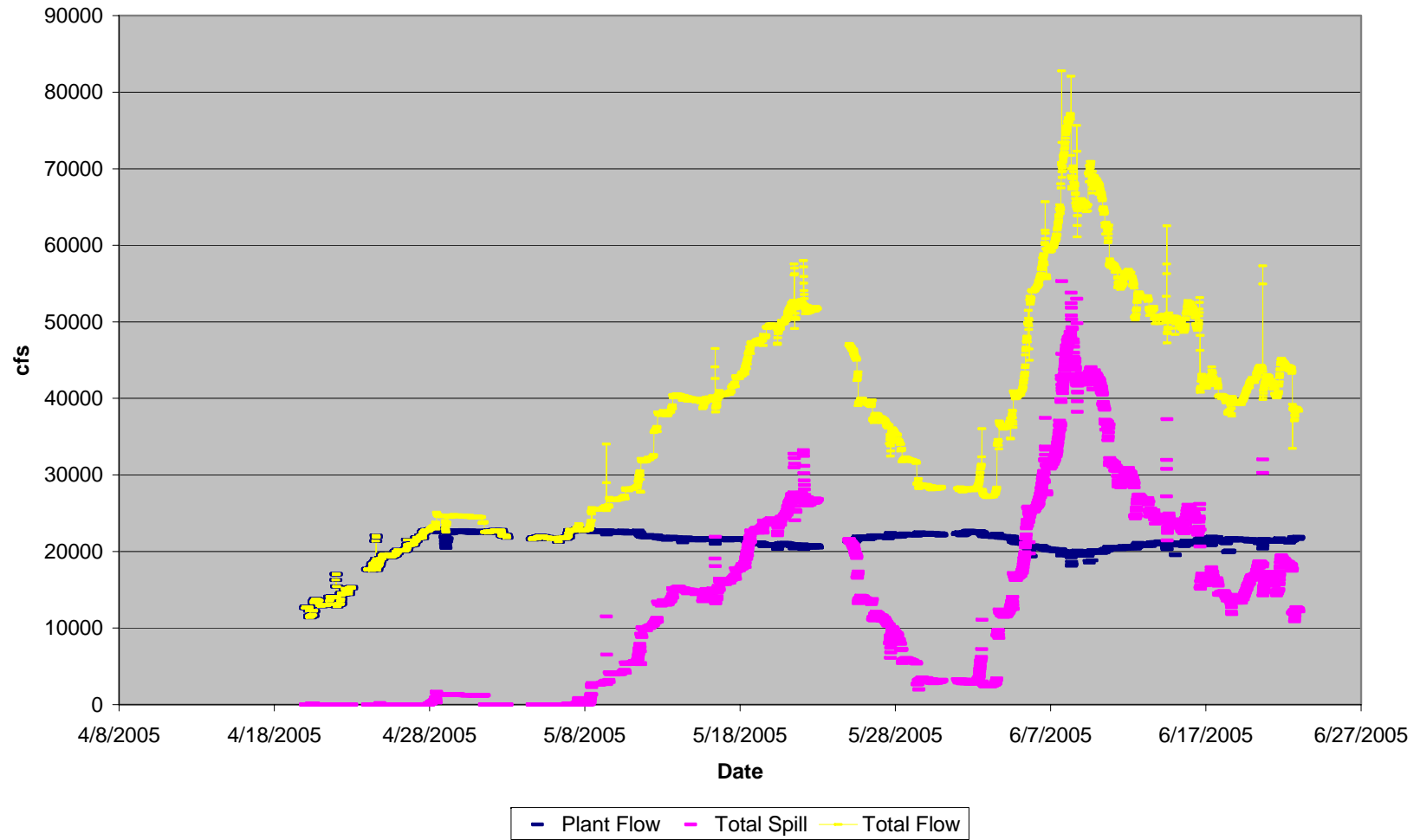
Figure 7





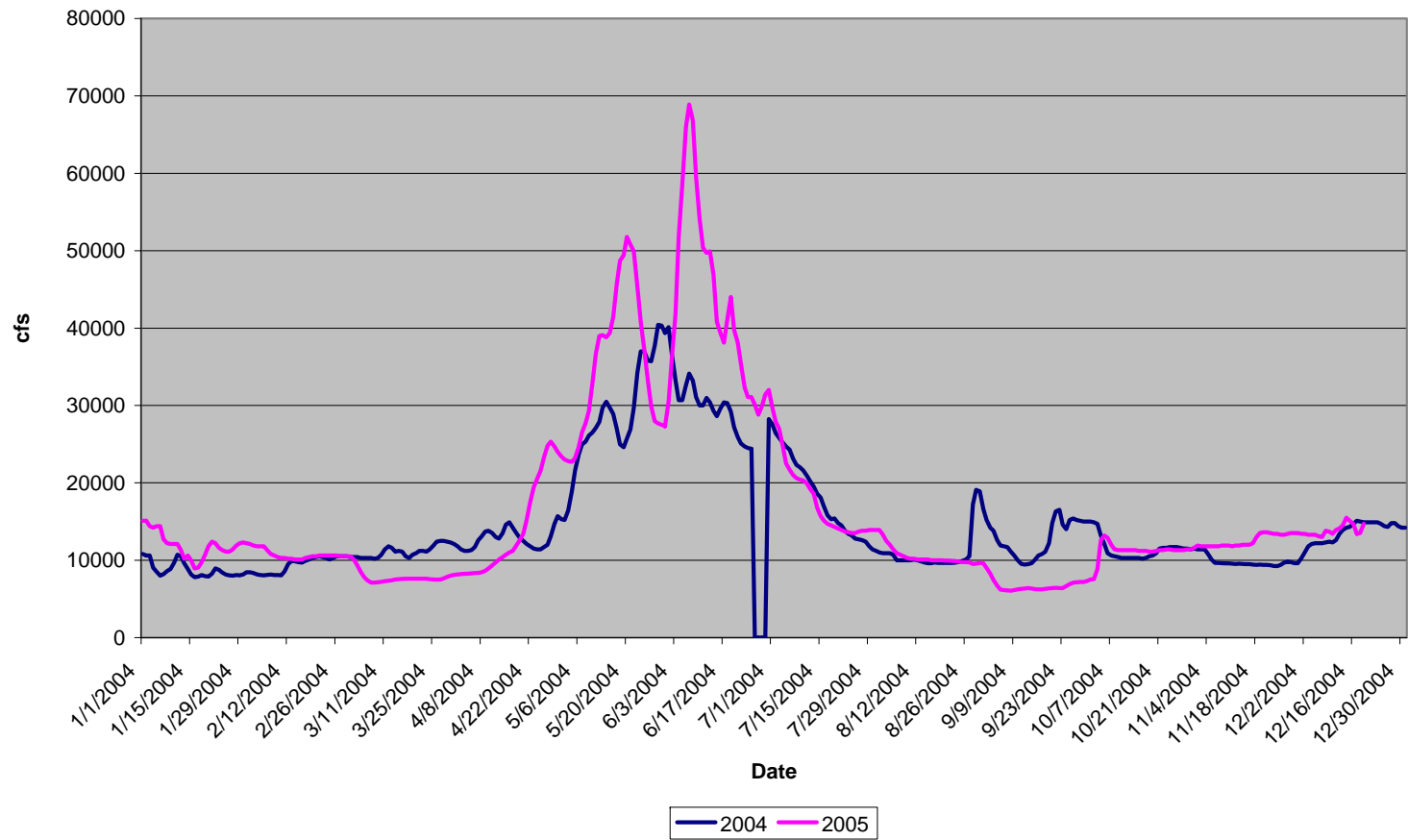
Main Dam Spillway - Right Abutment

Figure 8



Thompson Falls Plant Operations and Spill, Spring 2005

Figure 9



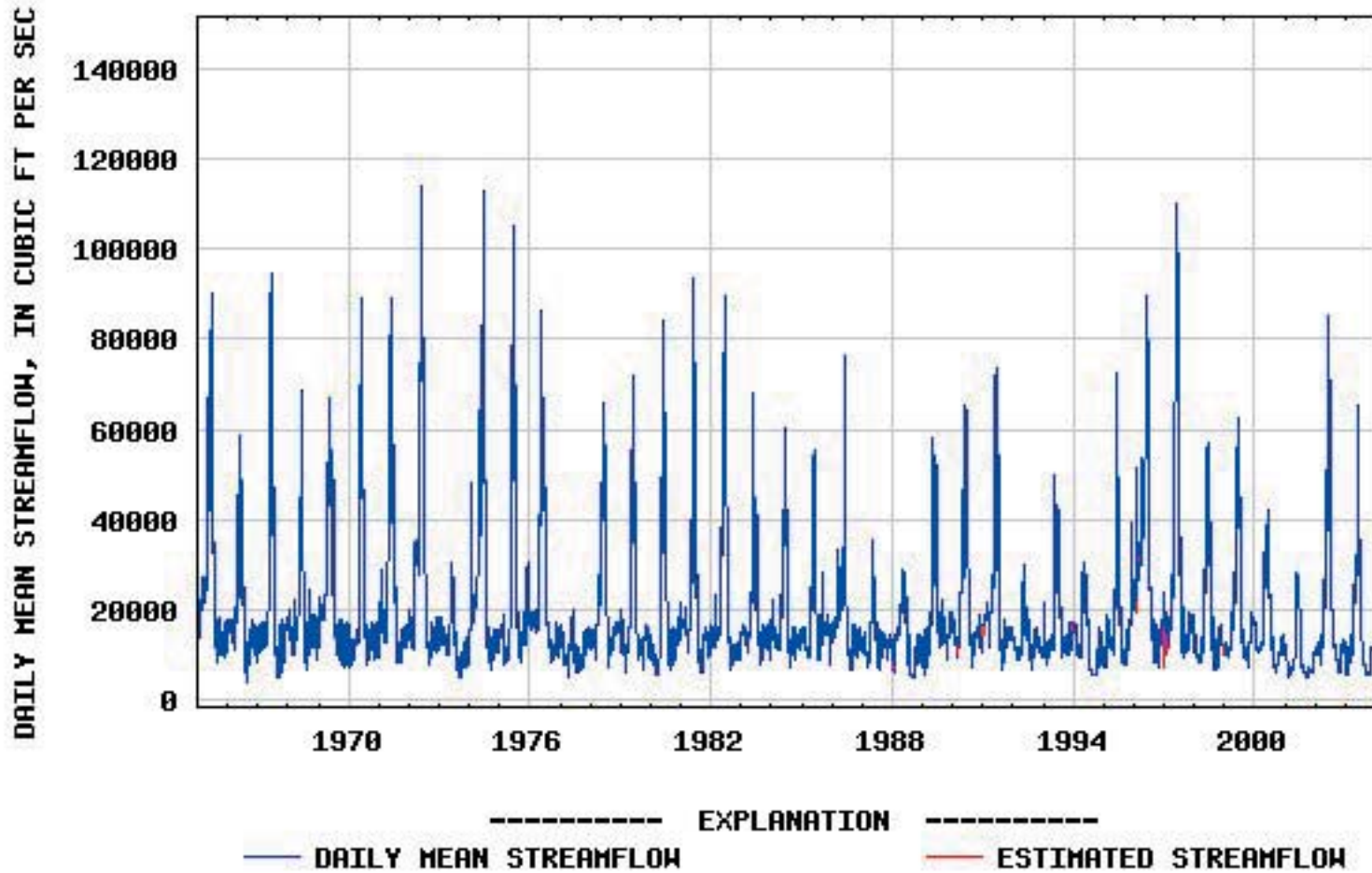
Clark Fork River, Plains, USGS, 2004 - 2005

Figure 10





### USGS 12389000 Clark Fork near Plains MT



Daily Mean Stream Flows, 1965-2004

Figure 11