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United States Department of the Interior

NATIONAL PARK SERVICE

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Memorandum

To: Steve Black, Superintendent, Big Hole National Battlefield
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Through: Dr. Ed Harvey, Chief, Water Resources Division (WRD)
Gary Rosenlieb, Chief, ASB (WRD)

From: Mike Martin, Hydrologist (WRD),

Subject: Trip report detailing floodplain impact assessment of the Big Hole River

Purpose and Summary of Findings

The purpose of this trip was to assess the geomorphic and hydrologic effects of a parking lot and road crossing that is situated in, and completely traverses the floodplain of the North Fork of the Big Hole River. The possible impacts that we evaluated include: channelization and other channel alterations associated with the bridge and/or culvert crossings, and disruption of flowpaths and hydrologic conveyance by the road grade, including any obvious differences in vegetation between the up and downstream sides of the road. We also evaluated the impact to floodplain and channel processes associated with the parking lot footprint and fill. The results of our assessment, including recommendations are detailed in this report.

Problem Statement

This short reach of the North Fork of the Big Hole River has experienced human alteration for some time. The road grade that completely traverses the floodplain is an historic alignment that has existed for many years. Currently, the road surface sits on a prism of fill that is about five to seven feet above the floodplain. There is a bridge crossing over the active channel that allows most flows to pass downstream unhindered, but for the rest of the length of road there is only one point of hydraulic passage, a two-barrel culvert crossing, about halfway between the bridge and the north edge of the floodplain. In a natural state, overbank flows could pass over and down the floodplain with little hindrance. Now, all flows that exceed channel capacity are retained upstream of the road grade until they reach a high enough level to access the single culvert crossing.

In addition to the road grade, a more recent floodplain impact is the 1960's era construction of an approximate 30-space parking lot located in one of the meander loops of the river

(Figure 1). Not only does this position place the structure in the immediate floodplain of the river but its proximity to the active channel will likely disrupt channel migration processes at some time in the future. This near one-acre, asphalt parking lot was placed on about 5 feet of imported fill, and its footprint takes up near half of the floodplain area within the meander. The northeast corner of the pad is only a few feet from an outside meander bend of the active channel. To add to the impact, the asphalt paving of the parking only provides minimal infiltration and recharge to the alluvial aquifer, if any.

Overview

The North Fork Big Hole River (NFBH) begins at the confluence of Trail Creek and Ruby Creek on the west side of the upper Big Hole River basin. The river then flows to the northeast for about 15 miles before joining the Big Hole River. The NFBH flows through Big Hole National Battlefield for about 1.5 river miles (Figure 1) with a very sinuous meandering channel, underfit in a broad, gently sloping glacial valley. The floodplain associated with the river is about 1000 feet wide and well vegetated with a variety of riparian species, including numerous willow stands and various herbaceous wetland riparian plants. One floodplain species of particular note is the *Camassia quamash*, which is one of the cultural resources protected by the park.



Figure 1 - Google Earth image of Big Hole National Battlefield. Note the position of the parking lot adjacent to the active channel.

The portion of the historic road alignment that traverses the more active floodplain begins at the north end of the parking lot and continues about 600 feet to the north-northwest (Figure 1). Currently, the road alignment is maintained by park staff as a hiking trail and light duty service road with a gravel-earthen surface. As mentioned, the entire length of the road (including the parking lot) through the floodplain is supported by a prism of imported fill with only two points that allow hydraulic passage, the bridge crossing over the main channel of the river and one culvert crossing. The culvert crossing is a pair of 48-inch, corrugated metal pipes set about two feet below the top of the road grade (Figure 2).



Figure 2 – culvert crossing that passes through the road fill. The left image is the downstream side (note the plunge pool. On the right image, the upstream side, note the accumulation of sediment.

More significantly, both the inlet and the outlet to the two pipes are set several feet above the natural grade of the floodplain.

The culvert crossing is basically non-functional in relation to natural floodplain processes. With all overbank flows restricted to a single hydraulic crossing point, the current road – culvert configuration represents a dramatic reduction of overbank flow conveyance during periods of high water. Adding to this problem, the above grade elevation of the culvert intake requires a substantial overbank flow to even reach the pipe. Likewise, the high elevation of the culvert outlet creates conditions of excessive flow energy. This type of configuration almost always leads to ponding and/or deposition of sediment on the upstream side, with the downstream side experiencing scour and channelization, sometimes severe. In addition to the geomorphic impacts, this culvert configuration compromises passage of fish and other aquatic species, as well as transfer of any sediment, organic matter, or nutrients to the downstream floodplain.

As mentioned, the only other hydraulic passage under the road grade and parking lot is the bridge located immediately north of the parking lot. This bridge crossing is a single span with no piers and does not appear to present a very severe hydraulic construction. The south abutment is located out of the active channel and the north abutment only encroaches into the flow field for about two feet. Furthermore, there are no signs of bridge related geomorphic effects such as mid-channel bars or downstream bank scour. Consequently, the bridge crossing is probably reasonably functional with respect to hydraulics, especially in-channel flows.

Geomorphic and Hydrologic Setting.

The valley that contains the North Fork of the Big Hole River was formed during a series of glacial advances and retreats during the Pleistocene Epoch. The resulting morphology of the valley is a very broad and deep, gently sloping, U-shaped “trough,” the bottom of which is filled with mostly fine-grained glacio-fluvial sediments. This large scale morphology places substantial control on the flow hydraulics and geomorphic evolution of the modern river channel that occupies the valley bottom. A river-valley system with

this type of configuration is referred to as “underfit,” alluding to the difference of scale between the river and the valley. This translates to a disparity between the energy available from river flows and the energy required to substantially re-work the valley sediment.

The NFBH is predominantly a sinuous, meandering channel with some degree of past braiding suggested by multiple abandoned channels, or “sloughs” across the broad floodplain. Beaver dams are also present and they may greatly affect channel gradients, flow dynamics, and water storage. The multiple channels and ponds periodically fill with groundwater, slope seepage/springflow, and overbank flows from the river, all helping to maintain hydrologic conditions that support associated riparian wetland vegetation.

The entire channel/floodplain system, including the riparian-wetland, has formed in deep, Quaternary-age valley fill where groundwater occurs in the permeable sands and gravels in the uppermost units. Interactions between ground water and surface water are an important component of the basin’s hydrology, with connectivity between the surface and the fluctuating water table supporting stream flow, especially at critical low flow periods.

Very shallow water table levels are common in this system, especially during the maximum recharge period that extends from early spring to early summer. Groundwater hydrographs for the basin follow a seasonal pattern influenced by snowmelt and irrigation practices. Low water table levels that occur in the winter months generally increase in March and April due to melting of the valley snowpack. Water table elevations continue to rise through May and June in response to contributions from the mountain snowpack and flood irrigation at lower elevations. Water table declines usually occur after mid-July following cessation of irrigation (Marvin and Voeller 2000).

The surface water hydrograph follows the same seasonal pattern as the alluvial groundwater, with peak streamflows usually occurring in the late-spring to early-summer months. When overbank flows do occur, the complex channel system, with interwoven wetland and riparian floodplain areas, greatly affects overbank flow dynamics by reducing energy and lowering flow velocities. Furthermore, the extensive woody riparian vegetation and the prolific herbaceous species on the floodplains, adds to energy dissipation and provides substantial soil stability.

In a more valley-wide view, overbank flows result in multiple divided pathways through the channel complex with shallow sheet flow in the floodplain/riparian areas. The broad and low sloping valley morphology, coupled with the extensive willow stands across the floodplain, may create backwater conditions during times of overbank flooding. Road embankments and undersized culverts can add substantially to these backwater elevations affecting upstream flood levels and velocities.

All of these factors; a broad, gently sloping valley, a complex channel and floodplain geometry, an underfit stream, and prolific riparian vegetation, work in concert to render the current channel of the NFBH very stable, at least along this reach and in this flow regime. Geomorphic evolution certainly takes place, as is evidenced by some degree of

point bar formation visible on aerial imagery (Figure 1), but these channel processes, specifically meander migration, appear to be continuing at a very slow rate.

Hydrology of the North Fork of the Big Hole River

The Big Hole River has a flood regime typical of most western Montana rivers in that flood peaks primarily result from rapid snowmelt in the high elevation mountains of the upper watershed. The mainstem of the Big Hole River typically shows two spring melt peaks in the hydrograph, the first peak comes in early spring when the Upper Big Hole Valley begins to melt off the season's snowpack, followed by a larger peak occurring when the high elevation mountainous areas melt in late spring (Atkins, 2013). The North Fork of the Big Hole River probably follows a similar runoff pattern although flow magnitudes would be much smaller due to the smaller size watershed.

There is no systematic gage record for the North Fork of the Big Hole River so any estimation of the flow frequency for this site has to be developed indirectly. There was a gage operated on the NFBH within the Battlefield from 5/24/1999 to 10/15/2003 (#06024505) but that record only consists of 16 instantaneous flow measurements and therefore is not applicable to a flood frequency analysis.

The nearest downstream systematic flow record is from the USGS gage located on the Big Hole River below Mudd Creek, near Wisdom Mt (#06024540). The watershed at this point drains an area of about 1200 square miles, which includes the entire North Fork of the Big Hole River catchment. Annual peak flows at this gage have ranged from 1340 to 6660 cubic feet per second (cfs) during the 15 years of record (1998 to 2012). A recent estimate of the 100-year flood for this reach of the Big Hole River was in the range of 11000 cfs, and the 2-year flood was about 4000 cfs (Atkins, 2013). We did not locate any design flood estimates for NFBH, but given the difference of watershed areas between the North Fork and the mainstem river at Wisdom, about 35 versus 1200 square miles, flood magnitudes would be substantially less on the NFBH for any given recurrence interval flow.

In the absence of a systematic gage record for a particular reach of a watercourse, one preferred method for developing design flood estimates is by using regional regression analysis (Ries, 2007). Regional regression equations developed by the USGS for this hydro-climatic zone suggest that an average watershed of this size (roughly about 35 square miles) and at about this elevation range, is capable of producing modest peak flows. Estimates for the 100-year flood range from about 800 to 1000 cfs. Flows of this magnitude would certainly exceed the channel capacity of this reach but, given that the floodplain of the NFBH exceeds 1000 feet in this area, a flood of less than 1000 cfs would not be capable of producing substantial flood depths or excessive flow velocities. Anecdotal reports from park staff suggests that overbank flows in the spring are common during the season, but severe, destructive floods generally do not occur.

Discussion and Conclusions

The primary concerns regarding the presence of the parking lot and road grade are floodplain and riparian-wetland impacts including: alteration of flowpaths, disruption of channel processes, unnatural erosion, vegetation affects, and loss of habitat.

Impacts associated with the parking lot

The location of the parking lot in the immediate floodplain of the river creates two issues, one is the likely encroachment on a Regulatory Floodplain, which is contrary to NPS policy, and the second is that this location, on an inner meander loop is subject to natural channel migration processes.

NPS Floodplain Policy prescribes that development in a Regulatory Floodplain will be avoided unless there is no practicable alternative (NPS, 2003). This policy was not only adopted to protect human life and capital investment from loss during floods, but also to protect natural floodplain values such as maintenance of riparian hydrology, flood storage and energy dissipation, to name a few. Given the nature of flooding on the NFBH, human life should not be at risk at this location, nor is it likely that the capital investment of the structure will be lost or compromised during flood conditions. However, the location of the parking lot in a riparian-wetland and floodplain environment impacts natural floodplain values in this immediate area. The impermeable surface of the lot interferes with natural infiltration and the five foot prism of fill affects overbank flow and flood/sediment storage to some degree. However, these two conditions may not result in any measurable effect on natural resources. Conversely, the direct loss of the floodplain-riparian habitat is very measurable, with the footprint of the parking lot covering, and essentially eliminating this valuable habitat type.

One of the management issues facing BIHO staff is the preservation of the *Camassia quamash*, previously identified as a cultural resource. This species is scattered throughout the riparian-wetland environment of the NFBH. During our site visit we identified multiple individuals of this species, both immediately upstream and downstream of the parking lot, strongly suggesting that this plant, currently monitored by park staff and the Upper Columbia Basin Network Inventory and Monitoring program for abundance, could colonize the area covered by the structure and its fill.

Another consideration associated with the location of the parking lot is the likelihood that natural channel migration will eventually overtake the footprint of the structure. Given the proximity to the active channel to the parking lot pad, it is almost a certainty that the channel will eventually migrate into the parking lot location. This is especially true at the outside of two meander bends near the northeast and southwest corners of the parking lot (Figure 1). The common reaction to such a scenario is usually to treat the “eroding” channel with rip-rap, essentially forestalling natural river processes in favor of protecting threatened infrastructure.

Since the structure has been in place since the 1960’s, it is somewhat surprising that there has not been some conflict between channel migration processes and the parking lot location. However, as mentioned, channel migration processes appear to be greatly

decelerated in this reach due to the valley and channel morphology and the prevalence of stabilizing riparian vegetation. With time however, natural channel migration will almost certainly erode into the lot location, and some action will need to be taken to forestall erosion of the asphalt pad and its underlying fill.

Impacts associated with the road grade

There is no doubt that the road grade, which traverses the entire floodplain, has an effect on the flood hydrology. Under natural conditions, overbank flows would move down-valley, accessing abandoned channels and spreading over the floodplain as shallow sheetflow. Currently, all overbank flows in this reach are held back by the fill until reaching a high enough level to access the double culvert, the only hydraulic passage in the overbank.

On the upstream side of the road grade, the near complete blockage of overbank flows by the road fill has produced obvious upstream ponding and some degree of sedimentation in the vicinity of the culvert. On the downstream side of the culvert, there are definite signs of scour with the formation of an approximate 200 square foot plunge pool at the culvert outlet (Figure 2). While such channel incision can be a serious concern, the erosion at this crossing has not propagated for a very great distance. The gentle slope of the floodplain and the prolific vegetation, especially the willow stands, serve to limit the erosive effects of the concentrated flows that periodically leave the culvert pipes. Nevertheless, the current configuration does result in unnatural erosion for a distance and the generation of sediment.

In accordance with the Montana Water Quality Act, the Montana Department of Environmental Quality (DEQ) has completed and submitted Total Mean Daily Load (TMDL) analysis to the US Environmental Protection Agency (EPA) for the North Fork of the Big Hole River and its two major tributaries, Ruby and Trail creeks (EPA, 2009). A TMDL is the maximum amount of a pollutant a water body can receive and still meet water quality standards. The ultimate goal of TMDLs is to eventually attain and maintain water quality standards in all of Montana's streams and lakes, and to improve water quality to levels that support all state-designated beneficial water uses. Following the analyses, the DEQ has determined that sediment is impacting beneficial water uses in these streams by smothering aquatic insect habitat, reducing fish spawning success, and/or filling pools which reduces fish habitat. Sediment loads were quantified for naturally occurring conditions and impacted conditions from the following sources: bank erosion, hillslope erosion, and roads. The most significant sources included natural sediment loads, agricultural related loads from riparian vegetation impacts that influence bank erosion, and unpaved roads. While the sediment contribution from lands administered by BIHO is probably much less than in more impacted reaches, sources do exist within the unit and may play a role in future management decisions.

In addition to the scour downstream of the culvert, we evaluated the possibility of downstream water deprivation affecting the riparian-wetland system. A detailed vegetation survey was beyond the scope of this assessment, but there appeared to be a definite difference in vegetation types between the upstream and the immediate

downstream areas. However, this apparent “dryer hydrology” on the downstream side of the culvert does not extend for any great distance primarily due to the presence of the underlying alluvial aquifer. Abandoned channels a few hundred feet downstream of the road grade were filled with water indicating a high water table. With respect to the riparian system, these high water table conditions provide natural sub-irrigation for the vegetation. Consequently, it appears the effects on the vegetation of the surface water retention by the road grade are overcome by the shallow water table in a very short downstream distance.

Summary and Recommendations

Despite the fact that there is substantial human alteration of the channel and floodplain system in this short reach of the North Fork of the Big Hole River, there does not appear to be any extensive or widespread resource impacts. This is likely due to the following reasons.

- 1) The current channel configuration is very stable due to a low gradient, broad floodplain, and extensive wetland-riparian vegetation. These characteristics combine to both slow the rate of channel migration and resist erosion due to concentrated flows like those that pass through the culvert periodically. This erosion resistivity has forestalled channel migration into the parking lot footprint and limited the downstream migration of the plunge pool at the culvert outlet.
- 2) There is apparently a great deal of water available to the riparian system from sub-irrigation, toe slope drainage, and other sources. The obvious upstream water retention of the road fill and the resultant “drying” downstream does not appear to extend beyond a few dozen feet. A detailed vegetation survey might reveal that the hydrologic effect is somewhat more extensive, but at the time of the site visit, there were multiple abandoned channels filled with water within a couple hundred feet downstream of the culvert.

However, while there do not appear to be extensive or widespread impacts associated with the road grade or parking lot, there is definite loss of riparian wetland habitat and compromised floodplain values within the immediate area of the disturbances.

The parking lot is a near one-acre, impermeable surface sitting on about 8000 cubic yards of imported fill, located in both a valuable habitat type (*Camassia quamash*) and likely, the Regulatory Floodplain. Furthermore, at some time in the future, channel migration will almost certainly encroach into the parking lot footprint resulting in a variety of management issues and potential negative results.

Consequently, we recommend Park Staff consider steps and opportunities to relocate the parking lot to a non-floodplain location. This can be done at the convenience of other management goals as there does not appear to be any urgency related to any of the resource effects. However, at some time in the future, it may become more of an emergency action and negative consequences will likely occur.

The road grade, which covers almost an acre of wetland riparian habitat, also is located within the Regulatory Floodplain. As we discussed, the apparent effects of this encroachment do not appear to extend for a great distance beyond the footprint of the road prism, but, a series of structural alterations could greatly improve natural flow conditions and protect floodplain values to varying degrees.

The most obvious improvement would be to replace the current culvert crossing with an on-grade structure that provides greater flow conveyance at all stage levels, especially the lower stage levels. Additionally, multiple crossing points could be added to the road grade to allow greater flow conveyance over a wider floodplain area. However, even with several conveyance points, flow would still be unnaturally concentrated to some degree and wetland riparian habitat would be covered by the road fill.

The most functional restoration that could be achieved while still maintaining the road alignment would require a raised causeway or boardwalk type of structure with a near completely open span. Or, for complete restoration, total removal of the road grade and fill. We recognize the difficulty and cost associated any type of reconfiguration of this historic road grade. Considering that the resource impacts of this flow obstruction do not appear to be widespread, park staff may want to consider only minor treatment, if any. Nevertheless, the option of a complete restoration of this floodplain and wetland disturbance may be available to park staff and is worthy of consideration. Funding may be available through mitigation compensation resulting from local projects.

WRD staff will be available to provide continued assistance, consultation and support regarding any of these issues, should BIHO staff choose to pursue further options.

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NEPE - Degroskey, Jocius, Lyon
UCBN I&M - Dicus, Starkey

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