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Portland District

BUREAU OF RECLAMATION

SEDIMENT QUALITY REPORT

HUNGRY HORSE RESERVOIR
COLUMBIA RIVER BASIN
SOUTH FORK FLATHEAD RIVER, MONTANA

Hungry Horse Reservoir

Sediment Quality Report
August 2020

EXECUTIVE SUMMARY

Hungry Horse Reservoir is located 15 miles south of the western Glacier National Park Entrance and 20 miles northeast of Kalispell, Montana. Congress authorized Hungry Horse Dam on June 5, 1944 (Public Law 78-329), for irrigation and reclamation of arid lands, controlling floods, improving navigation, regulating the flow of the South Fork Flathead River, generation of electric energy, and for other beneficial uses such as fish and wildlife, and recreation in Montana and downstream areas. Hungry Horse Dam houses four turbines with nameplate capacity of 107 megawatts each and a maximum hydraulic capacity of 11,200 cfs for power generation, but transmission capacity limits use to 3 units and 9,000 cfs. The dam generates, on average, a little under 1 billion kilowatt hours per year (Stene 1995).

Hungry Horse Dam stands 564 feet high. At full pool, the reservoir is slightly less than 30 miles in length, approximately 23,800 acres in area, and has a storage capacity of about 3.1 million acre-feet. Very little water is drawn out of the reservoir for irrigation purposes; therefore, nearly all the water that flows into the reservoir continues past the dam (Stene 1995).

The scope of this evaluation includes the sediments in the reservoir and the sediments in the 5.1 miles of the South Fork Flathead River located below the dam. Sediment concerns below the confluence of the South Fork Flathead River and the Flathead River are not discussed in this report. Drainage area of the reservoir is approximately 1,660 square miles (Figure 1-1 and Figure 1-2), mean annual precipitation within the basin is approximately 49 inches, and the basin is steep with almost 35 percent of its area with slopes greater than 50 percent (U.S. Geological Survey [USGS] 2018a).

Because the water and sediment entering the reservoir has little opportunity for contamination, the waters in the reservoir have only been sporadically sampled for chemical analysis, and the sediments have never been extensively sampled. While the reservoir sediments have not been analyzed in depth, sediment deposition at the upper end of the reservoir, which formed a delta where the South Fork Flathead River slows into slack water as it enters the reservoir, has been noted.

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ACRONYMS

Acronym	Description
MFWP	Montana Fish, Wildlife & Parks
mg/L	milligrams per liter
Reclamation	Bureau of Reclamation
SEF	Sediment Evaluation Framework for the Pacific Northwest
SKQ Dam	Seli'š Ksanka Qlispe' Dam
USGS	U.S. Geological Survey

SECTION 1 - INTRODUCTION

1.1 STUDY AREA

Hungry Horse Reservoir is located 15 miles south of the western Glacier National Park Entrance and 20 miles northeast of Kalispell, Montana. Congress authorized Hungry Horse Dam on June 5, 1944 (Public Law 78-329), for irrigation and reclamation of arid lands, controlling floods, improving navigation, regulating the flow of the South Fork Flathead River, generation of electric energy, and for other beneficial uses such as fish and wildlife, and recreation in Montana and downstream areas. Hungry Horse Dam houses four turbines with nameplate capacity of 107 megawatts each and a maximum hydraulic capacity of 11,200 cfs for power generation, but transmission capacity limits use to 3 units and 9,000 cfs. The dam generates, on average, a little under 1 billion kilowatt hours per year (Stene 1995).

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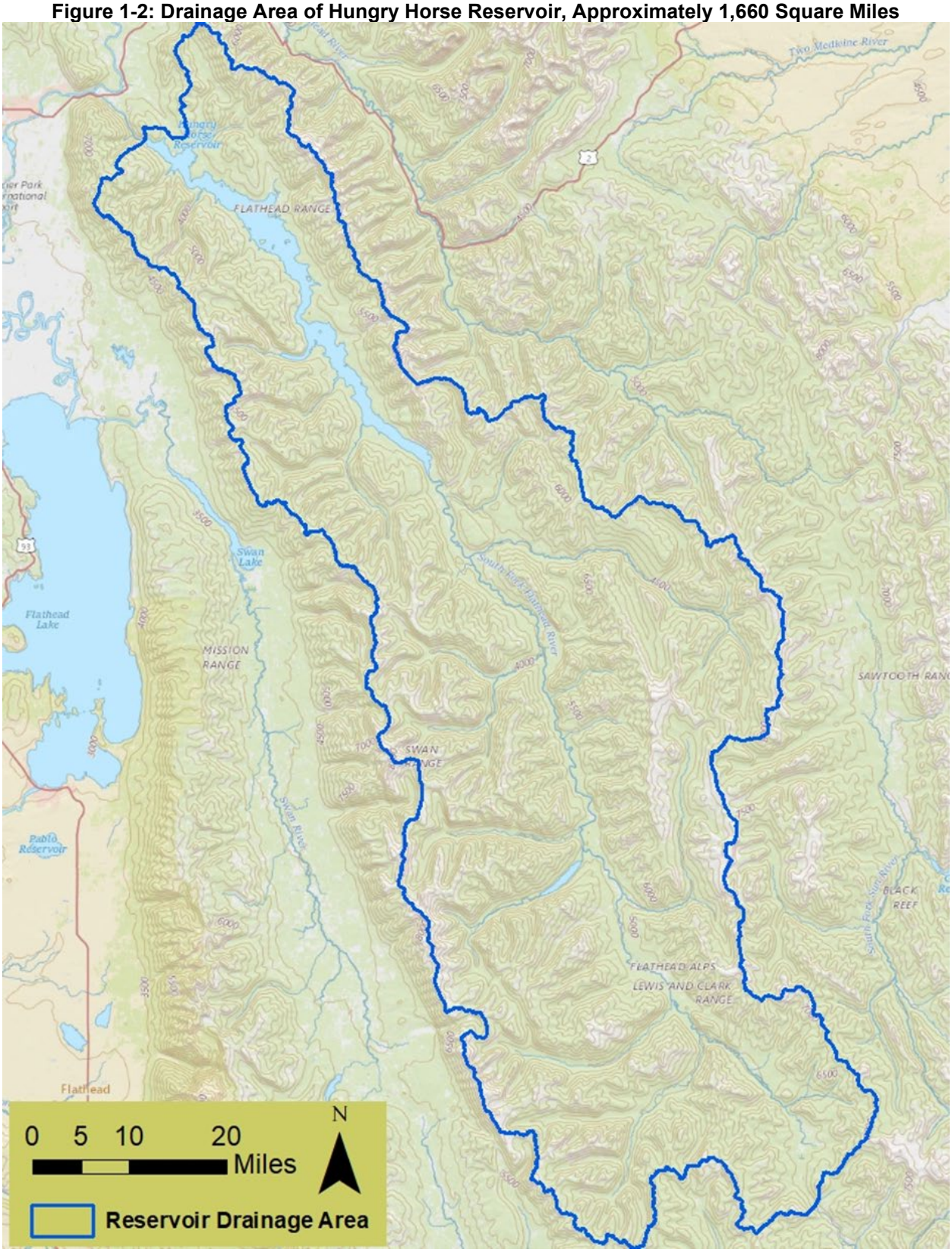
Because the water and sediment entering the reservoir has little opportunity for contamination, the waters in the reservoir have only been sporadically sampled for chemical analysis, and the sediments have never been extensively sampled. While the reservoir sediments have not been analyzed in depth, sediment deposition at the upper end of the reservoir, which formed a delta where the South Fork Flathead River slows into slack water as it enters the reservoir, has been noted.

Figure 1-1. Location of Hungry Horse Reservoir in Northwestern Montana and its Relation to Nearby Towns and Waterbodies

Figure 1-2: Drainage Area of Hungry Horse Reservoir, Approximately 1,660 Square Miles



Source: USGS 2018

1.2 SEDIMENT EVALUATION FRAMEWORK GUIDANCE

The Sediment Evaluation Framework (SEF) for the Pacific Northwest (Northwest Regional Sediment Evaluation Team 2016) was applied to this analysis to help guide the scope of analysis for characterizing existing conditions. The purpose of the SEF guidance is to provide a framework for assessing and characterizing sediment associated with dredging activities, including disposal, post–dredge surfaces, and water quality. The SEF guidance was specifically used to guide data acceptability, as well as identification of contaminants of interest when evaluating existing data.

SECTION 2 - SEDIMENT QUALITY

2.1 GENERAL DESCRIPTION

Hungry Horse Reservoir lies along the South Fork Flathead River. Located 15 miles south of the western Glacier National Park entrance, and 20 miles northeast of Kalispell, Montana (Figure 1-1). The South Fork of the Flathead River collects water from approximately 1,660 miles of almost completely undeveloped mountain peaks and valleys where it flows about 50 miles from its headwaters to Hungry Horse Dam and joins the North Fork of the Flathead River approximately 5.1 miles downstream of the Dam (Figure 1-2).

2.2 GEOLOGY AND SOILS

2.2.1 Geologic

The geologic history of the Flathead River and South Fork Flathead River has been largely shaped by (1) uplift of the Rocky Mountains (ca. 55 to 80 million years ago) due to subduction of the Farallon Plate (English and Johnston 2004); (2) development of the Rocky Mountain Trench; and (3) Quaternary glaciations. Predominantly following the uplift of the Rocky Mountains during the Laramide Orogeny, extensional fault systems led to the development of the Rocky Mountain Trench, a large depression extending from Flathead Lake, Montana, to the British Columbia-Yukon border (Van der Velden and Cook 1996). As the trench is characterized by a large linear depression, its topography influenced the movement of ice and development of hydrologic systems following deglaciation.

The geology of the area is dominated by Quaternary glacial, glaciofluvial, and glaciolacustrine deposits that have typically been deposited on metasedimentary rocks within the Belt Supergroup (Johns 1970). During the Last Glacial Maximum (between 20 and 30 thousand years ago), glacial ice covered the majority of the drainage west of the Rocky Mountain Trench (Johns 1970). This glacial ice included ice from alpine valley glaciers, which merged with the Flathead Lobe of the Cordilleran ice sheet (Alden 1953). Glacial ice from the North, South, and Middle Flathead Lake were large contributors of shaping the current landscape (Locke 1995). The terminal moraine of the Flathead Lobe is at the Polson Moraine, within glacial Lake Missoula, which wraps around a portion of Flathead Lake (Alden 1953).

Deglaciation of the Flathead Valley occurred between 12 and 15 thousand years ago; as the Flathead Lobe of the Cordilleran ice sheet retreated, a proglacial lake expanded (Smith 2004). This ancestral Flathead Lake was dammed by bedrock near the modern-day location of the Seli'š Ksanka Qlispe' (SKQ) Dam (Johns 1970). Base level for the Flathead River system would have been tied to the elevation of this incised bedrock prior to placement of the SKQ Dam. The ancestral Flathead Lake was much more extensive than the modern-day lake (Johns 1970). Lake levels receded as the Flathead River incised through the bedrock, allowing for the formation of terraces and reworking of fine sediment into eolian deposits (Smith, Blood, and LeFave 2000). Quaternary

deposits and re-worked deposits can reach depths of 1,200 feet (Smith, Blood, and LeFave 2000) within Flathead Valley.

2.2.2 Sediment Loading in the Reservoir

The sediment flows into the reservoir are primarily from the South Fork Flathead River and two smaller tributaries. Bedload data has not been measured, and very limited suspended sediment is available. No bathymetric measurements or any documentation of sediment accumulation relative to the pre-dam valley bottom have been made in the reservoir. Suspended sediment concentrations at these two tributaries, Sullivan Creek and South Fork Creek, were measured during spring runoff in April through June 2003. A mean suspended sediment concentration of 4.54 milligrams per liter (mg/L) and a maximum of 20.59 mg/L was reported at these tributaries (Steg et al. 2004). A new bathymetry map will be made available after this report has been developed and may be compared to topographical maps made before the reservoir filled to calculate sedimentation since inundation.

2.2.3 Past Dredging

No records of significant dredging of Hungry Horse Reservoir exist.

2.2.4 Land Use

The land surrounding the reservoir is popular for big game hunting. More than half of the land is managed by the Flathead National Forest, and the waters of the reservoir offer sport fishing opportunities for cutthroat trout (*Oncorhynchus clarki lewisi*), bull trout (*Salvenlinus confluentus*), and whitefish (*Coregonus clupeaformis)*. The surrounding mountains provide tributaries to Hungry Horse Reservoir from nearby alpine lakes and springs with little upstream human influence to affect water quality.

2.3 EXISTING DATA

Because the watershed upstream of Hungry Horse Reservoir is largely unaffected by human activities, there has been little concern for contaminant issues, which results in little historical studies to cite. However, some understanding can be developed by knowledge of the inputs and outputs of the waterbody. Where data has been used to present averages over a given period of time (Table 2-1), the data was sporadically collected and has little deeper meaning if plotted.

Table 2-1. Compilation of Surface Water (6.5 feet) Ion Concentration Readings at Hungry Horse Reservoir from 2004 to 2016

Analyte	Average	Maximum	Minumum	First sample	Last Sample
Alkalinity, total (mg/L)	69.53	76.3	52	9/2/2004	8/3/2016
Bicarbonate (mg/L)	84.73	93	63	9/2/2004	8/3/2016
Calcium (mg/L)	18.47	21.2	10	9/2/2004	8/3/2016
Chloride (mg/L)	0.56	0.9	0.4	9/2/2004	8/3/2016
Iron (ug/L)	20.23	30	10	9/2/2004	8/3/2016
Lead (ug/L)	4.40	6.49	2.85	6/7/2016	8/3/2016
Magnesium (mg/L)	5.33	8	4.7	9/2/2004	8/3/2016
Manganese (ug/L)	14.00	14	14	7/18/2013	7/19/2013
Potassium (mg/L)	0.30	0.30	0.30	7/16/2009	8/3/2016
Silica (mg/L)	3.64	4.20	3.20	7/16/2009	8/3/2016
Sodium (mg/L)	0.61	1.00	0.50	9/2/2004	8/3/2016
Sulfate (mg/L)	2.63	10	1.40	9/2/2004	8/3/2016
Zinc (ug/L)	12.15	12.15	12.15	7/18/2013	7/18/2013

Source: Bureau of Reclamation (Reclamation) (2017)

2.3.1 Sediment Characterization Studies

Approximately 65 percent of the basin lies within Federally protected lands, much of it in the Bob Marshall wilderness and Flathead National Forest, and the rest of the basin is sparsely developed. The terrain has a mean basin slope of 33 percent and is composed of unconsolidated alluvium and glacial deposits 40 to 50 inches thick underlain by metasedimentary and sedimentary rocks. In stream valleys, sediment depth increases to as much as 60 inches thick (Chase 2011).

The sediments within Hungry Horse Reservoir have not been rigorously chemically or physically analyzed. Historical aerial photographs have been acquired that could be used in future efforts to estimate the coarse sediment accumulation in the upstream delta of the reservoir, and a delta of sediment has formed at the upper end of the waterbody where the South Fork Flathead River slows as it enters the reservoir. A reconnaissance bathymetric survey is planned by the Bureau of Reclamation (Reclamation) in summer 2018.

2.3.2 Existing 303(d)

Hungry Horse Reservoir was listed on the Clean Water Act 303(d)-impairment list in 1996 due to flow alterations, siltation, and suspended solids downstream of the reservoir. In 2000, the Montana Department of Environmental Quality found the reservoir to be fully supporting its beneficial uses, this conclusion was based on the 1999 Montana Fish, Wildlife, & Parks (MFWP) report. The reservoir was delisted from 303(d) impairments in 2002 (Steg et al. 2004).

2.4 PHYSICAL DATA

Water releases from Hungry Horse Dam are managed to meet minimum flow requirements downstream of the dam for bull trout and to augment flow for salmon and steelhead in the Columbia River Basin (Chase 2011). Prior to the construction of Hungry Horse Dam, natural flows dominated the South Fork Flathead River with spring snowmelt peaking in late May or early June. These flows are believed to have cleaned downstream riverbed gravels and flushed fine sediments onto the riverbanks where they are bound by riparian vegetation. These spring floods moved sediments, shaped the river bed and channel, and provided clean gravel (MFWP 2011). Clean gravels are needed for spawning, security cover for young fish, and for fish food production. The space between gravels and cobbles provides habitat needed by aquatic insects (fish food). This habitat is lost when gravels and cobbles fill in with fine sediment. To maintain the river channel and clean the stream bed, current guidelines recommend allowing river flow to rise to bank full capacity for at least 48 hours every two to three years. Intermittent pulsing of river flows is intended to wash fine sediments back into the channel because vegetation cannot establish along the shoreline each year after the spring freshet. Adjusting river flows to more closely mimic natural annual hydrographs allows riparian vegetation to better stabilize the streambanks and hold fine sediments deposited on the shore during the spring freshet (MFWP 2011).

To help promote fish in the South Fork Flathead River, minimum flow targets have been established for the mainstem of the Flathead River at Columbia Falls (Marotz and Muhlfeld 2000). Minimum flow targets range from 3,200 to 3,500 cfs based on water availability. Hungry Horse Dam releases water to maintain this minimum flow when the combined flow of the North and Middle Forks of the Flathead River are less than 3,500 cfs. The minimum flow in the South Fork Flathead River downstream of Hungry Horse Dam is 900 cfs during abundant water years (wettest 60th percentile water years) and adjusts linearly from 900 to 400 cfs as water supply declines (driest 40th percentile) Falls (Marotz and Muhlfeld 2000).

Heller et al. (2016) concluded that the South Fork Flathead Rivers ecosystem would benefit if natural normative flows were further restored through management of flows for better land-water interaction as it would assist in remediating the severe embeddedness of the river bed. Such management changes would involve major operational changes to Hungry Horse Dam. For example, substantial changes would be needed to pass sediments through the dam. Heller et al. (2016) suggested that the restoration of sediment loads to the downstream river would increase riverine carrying capacity and productivity and greatly improve riverine conditions for invertebrates and fish below the dam.

2.5 CHEMICAL DATA

2.5.1 Organics

Sediments in the reservoir have not been directly sampled. However, some understanding of the organic material that may be found in the reservoir's sediments can be gained by looking at the data on organics in the reservoir's water.

2.5.2 Organic Carbon

Measuring the total organic carbon in a waterbody is a method to determine all of the compounds containing bioavailable carbon; this is important because a high organic carbon content is an indicator of excessive growth of microorganisms. The fuel for this growth is provided primarily through the decomposition of dead organic matter that contributes to the depletion of oxygen. If dissolved oxygen levels decline too low, large numbers of fish die, decompose, and exacerbate the cycle. Like other nutrients found in the Hungry Horse Reservoir, concentrations of organic carbon found in the waterbody are low but very capable of sustaining aquatic life. The total organic carbon recorded in the surface waters at Hungry Horse Reservoir is displayed in Table 2-2 as a compilation of all values recorded from 2007 to 2016 in the upper 2 meters of the reservoir water (Reclamation 2017).

Table 2-2. Compilation of all Surface Water (6.5 feet) Organic Carbon Measurements at Hungry Horse Reservoir from 2007 to 2016

Analyte	Average	Maximum	Minumum	First sample	Last Sample
Organic Carbon (mg/L)	1.67	2.8	0.9	5/24/2007	8/3/2016

Source: Reclamation (2017)

2.5.3 Nitrogen and Phosphorous

The primary form of inorganic nitrogen in the waters of Hungry Horse are nitrite and nitrate; ammonia is naturally converted to nitrite in waters with oxygen. Kjeldahl nitrogen, also referred to as organic nitrogen or nutrient-nitrogen, is a measure of the bioavailable nitrogen in a system that may be used in primary productivity. Because the primary source of nitrogen in the reservoir is from water runoff suspending organic materials as it flows downgradient toward the waterbody, a higher proportion of bioavailable nitrogen to inorganic nitrogen is anticipated. Inorganic and organic nitrogen readings recorded at the surface waters at Hungry Horse Reservoir are displayed in Table 2-3 as a compilation of all values recorded from 2004 to 2016 in the upper 2 meters of the reservoir water (Reclamation 2017).

Table 2-3. Compilation of all Surface Water (6.5 feet) Nitrogen and Orthophosphate Readings at Hungry Horse Reservoir

Analyte	Average	Maximum	Minumum	First sample	Last Sample
Inorganic Nitrogen (mg/L)	0.03	0.06	0.01	9/2/2004	8/3/2016
Kjeldahl Nitrogen (mg/L)	0.16	1	0.04	9/2/2004	8/3/2016
Orthophosphate (mg/L)	0.002	0.004	0.001	5/24/2007	6/23/2009

Source: Reclamation (2017)

Phosphate, like nitrogen, is an essential nutrient to life. Wherein nitrogen forms the building blocks of proteins, phosphate regulates metabolic activity. Orthophosphate (sometimes referred to as simply phosphate or reactive phosphorous) is the bioavailable form, whereas phosphorous is not readily bioavailable. However, the total phosphate concentration is important as phosphorous can become bioavailable, and if nitrogen and phosphate concentrations are too high, an algal abloom typically will occur, which can significantly reduce dissolved oxygen levels and result in massive fish die off. Like other nutrients in Hungry Horse Reservoir, nitrogen and phosphate are found at low levels but are generally high enough for aquatic life. Orthophosphate readings recorded at the surface waters at Hungry Horse Reservoir are displayed in Table 2-3 as a compilation of all values recorded from 2007 to 2009 in the upper 2 meters of the reservoir water (Reclamation 2017).

2.5.4 Metals

Sediments in the reservoir have not been directly sampled. However, some understanding of the metals that may be found in the reservoir sediments can be gained by looking at the data of metals in the reservoir's water. Overall, there is no indication of elevated metal concentrations within the waters of the reservoir as there no known sources of contamination in Hungry Horse Reservoir except for atmospheric deposition. Additionally, unlike other downstream locations such as Lake Roosevelt, mercury, like other metals, has not been recorded as a concern at Hungry Horse Reservoir.

2.5.5 Major Ions, Alkalinity, and Hardness

Bicarbonate water hardness in this system is generally classified as soft to moderately hard when bicarbonate. The alkalinity, metal ions, and water hardness measurements recorded from the surface waters at Hungry Horse Reservoir are displayed in Table 2-1 as a compilation of all water ionic values recorded from 2004 to 2016 in the upper 2 meters of the reservoir water (Reclamation 2017).

2.6 BIOLOGICAL DATA

Hungry Horse Reservoir hosts the strongest functioning habitat for the endangered bull trout and Westslope cutthroat trout (*Oncorhynchus clarki lewisi*) populations in the region and should be protected as a functioning control area isolated from introductions of nonnative species (U.S. Fish and Wildlife Service 2015). To protect the value of this habitat, analysis is needed to evaluate how changes in flows, temperatures, and other habitat conditions have influenced community composition, carrying capacity, and productivity of invertebrates and fish (Heller et al. 2016).

2.6.1 Elutriate Data

No elutriate data exists for this site.

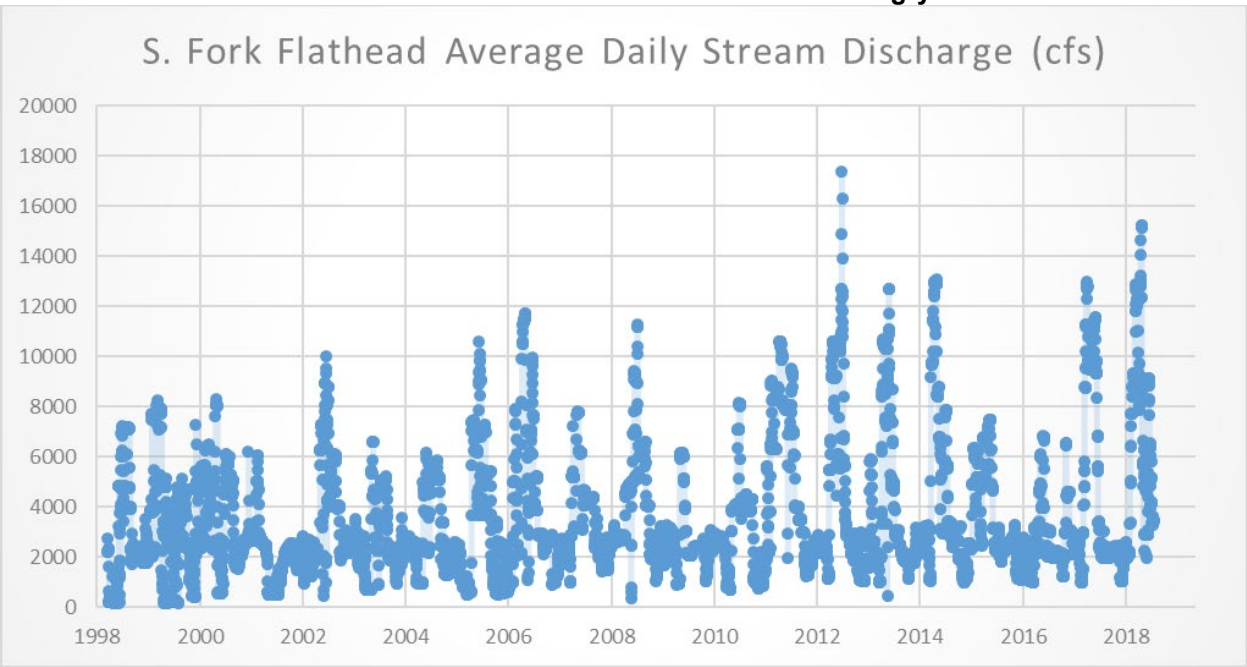
2.7 CHEMICALS OF CONCERN

This site has no listed chemicals of concern.

2.8 CONCEPTUAL SITE MODEL

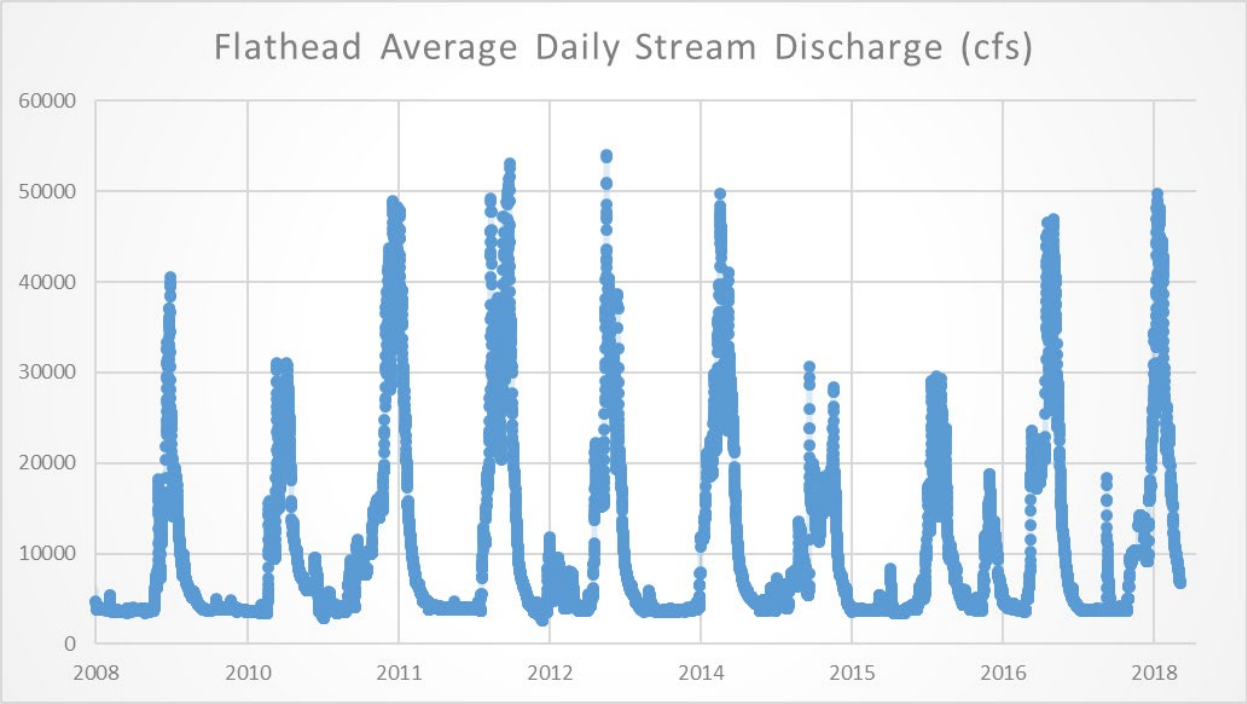
Reflecting the complexity of the upstream basin in which Hungry Horse Reservoir drains, the conceptual site model for Hungry Horse Reservoir is rather simple. The majority of flows enter Hungry Horse Dam from the South Fork Flathead River, and a few smaller tributaries add water directly to the reservoir (Figure 1-2). As there is no irrigation water drawn from the reservoir, nearly all of the water not lost to evapotranspiration continues down the South Fork Flathead River for 5.1 miles downstream of the dam before joining the Flathead River. The Flathead River has significantly more flow than the South Fork Flathead River (compare Figure 2-1 and Figure 2-2), and as such, the temperature and total dissolved gas water quality issues recorded in the South Fork Flathead River generally do not continue downstream of this confluence.

Figure 2-1. Average Daily Stream Discharge in Cubic Feet Per Second within the South Fork Flathead River Downstream of Hungry Horse Dam



Source: Reclamation (2017)

Figure 2-2. Average Daily Stream Discharge, in Cubic Feet Per Second, within the Flathead River Near Columbia Falls, Montana.



Note: Data from USGS 1236300 Flathead River at Columbia Falls, Montana, January 1, 2008, to January 1, 2018.

2.9 MANAGEMENT AREAS

The creeks and streams that drain into Hungry Horse reservoir are almost entirely contained within the Flathead National Forest, Bob Marshall Wilderness Area, or undeveloped rugged mountains managed by other agencies. These lands are managed primarily by the U.S. National Forest Service. The reservoir is managed by the Bureau of Reclamation.

2.10 LAND DEVELOPMENT AND TRENDS

No significant development is currently planned, and little development of the basin, beyond the construction of Hungry Horse dam, has historically occurred.

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