RECLAMATION
Managing Water in the West

FLATHEAD BASIN TRIBAL DEPLETIONS STUDY

U.S. Department of the Interior

Bureau of Reclamation
Pacific Northwest Region
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Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Cover photo: Part of the western slope of the Rocky Mountains that form a major portion of the Flathead River watershed, a major tributary to the Columbia River Basin.

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Executive Summary

The Bureau of Reclamation analyzed the potential use of storage water from Hungry Horse Reservoir to augment water supplies for the Confederated Salish and Kootenai Tribes of the Flathead Nation (CSKT). The information revealed by the analysis will be used to determine the best way to meet supplemental water requirements sought by the CSKT through their water rights settlement effort. In the analysis, the Tribes' 1855 Hellgate Treaty priority date was held senior to the 1920 water rights on Flathead Lake and the junior water rights on Hungry Horse Reservoir. Additionally, Hungry Horse Reservoir was drafted for flow augmentation as required under the 2008/2010 NOAA Fisheries Service Federal Columbia River Power System Biological Opinion (2008/2010 FCRPS BiOp), in each modeled scenario.

Three scenarios were modeled: 1) the Base Case which featured current diversions along with flow augmentation required by the 2008/2010 FCRPS BiOp; 2) the Natural Q scenario which is the Base Case with new CSKT diversions met with the natural Flathead River flows as much as possible; 3) the Natural Q plus 90K scenario which is the Base Case plus natural flows for the new CSKT diversions and a fixed amount of 90,000 acre-feet of water released from Hungry Horse Dam to help meet the new Tribal diversions.

Analysis of the model simulations between the Base case and the Natural Q and the Natural Q plus 90K scenarios depicted the effects the new CSKT diversions would have on Hungry Horse Reservoir, the Flathead River downstream of Hungry Horse Reservoir, Flathead Lake, and the lower Flathead River.

The modeled results showed that for Hungry Horse Reservoir there were no differences in the storage and discharges between the Base Case and the Natural Q scenario. The natural flow downstream of Hungry Horse Reservoir and normal Hungry Horse Dam discharges were able to meet the new diversions and additional discharges from Hungry Horse Dam were not required. For the Natural Q plus 90K scenario, the increased discharges from Hungry Horse Dam during the summer caused the elevation of the reservoir to be approximately 4 feet lower at the end of the summer. The increased fall drawdown affected the ability of Hungry Horse Reservoir to fill the following spring during dry years. An analysis of annual maximum elevations of Hungry Horse Reservoir showed a difference of one foot or less in 86 percent of the water years when comparing the Base Case and the Natural Q plus 90K scenarios.

A comparison of the amount of spring and summer discharges from Hungry Horse Reservoir between the Base Case and the Natural Q plus 90K scenarios showed that in above average water years, flood control releases would be made before April 10, the start of the spring flow augmentation period, and the rest of the discharges over the spring

and summer would not be changed. In near average water years, Hungry Horse Dam discharges would be decreased in the spring because the reservoir would be entering the flood control at a lower elevation and less water would need to be released in the April 10 through June 30 period. In below average water years, the flow augmentation volume in the summer would be decreased because of the inability to fill to as high a level in the Natural Q plus 90K scenario as in the Base Case.

New Tribal diversions were not fully met with the Natural Q scenario in most of the water years. Shortages of 20,000 acre-feet or greater occur 20 percent of the time with the maximum shortages being 120,000 acre-feet in the March through September period. In the Natural Q plus 90K scenario, most of the Tribal diversions are met with the extra 90,000 acre-feet released from Hungry Horse Reservoir. There were less than 20,000 acre-feet of diversion shortages for all of the years, with over 80 percent of the years having no shortages in the Natural Q plus 90K scenario. The shortages that did occur in this scenario occurred in the March through June period and in October.

Modeled Tribal diversions impacted the summer elevation of Flathead Lake in some years. In the modeling, no adjustments were made to the 4(e) outflows for drought management. A comparison of summer Flathead Lake elevations showed that in 83 percent of the time over the 70-year modeled period that there was no difference in summer elevations between the Base Case, the Natural Q scenario, and Natural Q plus 90K scenario. The greatest differences in elevation between the Base Case and the Natural Q plus 90K scenario was 0.4 feet which occurred less than 3 percent of the time over the 70-year modeled period. The differences in Flathead Lake summer elevations were due to the natural flow in excess of the Flathead Lake storage right being used for the new Tribal diversions rather than storage in Flathead Lake.

River flows at the Flathead River at Perma were decreased for the Natural Q and the Natural Q plus 90K scenarios when compared to the Base Case. The total volume decrease on an annual basis ranged from 104,000 to 120,000 acre-feet for both scenarios. The decreases in flows at the Perma gage were the greatest during the summer flow augmentation period of July through September with the differences being 9 percent of the total flow (619 cfs) for the Natural Q scenario and 13 percent of the flow (761 cfs) for the Natural Q plus 90K scenario.

This modeling analysis is not a proposal for current or future operations; it only gives results of possible effects that the new Tribal diversions could have on the Flathead basin given some predefined modeling assumptions. The results are intended to provide a starting point for further analysis of what effects new Tribal diversions could have in the Flathead basin.

Introduction

The Confederated Salish and Kootenai Tribes of the Flathead Nation (CSKT) are negotiating with the State of Montana and the United States regarding reserved and aboriginal water right claims that fall under the 1855 Hellgate Treaty and subsequent guidance. The treaty established the Reservation and guaranteed the Tribes the right to hunt and fish in common with non-Indians off the Reservation. The treaty also laid the framework for claims for future Tribal uses, including irrigation and other uses necessary to satisfy the purposes of the Tribal homeland. The Dawes Act and subsequent Flathead Allotment Act of 1904 opened up reservation lands to non-Indians resulting in a checkerboard land ownership pattern. This has increased the complexity of current water use patterns and the issues surrounding water rights settlement efforts.

The parties to the CSKT negotiations agreed to evaluate whether part of the Tribal water right could be met by augmenting water supplies with water from Reclamation's Hungry Horse Reservoir. The Pacific Northwest Regional Office of the Bureau of Reclamation (Reclamation) administers the reservoir which is upstream of the Reservation. The reservoir impounds over 3 million acre-feet of water which is used for flood control and power generation. Releases are also made to maintain minimum flows on the Flathead River in compliance with the 2000 U.S. Fish and Wildlife Service Biological Opinion (2000 USFWS BiOp), and to augment flows for downstream fisheries in compliance with the 2008/2010 NOAA Fisheries Service Federal Columbia River Power System Biological Opinion (2008/2010 FCRPS BiOp).

In late 2007, Reclamation was asked to model the potential use of storage water from Hungry Horse Reservoir to augment water supplies for the CSKT. Simulation studies were performed by Reclamation to investigate the effects of CSKT depletions (defined as the quantity of water diverted minus the quantity of water which returns to the river as a result of the diversion) on the entire Flathead River system. The estimated CSKT upper limit depletions for future use are about 128,000 acre-feet annually.

The results of the preliminary modeling studies, presented by Reclamation at a public meeting (CSKT, State of Montana Reserved Water Rights Compact Commission, and United States Water Rights Negotiation Session) on October 22, 2008, showed that only taking storage from Hungry Horse Reservoir to meet additional CSKT depletions drafted Hungry Horse Reservoir up to 6 additional feet in some years, causing reservoir releases to be reduced substantially in the following spring and summer and impacting the ability to comply with the 2008/2010 FCRPS BiOp. Based on this observation, additional modeling assumptions were developed to model the Tribal diversions by meeting the targets first with natural flow and subsequently with storage from Hungry Horse Reservoir.

Description of the Project Area

The headwaters of the Flathead River comprised of the North, Middle, and South Forks, flow on the western slope of the Rocky Mountains in Montana (Figure 1). The Middle Fork and South Fork originate near the Continental Divide in the United States; the North Fork originates in British Columbia, Canada. The South Fork joins the Middle and North Forks a few miles upstream of Columbia Falls, Montana. From Columbia Falls, the Flathead River flows in a southerly direction through a meandering channel in a wide floodplain before entering Flathead Lake about 20 miles downstream of Kalispell, Montana. The Flathead River continues southward from the lake until it joins the Clark Fork near Plains, Montana. The Clark Fork flows northwesterly into Lake Pend Oreille in Idaho.

The Flathead River passes through two dams: Hungry Horse Dam, located in western Montana at river mile 5 of the South Fork Flathead River, and Kerr Dam, located at the outlet of Flathead Lake. The Flathead River basin above Kerr Dam covers about 7,100 square miles and produces an average annual runoff of about 2.5 million acre-feet at Hungry Horse Dam and 8.3 million acre-feet at Flathead Lake. The average annual runoff is about 8.6 million acre-feet at Perma, Montana which is located on the Flathead River, 14 miles downstream from Kerr Dam and 11.2 miles upstream of the confluence with the Clark Fork.

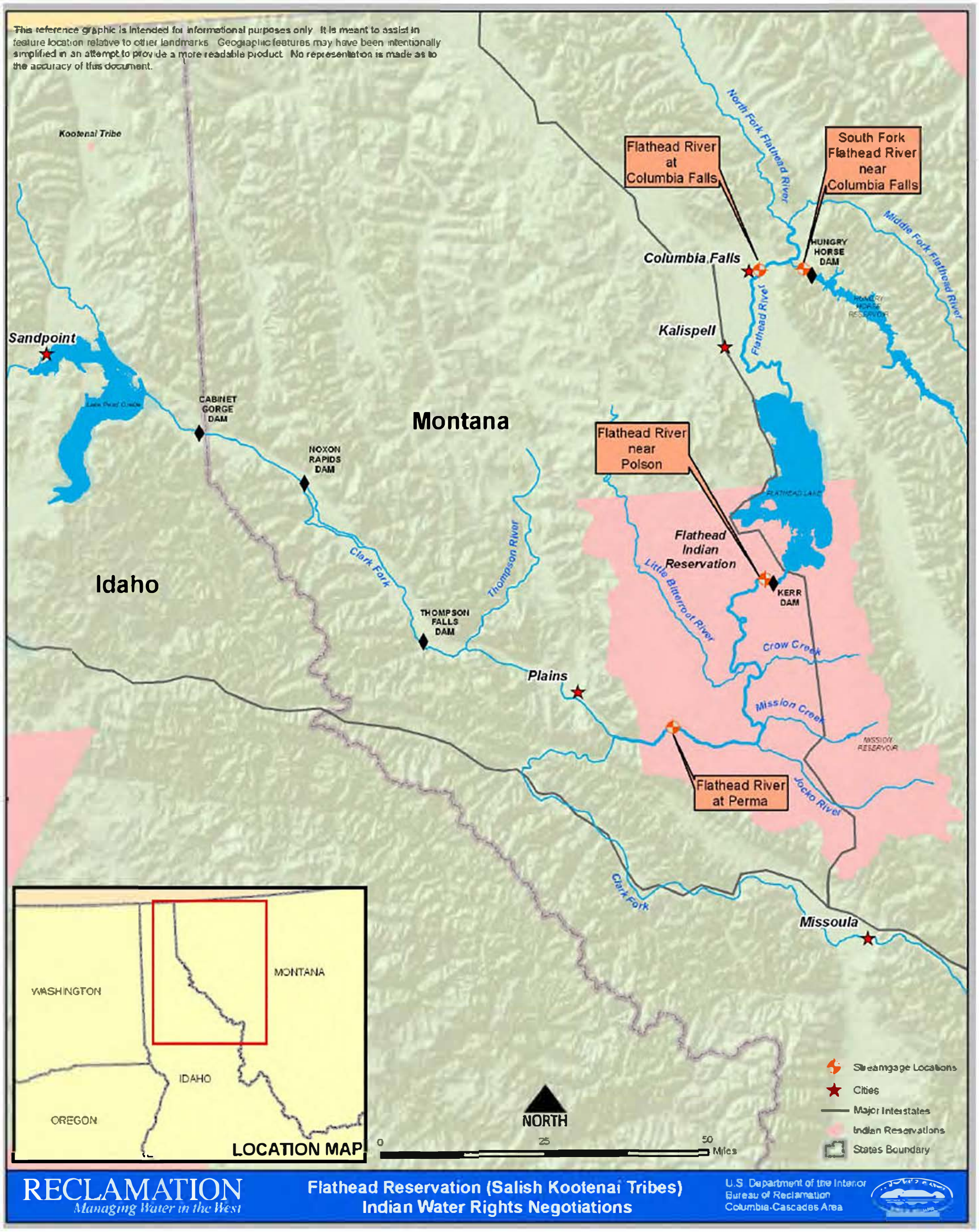

Figure 1. Map of Study Area

Hungry Horse Dam, owned and administered by Reclamation, is primarily operated for hydroelectric generation, flood control, fish and wildlife conservation, in-stream flow regulation, and recreation. It is part of the Federal Columbia River Power System and is utilized for Columbia River system flood control under VARQ Flood Control Operations. These operations are documented in "Final Environmental Impact Statement for the Upper Columbia Alternative Flood Control and Fish Operations" (US Army Corps of Engineers 2006) and the "Bureau of Reclamation Record of Decision for Upper Columbia Alternative Flood Control and Fish Operations Final Environmental Impact Statement" (Reclamation 2009). The reservoir is usually drafted during the winter and early spring for flood control and refilled by late June or early July. Although Hungry Horse Reservoir was not specifically authorized for fish and wildlife conservation, regulating streamflow to support endangered species locally and downstream in the Columbia River is mandated by the Endangered Species Act (ESA). Hungry Horse Dam water discharges provide flow augmentation for ESA-listed salmon and steelhead in the Columbia River during the spring and summer months and minimum flows for ESA-listed bull trout year-round in the Flathead River.

Flathead Lake is located about 51 miles downstream of Hungry Horse Reservoir on the mainstem Flathead River. The southern half of Flathead Lake is within the 1,244,000-acre Flathead Reservation. The Kerr Dam and Powerplant, components of the Kerr Project, regulate the top ten feet of Flathead Lake and are currently owned and operated by Pennsylvania Power and Light (PPLM). The facility is located within the Reservation approximately four miles downstream of the natural outlet of Flathead Lake and about five miles southwest of Polson, Montana. The Kerr Project operations address multiple purposes including hydroelectric generation, flood control, recreation, irrigation, and conservation of fish and wildlife resources. The CSKT has the option of purchasing and taking over the operation of Kerr Dam in 2015 (PPLM 2009).

Kerr Dam operates under a joint Federal Energy Regulatory Commission (FERC) license between PPLM and the CSKT with conditions that include minimum flow requirements (4[e] flows) to protect Tribal resources on the lower Flathead River and its tributaries. During the summer and early fall, Kerr Dam is operated to maintain Flathead Lake at a nearly full pool elevation as much as possible to benefit recreation interests. Flathead Lake also provides flood control protection locally, both upstream and downstream of the lake and for the Columbia River system. The lake is drawn down in winter and early spring and allowed to refill in mid-June when the threat of flooding is past.

Methodology and Assumptions

The purpose of this study was to evaluate the effects of supplementing water supplies by diverting water from the Flathead basin for uses that would be identified in the Tribes water right compact. With current operations, water is pumped from the forebay of Kerr Dam to provide water to users within the Flathead Indian Irrigation Project (FIIP). Potential new pumping locations and monthly diversion and return flow schedules were provided to Reclamation by the Tribes to support the modeling scenarios.

Under modeled conditions, new diversions are delivered by the existing FIIP pumping plant in the forebay of Kerr Dam, a new pumping plant on Flathead Lake, and a new pumping plant downstream at the confluence of Crow Creek and the Flathead River (Figure 2). The proposed maximum annual diversions from the Flathead basin are 229,383 acre-feet, with 144,397 acre-feet coming from Flathead Lake at the existing pump location and the new Flathead Lake pump site, and 84,987 acre-feet being pumped at the confluence of Crow Creek and the Flathead River (Table 1). When the proposed new diversions are fully met, maximum annual return flow total is estimated to be 101,225 acre-feet, with 3,796 returning to Flathead Lake; 37,309 acre-feet returning at the Crow Creek and Flathead River confluence; and 60,119 acre-feet returning from Mission Creek and the Jocko River back to the Flathead River (Table 2).

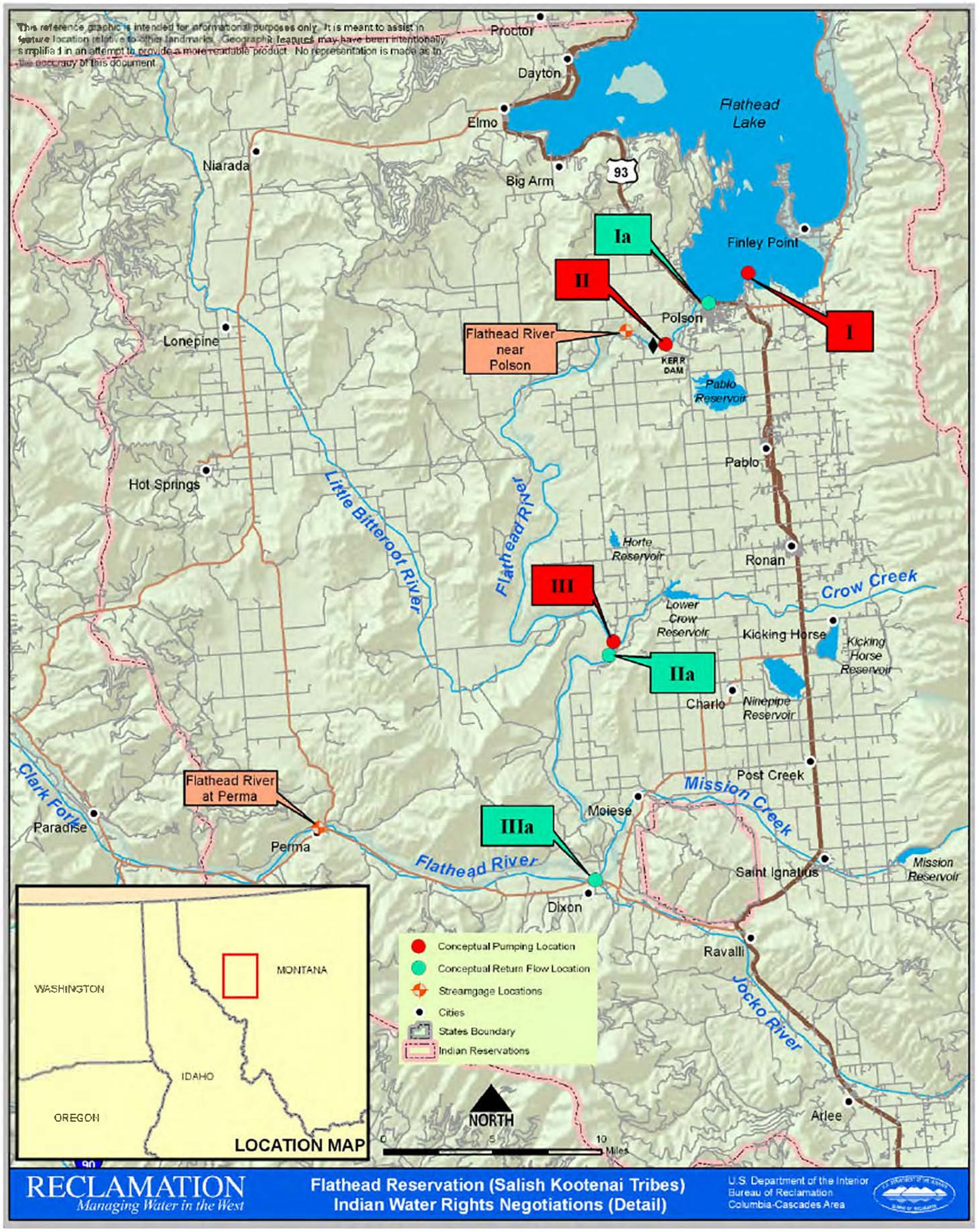

Figure 2 – Detailed Map of Study Area. Red dots show the points of pumping for the new Tribal diversions as given in Table 1. The green boxes show the points of estimated return flows as given in Table 2.

Table 1 - Estimated Upper Limit Diversions for Natural Q and Natural Q plus 90K scenarios. These values represent additional total diversion from the Flathead system (source HKM, file Flathead Depletions.xls, 12/28/2007).

ESTIMATED MAXIMUM AMOUNT												
I. -New Pumping from Flathead Lake (Acre-Feet)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1,266	1,085	1,266	1,085	4,544	9,590	16,458	16,975	12,753	2,953	1,085	1,085	70,145
II. - Increased Pumping from Flathead River at existing Pumping Plant (Acre-Feet)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0	0	0	200	8,001	18,069	16,442	16,994	12,241	2,306	0	0	74,252
III. - New Pumping from Flathead River upstream from mouth of Crow Creek (Acre-Feet)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
53	190	203	666	6,426	26,564	24,488	14,248	9,890	2,131	72	58	84,987
Total Increased Pumping from Flathead Lake and River (Acre-Feet)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1,319	1,274	1,469	1,951	18,972	54,223	57,388	48,217	34,883	7,390	1,157	1,142	229,383

Table 2 - Estimated Return Flows due to Upper Limit Diversions for Natural Q and Natural Q plus 90K scenarios. These values represent total additional local gains to the Flathead system (source HKM, file *Flathead Depletions.xls*, 12/28/2007).

ESTIMATED MAXIMUM AMOUNT												
I a. - Return Flows back to Flathead Lake (Acre-Feet)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
296	275	272	255	264	280	418	417	374	332	314	299	3,796
II a. - Return Flows in Crow Creek back to Flathead River (Acre-Feet)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1,289	1,020	823	831	5,502	10,372	5,389	3,045	2,948	2,688	1,843	1,560	37,309
III a. - Return Flows in Mission Creek and Jocko River back to Flathead River (Acre-Feet)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
812	803	683	1,052	4,513	21,957	15,362	6,731	4,040	2,023	1,162	980	60,119
Total Return Flows to Flathead Lake and River (Acre-Feet)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2,397	2,098	1,779	2,138	10,279	32,610	21,168	10,192	7,362	5,042	3,320	2,839	101,225

A simulation model was constructed to identify the effects of additional Tribal diversions on the Flathead basin. The Modsim[1] model was used to perform a daily time-step simulation using hydrologic inputs from water years 1929 through 2008. This approach assumes that future hydrologic conditions will be similar to past hydrologic conditions.

The modeling of natural flows was based on the following priority date scheme. Based on the Hellgate Treaty, the earliest priority is given to the new Tribal diversions that are withdrawn from Flathead Lake and the lower river. The next priority is given to the 1920 Flathead Lake flow rate water right held by PPLM which is 14,540 cfs to generate power at Kerr Dam. This water right is a flow rate into Flathead Lake until the full volume of the Lake is met. This flow right also includes the required 4(e) flows so the lake may not fill because part of the water right is used to meet these flows. The model keeps track of the total volume being accrued to this water right and when that volume equals the full volume of the lake, the water right is met in the model.

A second 1920 water right held by PPLM is a storage right for Flathead Lake and the volume claimed is "the amount necessary to fill (the) storage reservoir at any time". There was much discussion between Reclamation, the State of Montana Department of Natural Resources and Conservation (MT DNRC), PPLM and CSKT regarding how to interpret this storage water right for Flathead Lake and how it should be handled in the model. There was no indication that Hungry Horse Reservoir or Flathead Lake had been operated historically to fulfill this 1920 storage right or how this right relates to the flow right held by PPLM that was mentioned above. There was also confusion on how to interpret the original storage water right since it was not clear what the intent was. As far as the agencies listed know, the Flathead basin has not been operated historically with this storage right. The decision was made to model the basin based on the historic operations using the 1920 flow right of 14,540 cfs until Flathead Lake fills and not model the 1920 storage right[2]. The last priority is given to Hungry Horse Reservoir storage which is a 1947 water right and is the most junior water right for these two locations.

Three scenarios were modeled:

1. The Base Case simulates the 2008/2010 FCRPS BiOp. It includes the current level of diversions for irrigation in the Flathead basin and Hungry Horse Dam flow augmentation releases which are discussed later.

2. The Natural Q scenario includes the 2008/2010 FCRPS BiOp draft requirements

[1] Colorado State University 2009. MODSIM-DSS is a generalized river basin Decision Support System and network flow model developed at Colorado State University specifically for river basin managers.

[2] Discussion and decision on this point was made at a meeting between Reclamation, MT DNRC and CSKT held on February 11, 2010 in Missoula, MT.

and the new Tribal diversions that are met as much as possible with the natural flow in the Flathead River.

3. The Natural Q plus 90K scenario includes the 2008/2010 FCRPS BiOp draft requirements and the new Tribal diversions that are met first with natural flow water plus an additional fixed 90,000 acre-feet of storage water released from Hungry Horse Reservoir. For the months of July, August and September, new Tribal depletions from Flathead Lake are approximately 90,000 acre-feet (July – September diversions from the lake minus return flows to the lake; see Table 1). This amount of storage is taken from Hungry Horse Reservoir during these summer months to eliminate the shortages to the new diversions and to minimize the impact of the additional diversions on Flathead Lake elevations and downstream flows.

In the modeling for all the scenarios, Hungry Horse Dam provides minimum flows and follows ramping rates for flows in the South Fork of the Flathead River downstream of Hungry Horse Dam and in the Flathead River at Columbia Falls for ESA species protection (Tables 3 and 4). Water is released for flow augmentation for the lower Columbia River during the months of July through September. For flow augmentation the reservoir is drawn down to an elevation of 3550 feet (10 feet from full) by September 30, except in the driest 20 percentile of water years when the reservoir is drawn down to 3540 feet (20 feet from full). The driest 20 percentile water years, based on data from 1971 through 2000, are operationally defined as years in which the April through August volume forecast at The Dalles Dam on the lower Columbia River is less than 71,841,000 acre-feet. This flow augmentation water is released after Hungry Horse Reservoir reaches its maximum fill, which is usually around the first week of July, and continues through the end of September. These releases improve flow conditions for endangered species in the Columbia River.

Table 3: Flathead Flow Minimums below Hungry Horse Dam (USGS gage 12362500) and Columbia Falls (USGS gage 12363000)

If the April-August forecast is:	below Hungry Horse Dam	below Columbia Falls
greater than 1,790 KAF	900 cfs	3,500 cfs
1,190-1,790 KAF	400-900 cfs	3,200-3,500 cfs
less than 1,190 KAF	400 cfs	3,200 cfs

Table 4: Hungry Horse Dam Ramping Rates

If the discharge below Columbia Falls is:	Ramping UP may not exceed:
greater than 10,000 cfs	12,000 cfs /day
8,000 – 10,000 cfs	3,600 cfs / day
below 8,000 cfs	1,800 cfs / day

If the discharge below Columbia Falls is:	Ramping DOWN may not exceed:
greater than 12,000 cfs	5,000 cfs /day
8,000 – 12,000 cfs	2,000 cfs / day
6,000 – 8,000 cfs	1,000 cfs / day
below 6,000 cfs	600 cfs / day

In the modeling for all scenarios, the flow augmentation water from Hungry Horse is passed through Flathead Lake during the summer months. Kerr Dam also releases minimum downstream flows (4[e]) (Table 5) and follows ramping rates as required by its FERC licensing which provide flows for local fisheries (Table 6). The flow augmentation water from Hungry Horse is in excess of the Kerr Dam minimum flow requirements. The model also followed Flathead Lake filling criteria of raising the elevation of the Lake to elevation 2890 feet by Memorial Day (May 30th). The lake was then raised as rapidly and early thereafter as possible to elevation 2893 feet while taking into account the flood potential still existing in the river basin above and below the lake as determined by the US Army Corps of Engineers. When the flood potential is past, then the filling of the Lake is accelerated to reach elevation 2893 feet by June 15.

Table 5: Minimum Flathead River Flows Below Kerr Dam (U.S. Geological Survey gage 12372000)

Flathead River Mainstem Minimum Flow Daily Values As Measured at USGS Gage #12372000 Below Kerr Dam												
	Month											
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3200	3200	3200	3200	5510	12700	12280	3200	3200	3200	3200	3200
2	3200	3200	3200	3200	6020	12700	11860	3200	3200	3200	3200	3200
3	3200	3200	3200	3200	6530	12700	11440	3200	3200	3200	3200	3200
4	3200	3200	3200	3200	7040	12700	11020	3200	3200	3200	3200	3200
5	3200	3200	3200	3200	7550	12700	10600	3200	3200	3200	3200	3200
6	3200	3200	3200	3200	8060	12700	10180	3200	3200	3200	3200	3200
7	3200	3200	3200	3200	8570	12700	9760	3200	3200	3200	3200	3200
8	3200	3200	3200	3200	9080	12700	9340	3200	3200	3200	3200	3200
9	3200	3200	3200	3200	9590	12700	8920	3200	3200	3200	3200	3200
10	3200	3200	3200	3200	10100	12700	8500	3200	3200	3200	3200	3200
11	3200	3200	3200	3200	10610	12700	8080	3200	3200	3200	3200	3200
12	3200	3200	3200	3200	11120	12700	7660	3200	3200	3200	3200	3200
13	3200	3200	3200	3200	11630	12700	7240	3200	3200	3200	3200	3200
14	3200	3200	3200	3200	12140	12700	6820	3200	3200	3200	3200	3200
15	3200	3200	3200	3200	12650	12700	6400	3200	3200	3200	3200	3200
16	3200	3200	3200	3320	12700	12700	6200	3200	3200	3200	3200	3200
17	3200	3200	3200	3440	12700	12700	6000	3200	3200	3200	3200	3200
18	3200	3200	3200	3560	12700	12700	5800	3200	3200	3200	3200	3200
19	3200	3200	3200	3680	12700	12700	5600	3200	3200	3200	3200	3200
20	3200	3200	3200	3800	12700	12700	5400	3200	3200	3200	3200	3200
21	3200	3200	3200	3920	12700	12700	5200	3200	3200	3200	3200	3200
22	3200	3200	3200	4040	12700	12700	5000	3200	3200	3200	3200	3200
23	3200	3200	3200	4160	12700	12700	4800	3200	3200	3200	3200	3200
24	3200	3200	3200	4280	12700	12700	4600	3200	3200	3200	3200	3200
25	3200	3200	3200	4400	12700	12700	4400	3200	3200	3200	3200	3200
26	3200	3200	3200	4520	12700	12700	4200	3200	3200	3200	3200	3200
27	3200	3200	3200	4640	12700	12700	4000	3200	3200	3200	3200	3200
28	3200	3200	3200	4760	12700	12700	3800	3200	3200	3200	3200	3200
29	3200	3200	3200	4880	12700	12700	3600	3200	3200	3200	3200	3200
30	3200		3200	5000	12700	12700	3400	3200	3200	3200	3200	3200
31	3200		3200		12700	12700	3200	3200		3200		3200

Table 6. Flathead River Ramping Below Kerr Dam at U.S. Geological Survey gage 12372000

If the required release from Flathead Lake is:	Ramping may not exceed:
greater than 40,000 cfs	10,000 cfs / day
20,000 – 40,000 cfs	5,000 cfs / day
10,000 – 20,000 cfs	2,500 cfs / day
5,000 – 10,000 cfs	1,000 cfs / day
below 5,000 cfs	500 cfs /day

The order that water rights are prioritized in the model simulation, meeting 4(e) flows and the USFWS minimum flow requirements at Columbia Falls affect the ability of Flathead Lake and Hungry Horse Reservoir to fill during dry years. The model results therefore differ from historic records in the Flathead basin. In 2001, the only dry water year since flow augmentation water has been required from Hungry Horse; Flathead Lake was allowed to temporarily store some of the Hungry Horse flow augmentation water in early July and then released the volume later in August. This temporary reshaping of the flow augmentation water by Flathead Lake meant the Lake remained at a higher elevation longer in July and early August. The modeled Base Case and the other scenarios do not allow the temporary storage of the flow augmentation water in Flathead Lake; therefore, Flathead Lake elevations are lower in the model than what has historically occurred.

Results

Model simulations were performed and comparisons were made between the Base Case, the Natural Q scenario, and the Natural Q plus 90K scenario.

Hungry Horse Reservoir

In the Base Case scenario, Hungry Horse Reservoir is operated in accordance with the 2008/2010 FCRPS BiOp and the 2000 USFWS BiOp. The reservoir is drafted for flood control during the spring depending on the local forecasted inflow volumes and Variable Flow flood control (VARQ) needed for the Federal Columbia River Power System. Hungry Horse fills to a maximum level usually during the first week of July, and releases flow augmentation water during the July through September period.

In the Natural Q scenario, there is no change to the storage at Hungry Horse Reservoir or the discharges from Hungry Horse Dam when compared to the Base Case. Under the order of water rights priorities that were previously discussed, the natural flows upstream of Hungry Horse Reservoir would be passed through the reservoir for use in the Tribal diversions and Flathead inflow water rights only if there was not enough natural flow downstream of Hungry Horse to meet the senior rights. In all years modeled, the water rights of the Tribal diversions and Flathead Lake inflow are filled by the natural flows in the Flathead basin downstream of Hungry Horse Reservoir and the normal water releases from Hungry Horse Dam. As a result, there is no change to the storage at Hungry Horse Reservoir or the discharges from the dam when comparing the Natural Q to the Base Case.

In the Natural Q plus 90K scenario, 90,000 acre-feet of storage (493 cfs average) is released from Hungry Horse Reservoir during July through September in every water year and is not dependent on whether it is a wet or a dry year. Figures 3 and 4 show that during wet and average water years, there is no change in the refill of Hungry Horse Reservoir when comparing the Base Case/Natural Q plot to the Natural Q plus 90K plot. In these figures, the Natural Q scenario exactly matches the Base Case so that the Base Case line is hidden underneath the Natural Q line. In dry years, releasing the extra 90,000 acre-feet of water in the summer can impact the ability of Hungry Horse Reservoir to fill the following year, the reservoir will not fill as high as the Base Case under these dry conditions. In addition, the Natural Q plus 90K scenario causes Hungry Horse Reservoir to be 4 feet lower than the Base Case at the end of the summer draft period for the listed species downstream. This results in a lower elevation in the fall and winter for the resident ESA listed species.

Figure 5 shows an exceedance plot of annual maximum elevations for Hungry Horse Reservoir. This plot shows that the maximum elevation of Hungry Horse Reservoir is not changed for the Natural Q plus 90K scenario in slightly more than 50 percent of the water years when compared to the Base Case and Natural Q scenarios (the Base Case and Natural Q scenarios plot on top of each other). There is a 1-foot or less difference in elevation between the Natural Q plus 90K and the Base Case/Natural Q scenarios about 86 percent of the time. The greatest difference in maximum elevations is about 4.5 feet.

Specific examples of Hungry Horse Reservoir elevations are shown in Figures 6, 7, and 8. In Figure 6, the differences in maximum elevations range from less than a foot in 1940 to approximately 4.5 feet in 1941. Less extreme differences in the reservoir maximum elevations are shown in Figures 7 and 8.

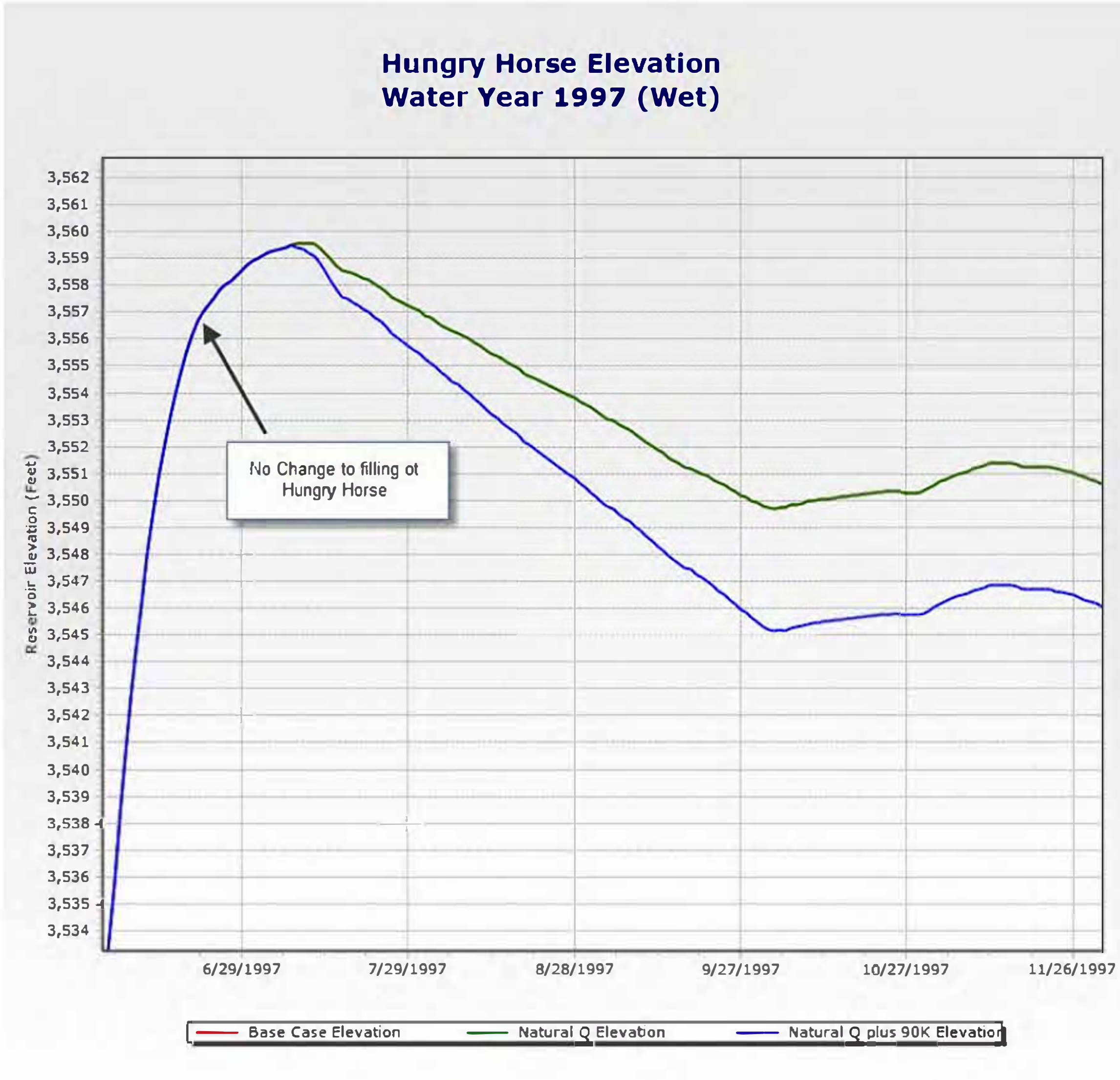

Figure 3. Modeled Hungry Horse Reservoir Elevations for Water Year 1997 which was an above average water year. The Base Case line is hidden under the Natural Q line.

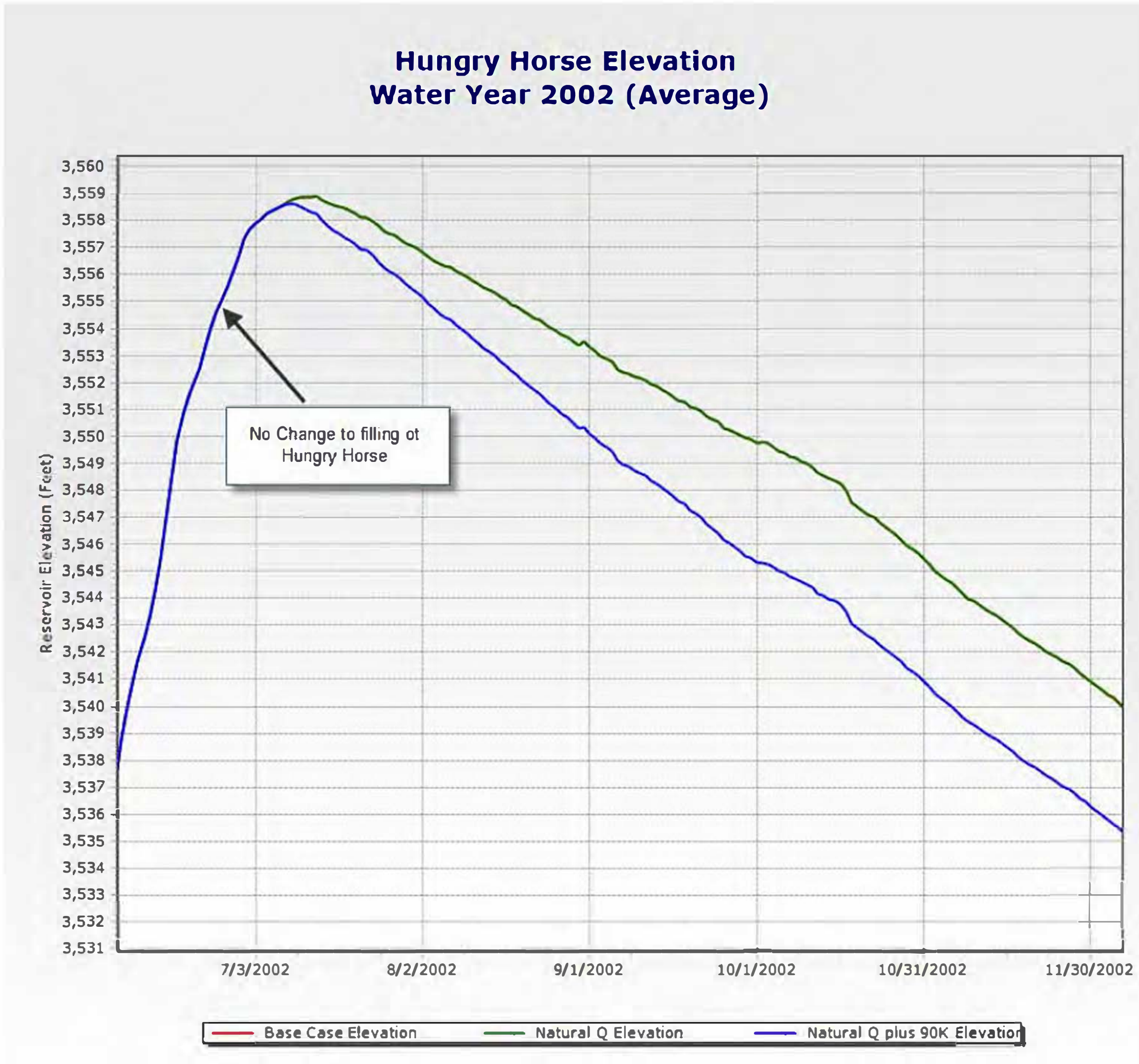

Figure 4. Hungry Horse Reservoir Elevations for Water Year 2002 which is a near average water year. The Base Case line is hidden under the Natural Q line.

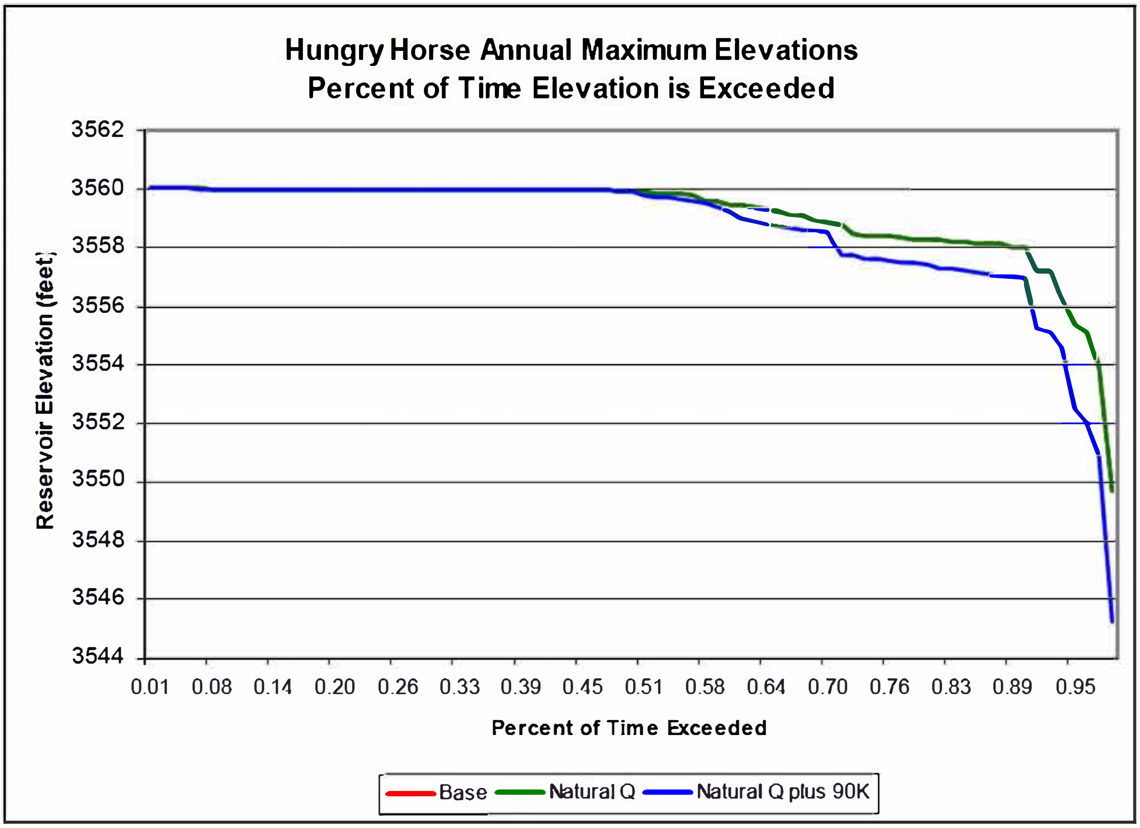

Figure 5. Annual Maximum Elevations of Hungry Horse Reservoir Exceedance Plot. The Base Case line is hidden under the Natural Q line.

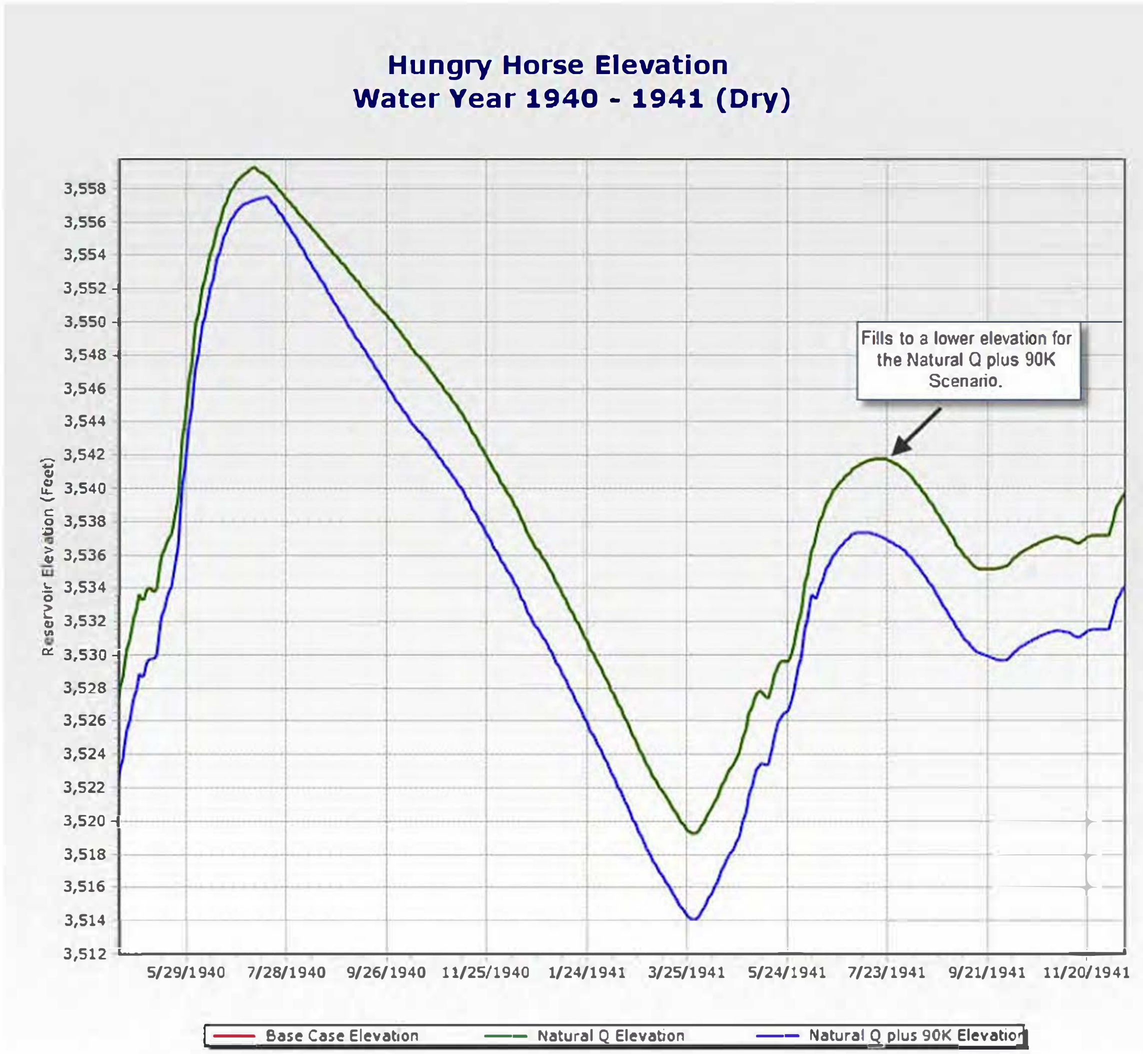

Figure 6. Hungry Horse Reservoir Elevations Base Case and Natural Q compared to the Natural Q Plus 90K. 1940-1941. The Base Case line is hidden under the Natural Q line.

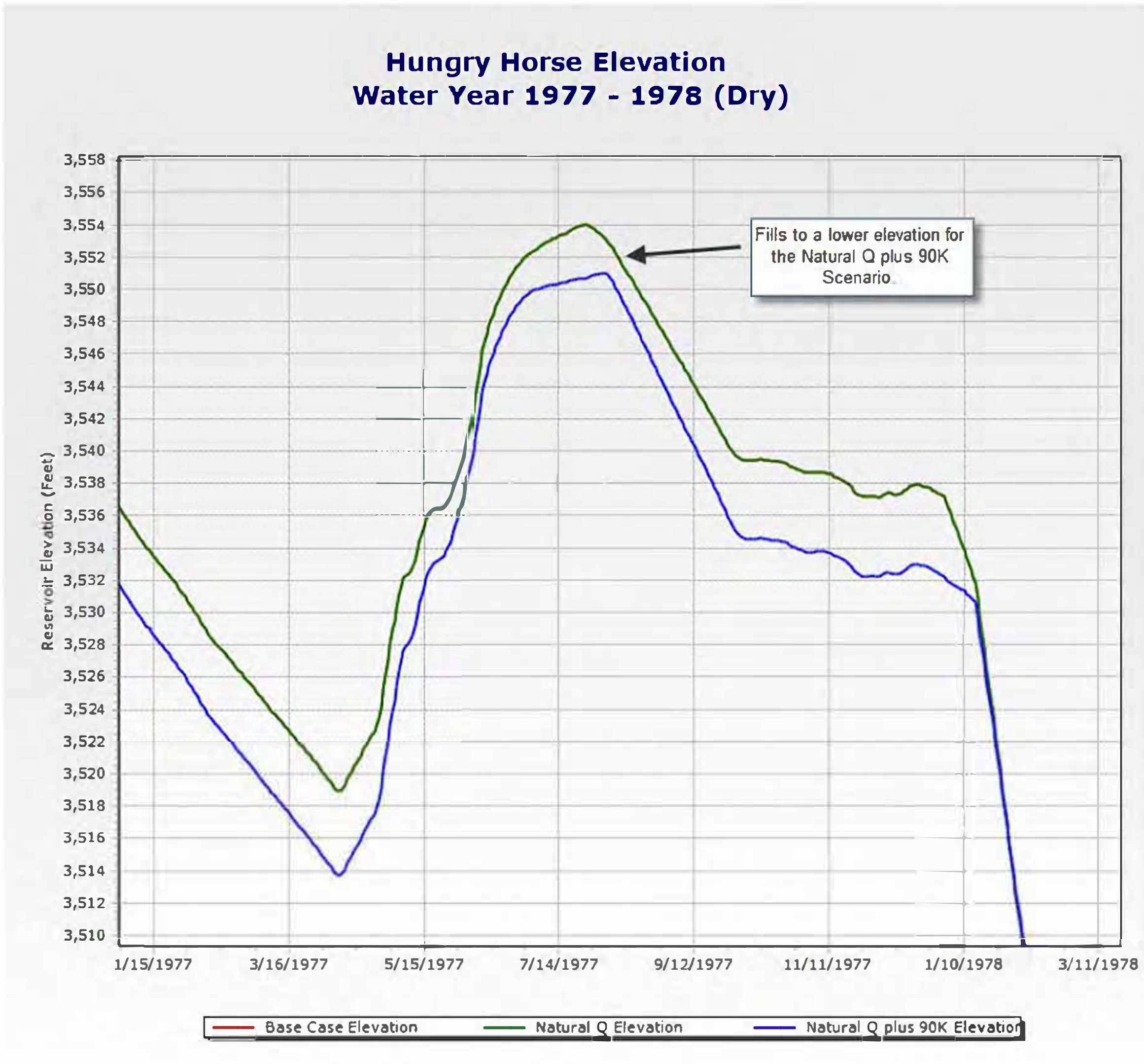

Figure 7. Hungry Horse Reservoir Elevations comparing Natural Q to Natural Q Plus 90K Scenarios. 1977 - 1978. The Base Case line is hidden under the Natural Q line.

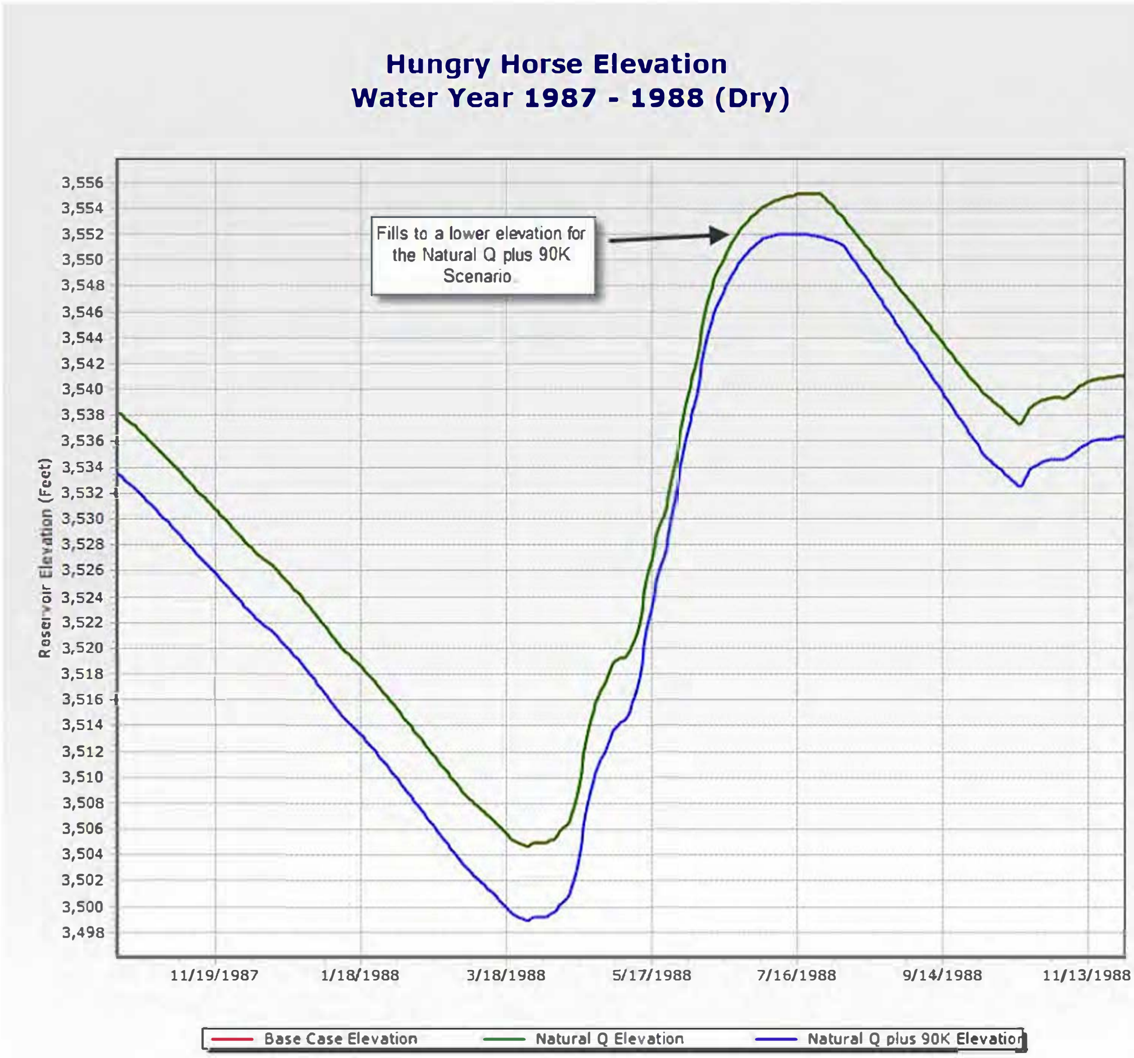

Figure 8. Hungry Horse Reservoir Elevations comparing Natural Q to Natural Q Plus 90K scenarios 1987 – 1988. The Base Case line is hidden under the Natural Q line.

Minimum flows on the Flathead River in compliance with the 2000 USFWS BiOp were met in all the scenarios. Discharges from Hungry Horse Dam in the spring and summer were not reduced in above average water years the in the Natural Q plus 90K scenario when compared to the Base Case. Even though the extra 90,000 acre-feet was released the previous summer, Hungry Horse Reservoir would start drafting for flood control in these above average water years prior to April 10 so the reservoir would release the same amount of water during the spring and summer (plus the additional 90,000 acre-feet) migration periods when compared to the Base Case. An exceedance plot of the April 10 through June 30 volumes for all three scenarios are shown in Figure 9. The Base Case and the Natural Q plots are exactly the same and plot on top of each other. The greatest decrease in discharge in the spring with the Natural Q plus 90K scenario was around 103,000 acre-feet (641 cfs average); there were 26 years where the differences were less than 100 acre-feet (less than 1 cfs average). Specific examples include 1945, which was an 83 percent of average year (Figure 10), and 1936, which was a 95 percent of average year (Figure 11). The April 10 through June 30 flows were decreased by about 84,000 acre-feet (522 cfs average) in 1945 and decreased by about 99,000 acre-feet (616 cfs average) in 1936. The decreases in spring discharges from Hungry Horse Dam will decrease the amount of water coming from the Flathead basin which will decrease flows in the Columbia River during the spring migration of endangered species.

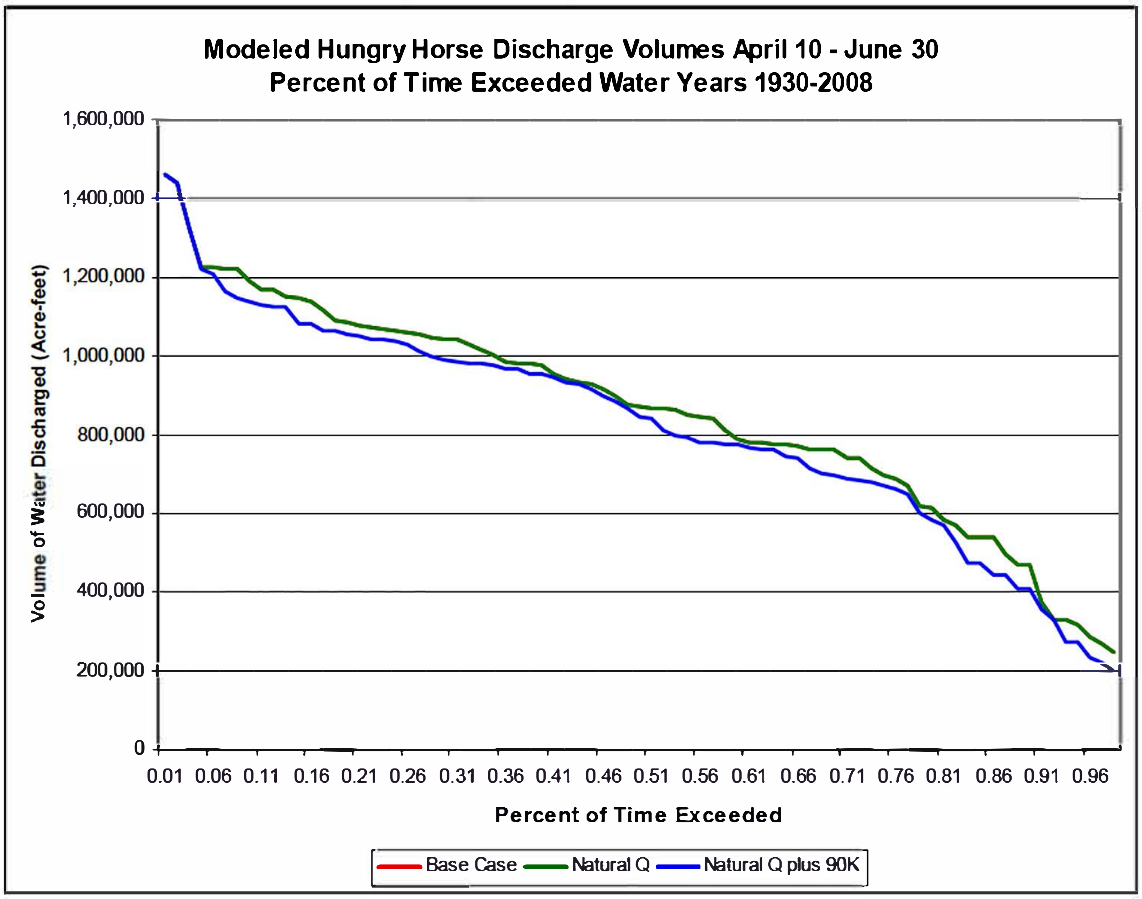

Figure 9. Modeled Hungry Horse Dam April 10 through June 30 Discharge Volumes Exceedance Plot.

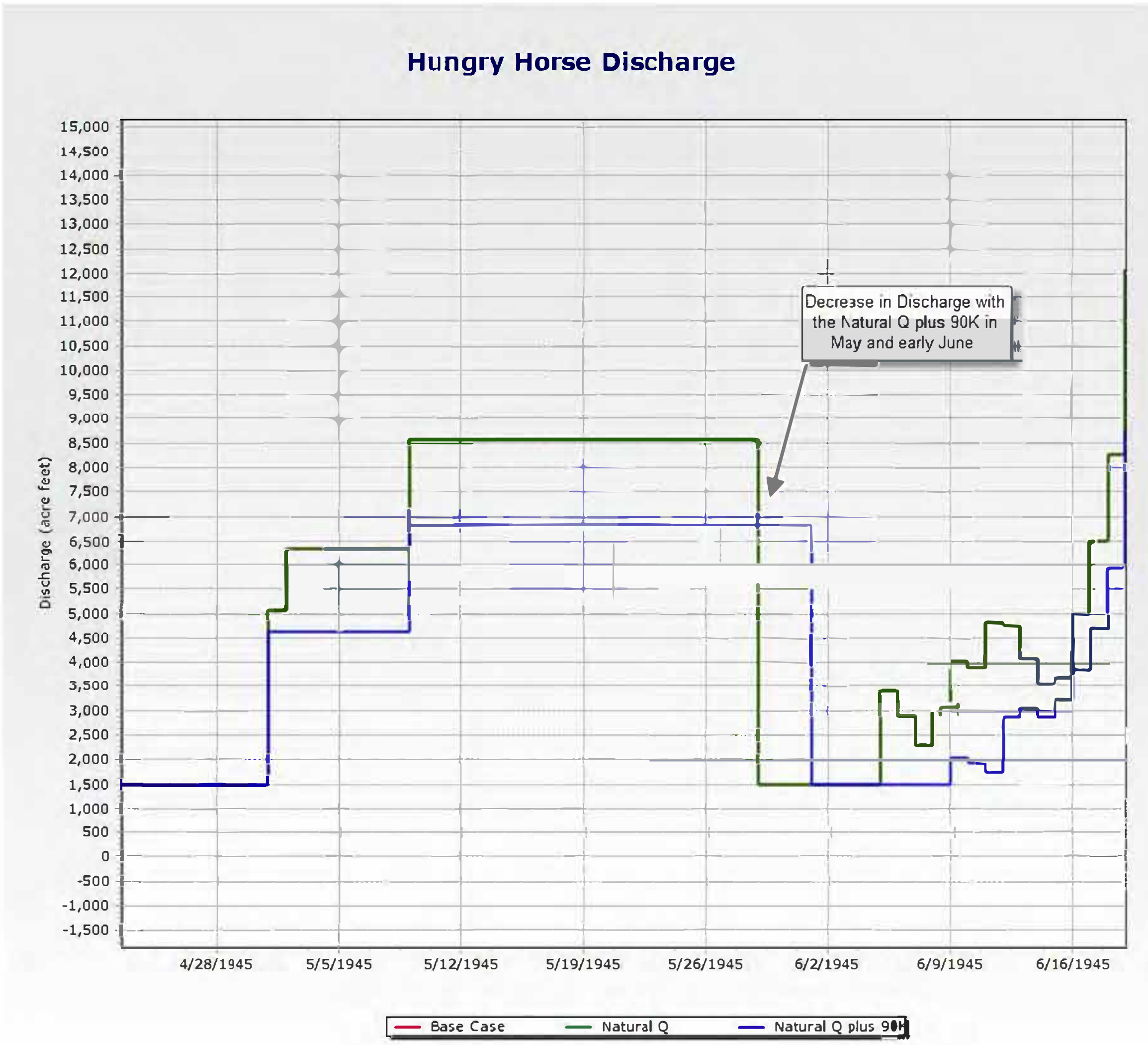

Figure 10. Hungry Horse Dam Discharges in spring of 1945 (83 percent of average year), showing a decrease in discharge with Natural Q plus 90K Scenario.

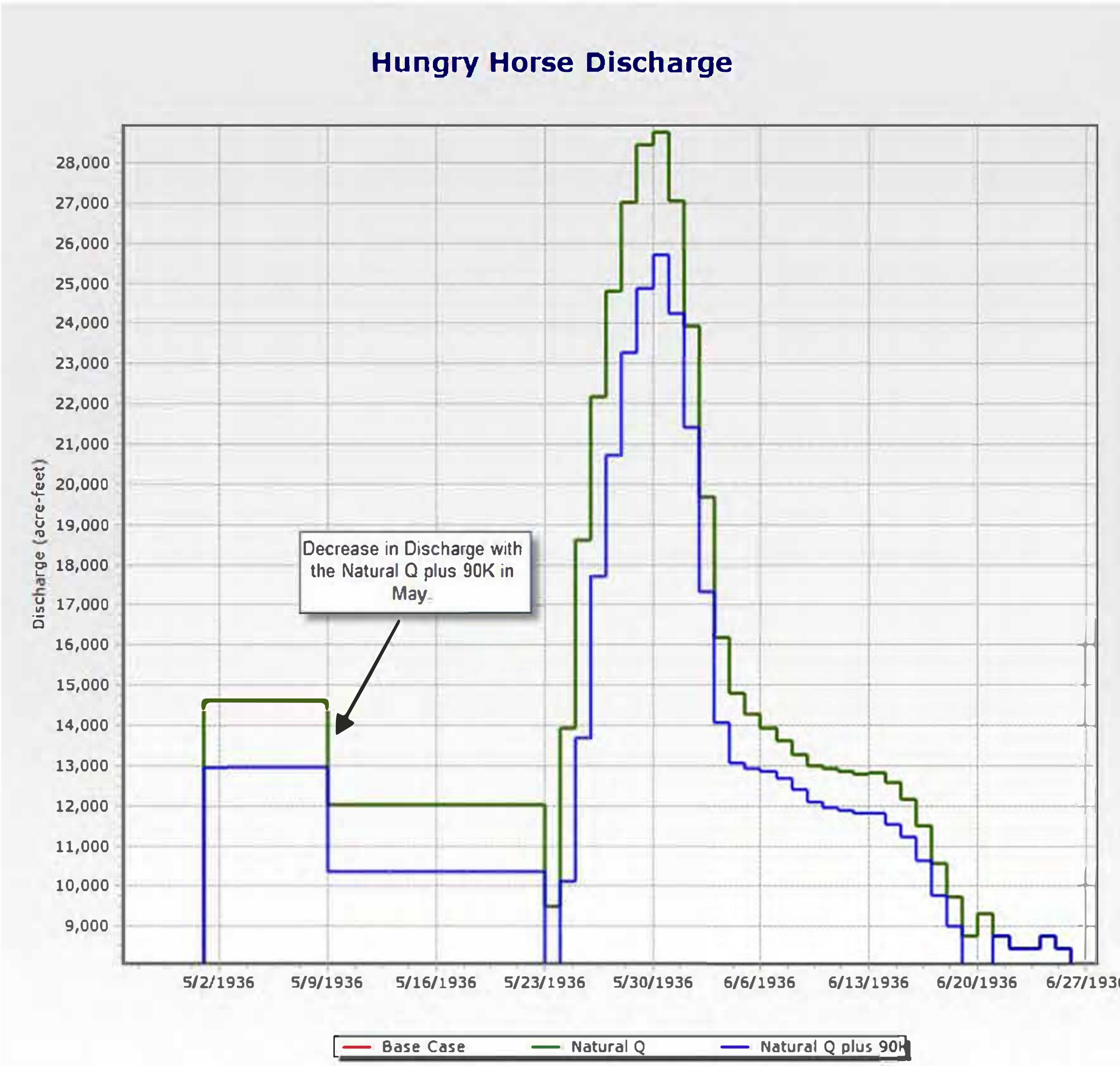

Figure 11. Hungry Horse Dam Discharges in spring of 1936 (95 percent of average year), showing the decrease in discharge with Natural Q plus 90K scenario.

In dry water years, summer flow augmentation supplied by Hungry Horse Reservoir for Columbia River endangered species is decreased in the Natural Q plus 90K scenario when compared to the Base Case. The volume of decrease in any given year depends on the maximum fill of Hungry Horse Reservoir in early July. In real-time operations, the reservoir may be held slightly short of completely filling in order to maintain a steady discharge through the maximum fill period and not cause a double peak on the downstream reach. A double peak occurs when the discharges are lowered to fill the reservoir and then increased significantly in order to start flow augmentation or irrigation releases after the reservoir is filled. To avoid a double peak, some flow augmentation water would be released before the maximum fill date.

Years when there was more than 24,000 acre-feet (approximately 1 foot in elevation) decrease in the maximum storage at Hungry Horse Reservoir due to the 90K releases during the previous year are listed in Table 7. The most extreme difference in flow augmentation volume is over 71,000 acre-feet in 1988. There is a 15 percent chance that the flow augmentation volume discharged from Hungry Horse Dam will be reduced by about 24,000 acre-feet or more (more than 1 foot lower in elevation) when comparing the Natural Q plus 90K to the Base Case, there is no difference in flow augmentation volumes approximately 50 percent of the time (Figure 12).

Table7. Hungry Horse Dam Summer Flow Augmentation Decreases for the Natural Q Plus 90K Scenario when compared to the Base Case.

Year	Flow Augmentation Shortage (in acre-feet)
1988	71,704
1977	69,375
1944	66,950
2001	62,117
1937	46,187
1940	42,385
1941	38,858
1930	26,788
1951	25,530
1974	25,231
1999	24,242
1965	24,060

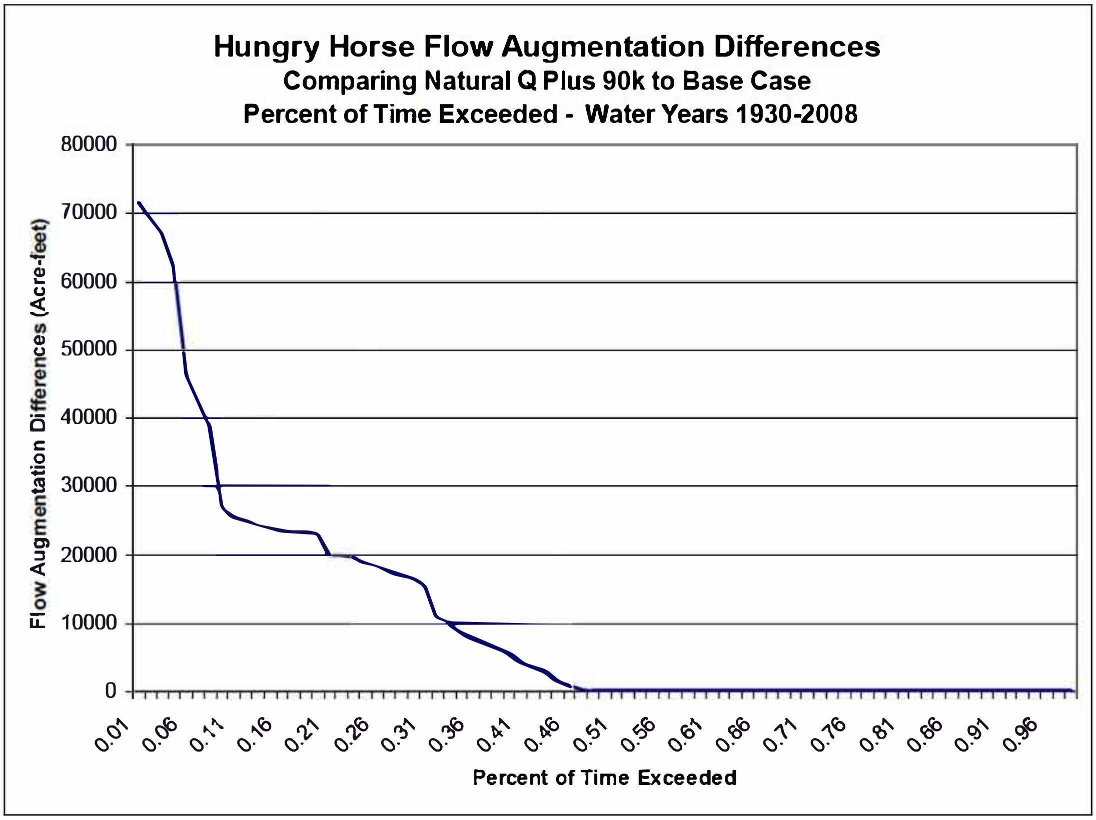

Figure 12. Hungry Horse Dam Summer Flow Augmentation Differences between Base Case and Natural Q Plus 90k, Percent of Time Exceeded, 1930-2008.

Flathead Lake

The modeled Base Case scenario shows that during dry years, Flathead Lake is drafted lower during the summer months than may have occurred historically. This is because the 4(e) flows were strictly adhered to in the model and the flow augmentation water from Hungry Horse Dam was passed through Flathead Lake downstream to the lower river. Historically, in a year such as 2001 which is the only dry year since 4(e) flows and flow augmentation requirements have been in place, flow augmentation water was temporarily stored in Flathead Lake in July and early August and released later in August allowing the Lake to be at higher elevations for a longer period in the summer. There were some adjustments made to the April 15 target elevation for flood control in the model during the four driest years (1941, 1944, 1977, and 2001) because the adaptive management of Flathead Lake elevations, similar to what was done in 2001, would most likely occur in the driest years to reduce the amount of draft on Flathead Lake. In addition, a Drought Management Plan is being developed for Flathead Lake where adaptive management of the target elevations and the 4(e) flows that could occur are based on the forecasted runoff in the Flathead basin. These adjustments could help alleviate the adverse impacts on Flathead Lake levels during a dry year.

For the Natural Q scenario, in a higher than average water year such as 1997 (143 percent of average runoff), the natural flow and Hungry Horse Dam discharges were able to supply all of the new Tribal diversions. In the same scenario, an average water year such as 2002 (99 percent of average runoff), the natural flows and current Hungry Horse discharges failed to meet the Tribal diversions by less than 10,000 acre-feet early in May and late in October. In a below average water year like 2001 (57 percent of average runoff), natural flow and current Hungry Horse discharges failed to meet the new Tribal diversions by about 95,000 acre-feet. Figure 13 shows an exceedance plot of the new Tribal diversion shortages for the March through September period. On this plot, for the Natural Q scenario, there are shortages up to 20,000 acre-feet about 20 percent of the time. The maximum shortages for this period were around 120,000 acre-feet. The Natural Q plus 90K exceedance plot showed less than 20,000 acre-feet of shortages for all of the years. This figure illustrates that the extra 90,000 acre-feet released from Hungry Horse Dam in the July through September period reduced the amount of new Tribal diversion shortages at Flathead Lake.

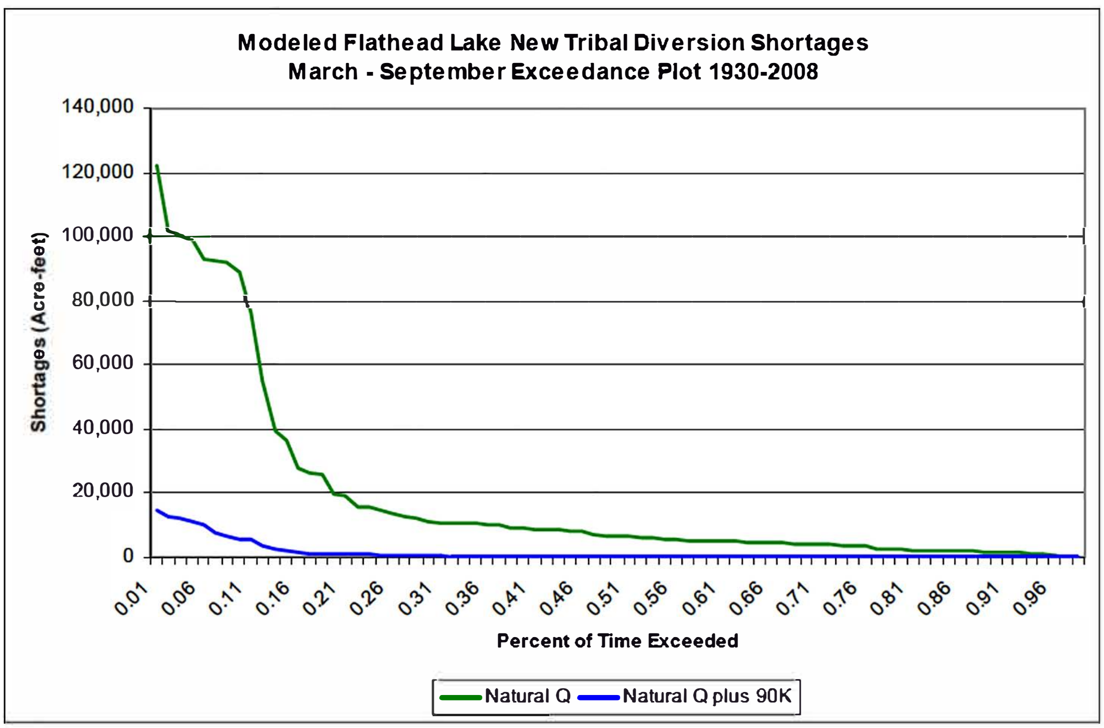

Figure 13. Modeled Flathead Lake March through September New Tribal Diversion Shortages Exceedance Plot.

Flathead Lake summer elevations could be impacted by the new Tribal diversions since the diversions have the senior water right in the basin. Flathead Lake has a priority flow right of 14,540 cfs to fill the Lake and to meet the 4(e) flows after the Tribal diversions are met. The accumulation of the 14,540 cfs was tracked in the model; when the full volume of Flathead Lake had accumulated, this right was filled. The next priority allowed natural flow to be stored in Hungry Horse Reservoir to its full volume. The actual filling of Flathead Lake in the model reached a lower elevation in the dry years for the Natural Q and Natural Q plus 90K scenarios when compared to the Base Case because natural flows were being used for the new Tribal diversions, and because the 4(e) flows, which are a part of the inflow water right, were still being released from the lake during the spring refill.

Figure 14 shows an exceedance plot of the modeled July through September Flathead Lake elevations. This plot shows that in 83 percent of time in the 70-year period there is no difference in summer Flathead Lake elevations between the Base Case, Natural Q scenario, and Natural Q plus 90K scenario. The greatest difference in elevations is 0.4 feet between the Base Case and the Natural Q plus 90K and occurs less than 3 percent of the time. The lowest elevation for the Natural Q scenario is 0.2 feet lower than the Base Case lowest elevation and the lowest elevation for the Natural Q plus 90K scenario is 0.2 feet higher than the Base Case lowest elevation.

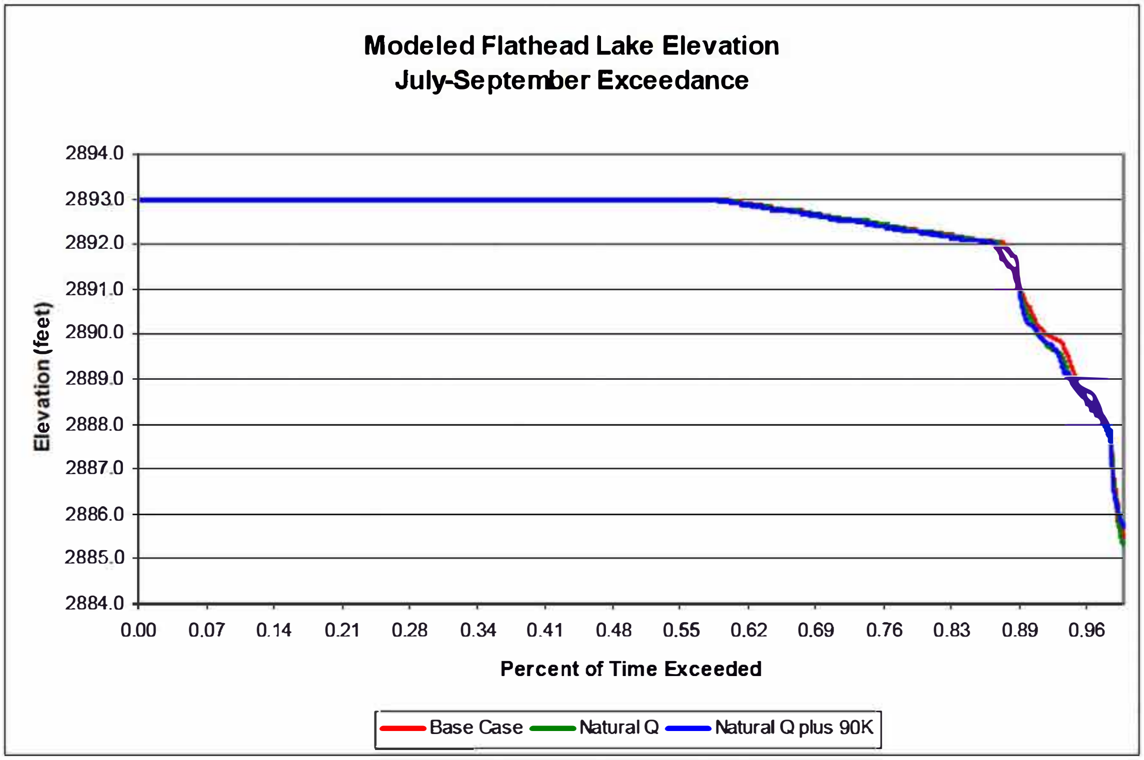

Figure 14. Modeled Elevation Duration Curve for Flathead Lake, July through September.

The difference in Flathead Lake summer elevations between the Base Case and the Natural Q and Natural Q plus 90K scenarios in individual dry years is shown in more detail in Figures 15, 16, and 17. These three figures show that in the dry water years, Flathead Lake will not fill to as full an elevation in the spring and summer for the Natural Q and Natural Q plus 90K scenarios when compared to the Base Case. The lower elevations in the Natural Q plus 90K scenario are due in part to the decrease in discharges from Hungry Horse Dam during this period in the dry years after the reservoir discharged an additional 90,000 acre-feet the previous summer. The lower elevations in the Natural Q and the Natural Q plus 90K scenarios also occur because historically Flathead Lake used natural flows in excess of the 14,540 cfs water right to fill. The new Tribal diversions are now taking that excess water. The 14,540 cfs Flathead Lake priority flow rate is met every year, but the new Tribal diversions prevent the lake from filling as high as in the Base Case. Flathead Lake discharges that are in excess of the 4(e) flows are also decreased because of the natural flows going to new Tribal diversions. These figures (15, 16, and 17) also show that the Natural Q plus 90k scenario, where 90,000 acre-feet is discharged from Hungry Horse Dam in the July through September period, Flathead Lake elevations recover higher than the Base Case in 1940 and 1988 (Figures 15 and 17). The Natural Q plus 90K scenario helps to achieve the objectives of meeting all the Tribal diversions during the summer and allowing a higher elevation in Flathead Lake when this scenario is compared to the Natural Q scenario.

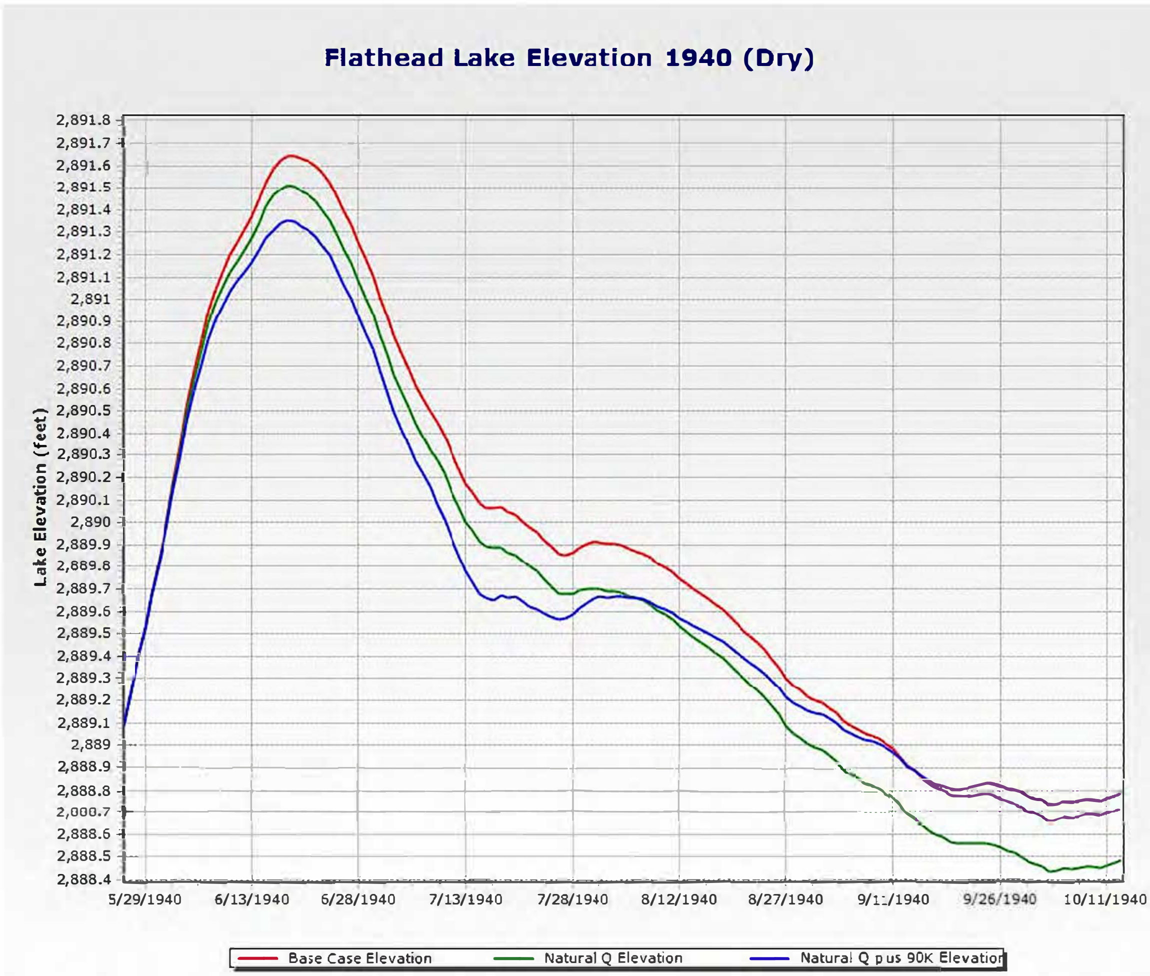

Figure 15. Flathead Lake Elevations Comparing Base Case, Natural Q and Natural Q plus 90K, 1940.

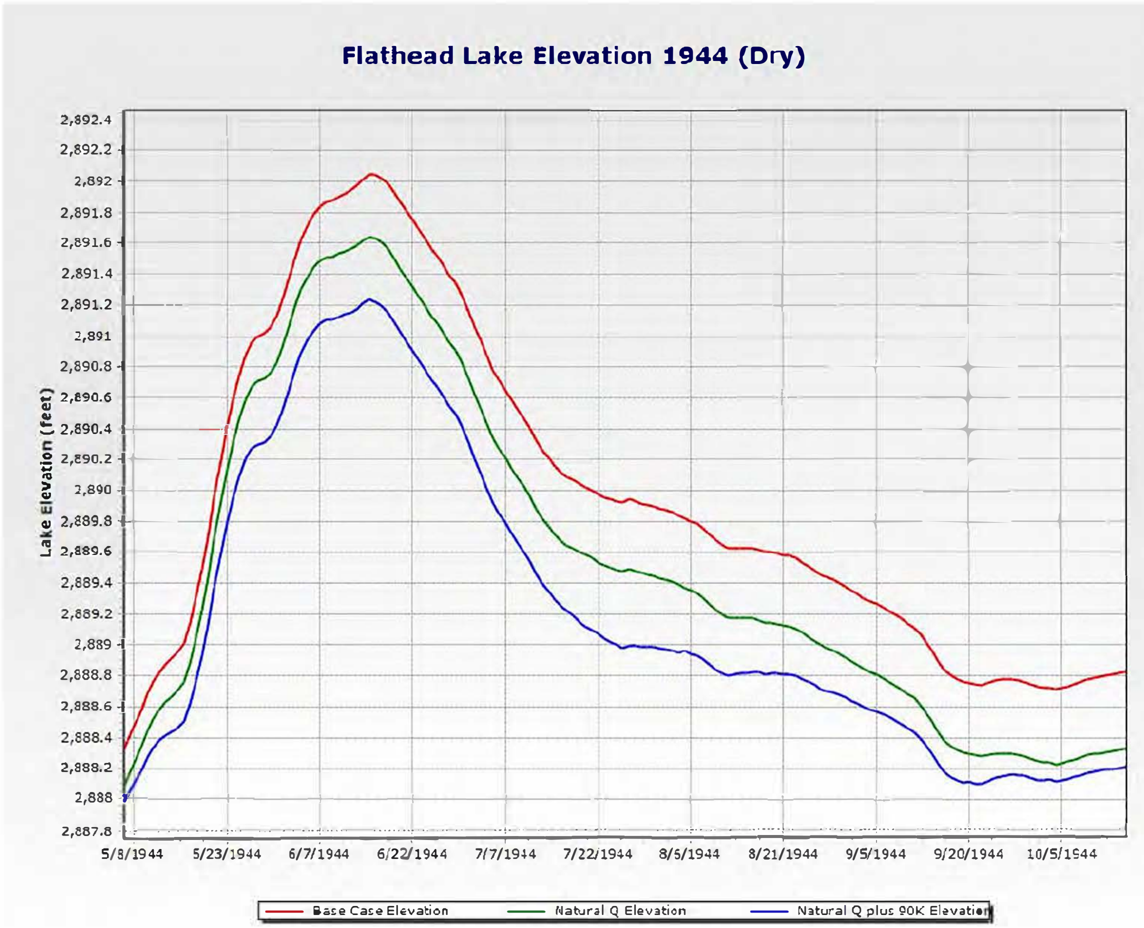

Figure 16. Flathead Lake Elevations Comparing Base Case, and Natural Q, and Natural Q plus 90K, 1944.

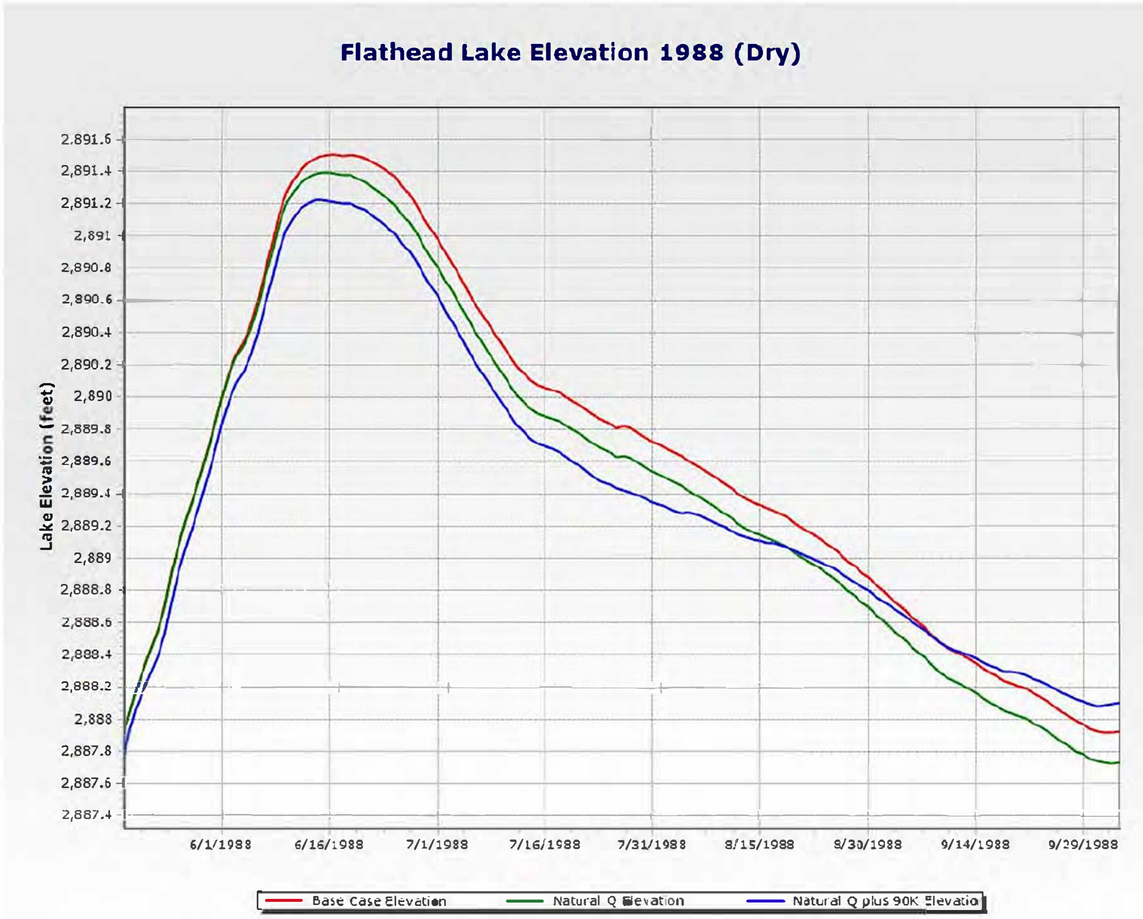

Figure 17. Flathead Lake Elevations Comparing Base Case and Natural Q, 1988.

Flathead River at Perma

Flows in the Flathead River at the Perma gage are analyzed because this is the last gage point on the Flathead River before it joins the Clark Fork. The total effects of the three scenarios on the change in flows from the Flathead River downstream can be compared at this gage.

Exceedance plots of the volumes of modeled flows on the Flathead River at Perma for the spring and summer migration periods are plotted on Figures 18 and 19. The spring migration period of April 10 through June 30 is shown on Figure 18. The differences in spring volumes between the Base Case, Natural Q scenario, and the Natural Q plus 90K scenario look small when compared to the total volume on the Flathead River for this period. The greatest difference in volumes when comparing the Natural Q to the Base Case was approximately 31,000 acre-feet (193 cfs average) which was less than 1 percent of the total volume for this spring period. The greatest difference in volume between the Base Case and the Natural Q plus 90K scenario was about 133,000 acre-feet (828 cfs average) which was less than 4 percent of the total volume for the same period.

An exceedance plot of volume of modeled flows at Perma during the period of July 1 through September 30 is shown on Figure 19. This plot shows that the difference in volumes in most years is greater for the Natural Q scenario when compared to the Base Case than the Natural Q plus 90K scenario when compared to the Base Case. This is due to the discharge of the additional 90,000 acre-feet of water in the July through September period in the Natural Q plus 90K scenario. The greatest difference in volume for the Natural Q scenario when compared to the Base Case was approximately 113,000 acre-feet (619 cfs average) which was less than a 9 percent change of the total volume for this summer period. The greatest difference in the Natural Q plus 90K scenario and the Base Case was approximately 139,000 acre-feet (762 cfs average) which was about 13 percent of the total volume for the summer period. It should be noted that the most extreme volume changes for these two distinct migration periods do not occur during the same years.

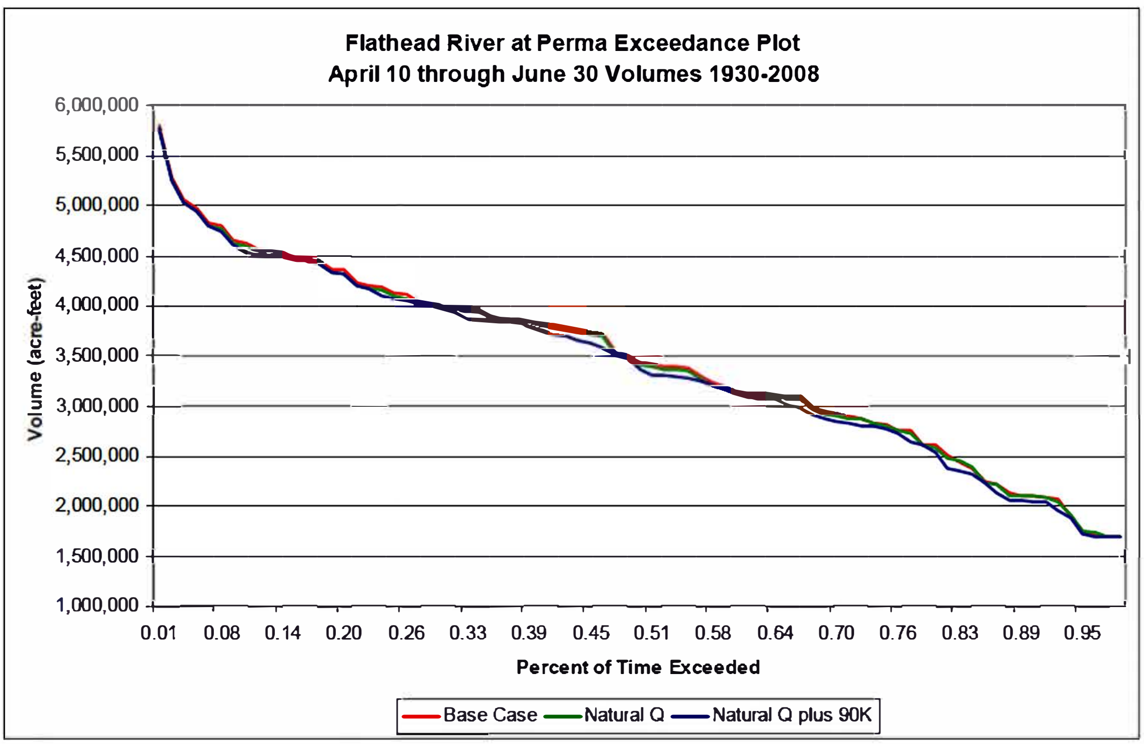

Figure 18. Flathead River at Perma Volume April 10 through June 30 (Spring Migration Period) Exceedance Plot.

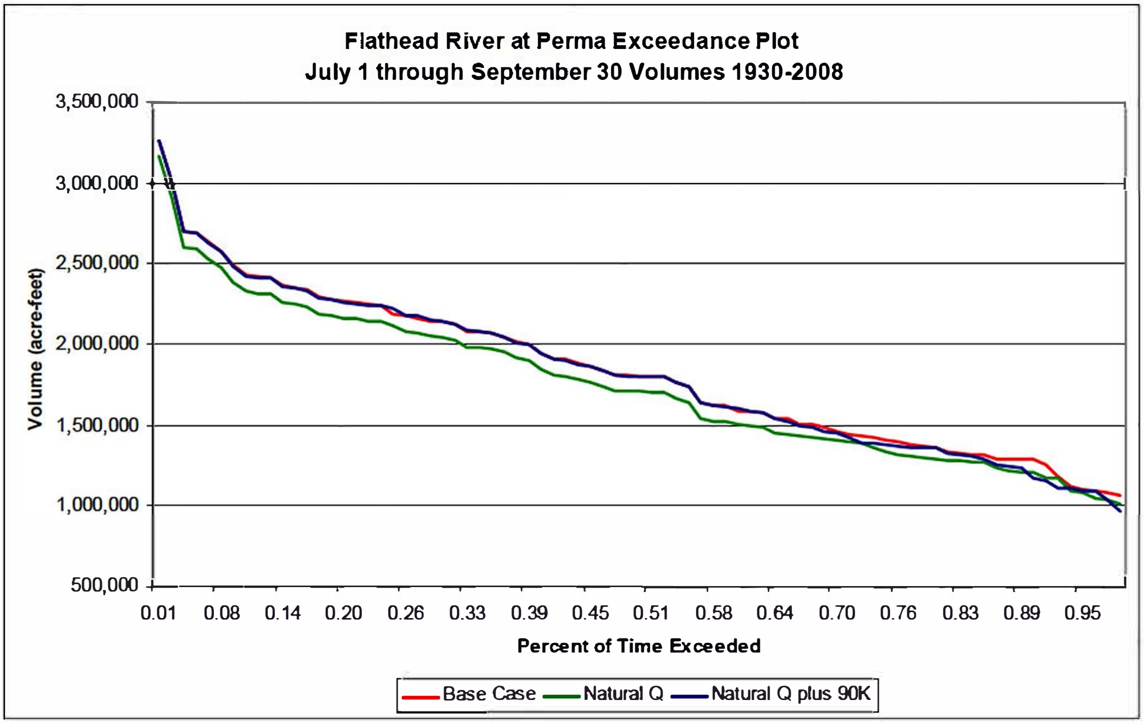

Figure 19. Flathead River at Perma Volume July 1 through September 30 (Summer Migration Period) Exceedance Plot.

Individual water years for the Flathead River at the Perma gage comparing the three scenarios are shown in Figures 20 and 21. These plots show the decrease in flows during the spring due the new Tribal diversions for the Natural Q and Natural Q plus 90K scenarios when compared to the Base Case. During the summer months, the decrease in flows is not as great for the Natural Q plus 90K scenario most years because of the additional 90,000 acre-feet of water discharged from Hungry Horse Reservoir during that period. The average annual difference in volumes at the Flathead River at Perma gage for the Natural Q scenario when compared to the Base Case is approximately 104,000 acre-feet, and for the Natural Q plus 90K scenario 120,000 acre-feet when compared to the Base Case. These amounts reflect the effects of the depletions from the new Tribal diversions.

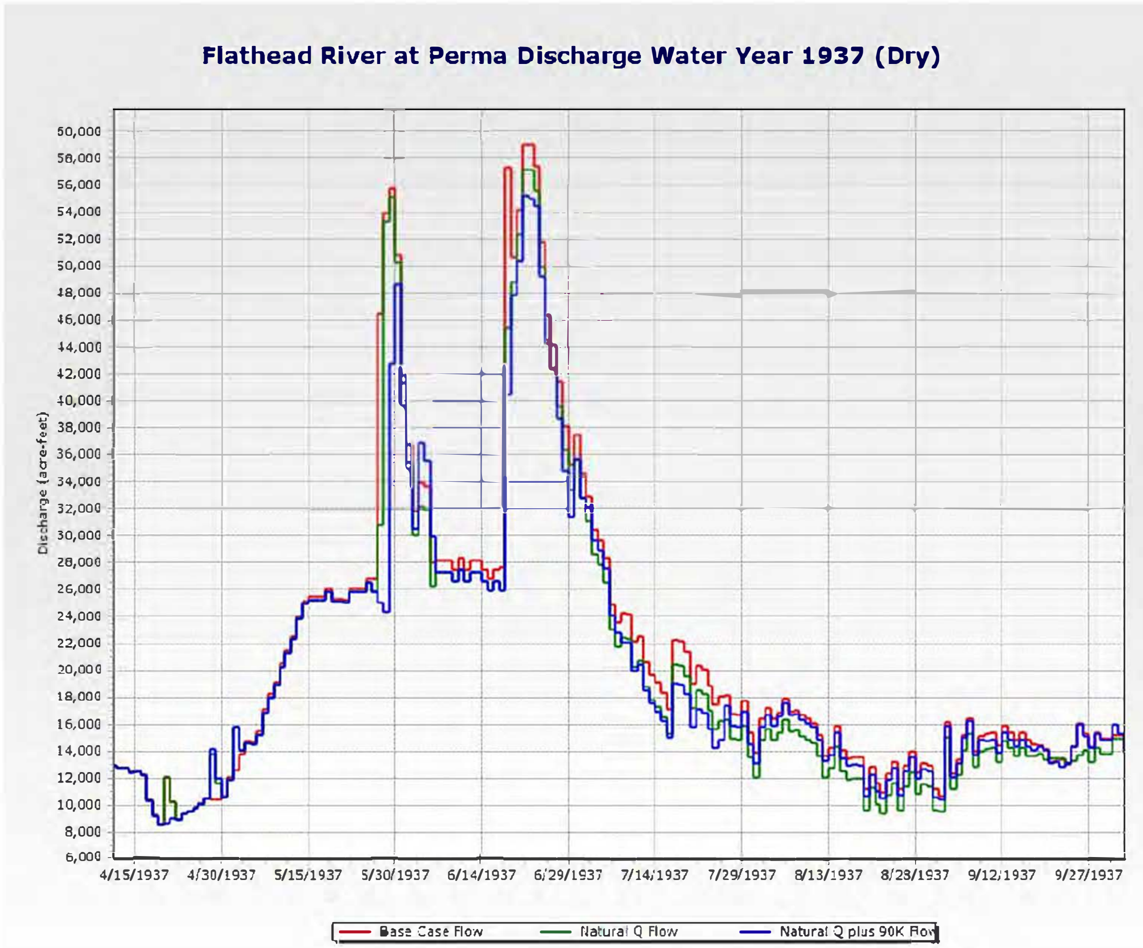

Figure 20. Flathead River at Perma Discharges in 1937, a below above average water year.

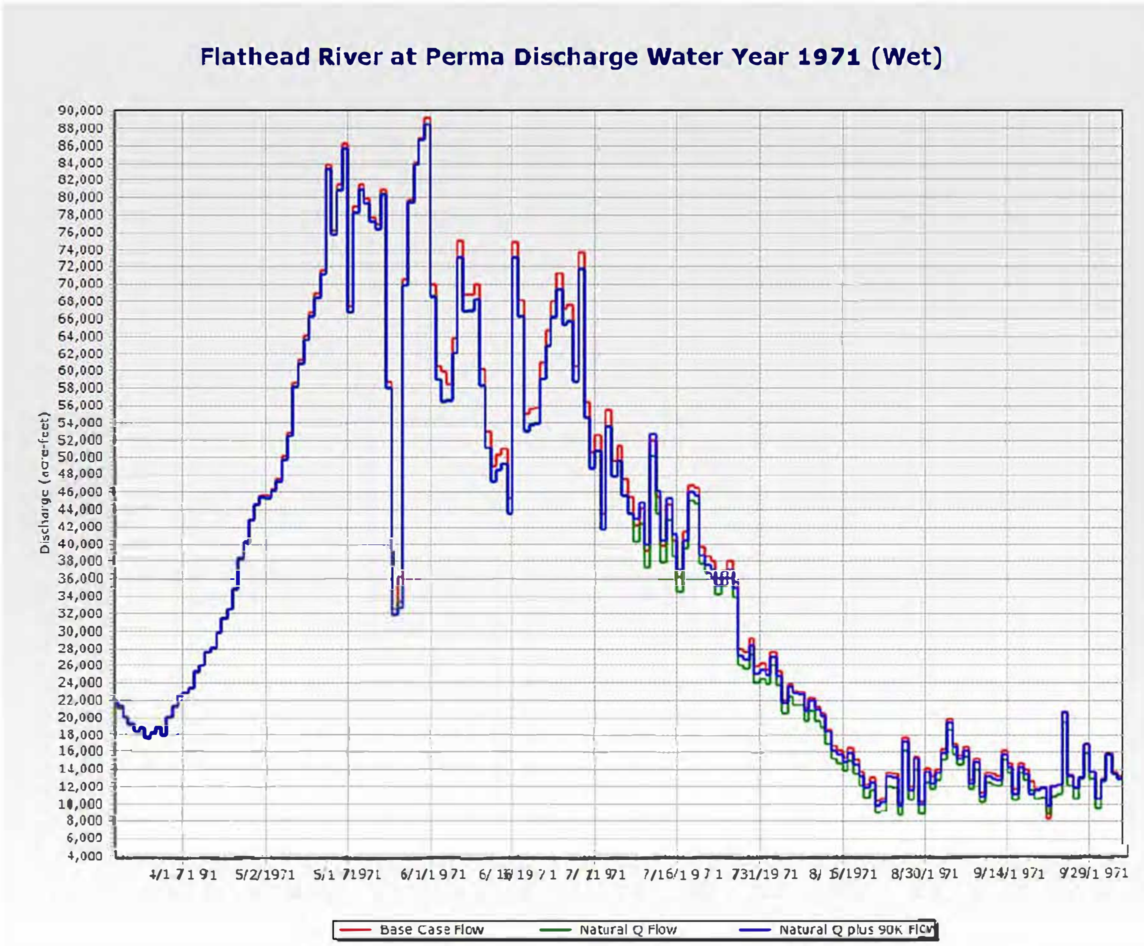

Figure 21. Flathead River at Perma Discharges in 1971, an above average water year.

Summary

The Flathead basin was modeled to analyze the effects of new Tribal diversions from Flathead Lake and the lower Flathead River. There were three scenarios modeled: the Base Case; the Natural Q scenario where natural flows were used to meet Tribal diversions as the highest priority; and the Natural Q plus 90K scenario where 90,000 acre-feet of extra storage is released from Hungry Horse Dam to supplement flows for the diversions and reduce the impacts to Flathead Lake storage.

The modeled results show that for Hungry Horse Reservoir there are no differences in the storage and discharges between the Base Case and the Natural Q scenario. The natural flow downstream of Hungry Horse Reservoir and normal Hungry Horse Dam discharges are able to meet the new diversions so additional discharges from Hungry Horse Dam are not required. For the Natural Q plus 90K scenario, the increased discharges from Hungry Horse Dam during the summer caused the reservoir elevation to be lower at the end of the summer which can affect the ability of Hungry Horse Reservoir to fill the following spring in dry years. An exceedance analysis of the annual maximum elevations of Hungry Horse Reservoir shows that in 86 percent of the water years, there is a one foot or less difference in elevations between the Base Case and the Natural Q plus 90K scenario. In above average water years, flood control releases would start before April 10, which starts the spring flow augmentation period, and the rest of the discharges over the spring and summer would not be decreased. In near average water years, Hungry Horse Dam discharges would be decreased in the spring because the reservoir would be entering the flood control at a lower elevation and less water would need to be released in the April 10 through June 30 period. In below average water years, the flow augmentation volume in the summer would be decreased because of the inability to fill to as high a level in the Natural Q plus 90K scenario as in the Base Case.

New Tribal diversions were not fully met with the Natural Q scenario in most of the water years. Shortages of 20,000 acre-feet or greater occur 20 percent of the time with the maximum shortages being 120,000 acre-feet in the March through September period. In the Natural Q plus 90K scenario, most of the diversion shortages were met with the extra 90,000 acre-feet released. There were less than 20,000 acre-feet of shortages for all of the years, with over 80 percent of the years having no shortages in the Natural Q plus 90K scenario. The shortages that do occur in this scenario occur in the March through June period and in October.

The new Tribal diversions can impact the summer elevation of Flathead Lake. In the modeling, no adjustments are made to the 4(e) outflows for drought management. A comparison of summer Flathead Lake elevations show that in 83 percent of the time over the 70-year modeled period that there is no difference in summer elevations between the Base Case, the Natural Q scenario, and Natural Q plus 90K scenario. The greatest differences in elevation between the Base Case and the Natural Q plus 90K scenario is 0.4 feet which occurs less than 3 percent of the time over the 70-year modeled period. The differences in Flathead Lake summer elevations are due to the water in excess of the Flathead Lake flow right going to the new Tribal diversions rather than storage in Flathead Lake.

River flows at the Flathead River at Perma are decreased for the Natural Q and the Natural Q plus 90K scenarios when compared to the Base Case. The total volume decrease on an annual basis ranges from 104,000 to 120,000 acre-feet. The decreases in flows at the Perma gage are the greatest during the summer flow augmentation period of July through September with the differences being 9 percent of the total flow (619 cfs) for the Natural Q scenario and 13 percent of the flow (761 cfs) for the Natural Q plus 90K scenario.

The analysis done in this study may show the most extreme effects of the new Tribal diversions in the Flathead basin. This is because of the assumptions used in the model; the new Tribal diversions were set at the maximum amount and there was very little adaptive management of Hungry Horse and Flathead Lake operations. This analysis is not a proposal of current or future operations; it only gives results of possible effects that the new Tribal diversions could have on the Flathead basin given these rigid assumptions. The results are intended to give a starting point for further analysis of what effects new Tribal diversions could have in the Flathead basin.

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