Summary Report on Hydrologic-Related Issues for Lyndon B. Johnson National Historical Park

June 2008

Introduction

In March 2008, WRD staff traveled to LYJO in response to a technical assistance request to evaluate the local riparian system associated with the Pedernales River. After discussing a number of hydrology related concerns with park staff, it became apparent that a more comprehensive hydrologic assessment was appropriate. Consequently, we decided to expand the scope of the assessment to include several other hydrologic issues present in the park.

These are the primary issues addressed in this document:

1) Establishing/maintaining a riparian corridor consistent with the historic scene from the Core Ranch Period of 1963-1973,

2) Evaluation of the flood hazard associated with historic structures and cultural features within the park,

3) Stability of on-site, historical dams, and

4) Evaluation of bank erosion and channel migration.

The overall objective of this document is to summarize original field observations along with the results of previous evaluations and studies and present conclusions and recommendations related to the four identified issues.

Overview

Fluvial System

The Pedernales River is a perennial, spring-fed stream that headwaters on the Edwards Plateau. It flows from west to east for about 100 miles through the Texas Hill Country, ultimately forming a confluence with the Colorado River in Central Texas.

In the area of LYJO, the channel is predominantly bedrock controlled with a varying thickness of overlying soil and alluvium. The relatively shallow limestone that underlies the park is reportedly the San Saba member of the Glen Rose Limestone. The overlying soil varies in thickness from near zero to over six feet in places. The composition is predominantly loamy,

fine sand in the upper profile with some pebbles and cobbles in a sandy matrix at depth (**Figure 1**). Overall, the exposed soil profile appeared to be very non-cohesive and, therefore, susceptible to erosion. Both upstream and downstream of the park, the topsoil has been eroded from the underlying bedrock on the left (north) bank of the river.

Figure 1 – Exposed bank of river showing general composition of alluvial material

Streamflow

The Pedernales generally maintains a baseflow throughout the year and may rise rapidly in response to rainfall events, possibly experiencing substantial peak flows. In fact, due to a combination of local physiography and geographic position, this area of Texas is extremely flood prone (Baker, 1975).

Three United States Geological Survey (USGS) gage records exist for the Pedernales River near LYJO, however, only two locations are still in operation, #08152900 near Fredricksburg and #08153500 near Johnson City. A third gage existed at Stonewall Texas (#08153000) from about 1925 to 1934. Of the two gages still in operation, Fredricksburg has 26 years of record and Johnson City has 71 years of record. Johnson City is downstream from LYJO and, at that location, the Pedernales drains a watershed about 40% percent larger than at LYJO (901 as

opposed to 608 square miles at the two respective locations). Consequently, we would expect discharge values to be proportionately higher at the Johnson City Gage than in the area of LYJO.

In addition to the USGS gages, the Lower Colorado River Authority (LCRA) posts real-time stage and flow data on their website (www.LCRA.org) for three locations on the Pedernales; Fredricksburg, Stonewall, and Johnson City. Details regarding these sites were not readily available, nor was there any indication that systematic, historic records are maintained.

Examination of the long term USGS record of daily mean flows at Johnson City indicates that streamflow is highly variable on the Pedernales River. Since 2000 the greatest daily mean values have occurred at various times throughout the year and have varied in magnitude from less than 2000 cubic feet per second (cfs) to almost 50,000 cfs. Annual peaks also have a high degree of variability, having occurred in all 12 months of the year with magnitudes ranging from less than 1000 cfs to the flood of record, 441,000 cfs on September 11, 1952.

The Riparian System

A healthy, well developed riparian corridor provides many benefits to the fluvial system. These include water quality protection by "filtering" non-point source contaminants and sediment, flood control by absorbing and slowing flood waves, streamflow maintenance by augmenting baseflows, buffering water temperatures through shading, and providing diverse wildlife habitat.

At the present time, very little of the original riparian system remains along the north bank of the Pedernales River within LYJO. Informal observation of nearby reaches of the Pedernales suggests that even in a completely natural state, the riparian system may not have been very dense nor extensive. Nevertheless, whatever riparian vegetation existed along this reach of the river under natural conditions, was heavily altered by earlier residents for agricultural purposes, leaving essentially no riparian corridor in LYJO.

Dams

Three low-head dams exist within the vicinity of the park, two within its boundaries and one upstream. The most downstream, and oldest structure is the Jordan Dam, constructed in 1940. Upstream is the Johnson Dam, which was constructed under the direction of President Johnson in 1952. Even farther upstream and outside of park property is Hodges Dam, also referred to as the State Park Dam, which was constructed in 1968. The two structures within the park are both historic and of significance to the historic landscape.

Discussion and Recommendations

The riparian system and the historic scene

As mentioned, the vast majority of the original riparian system on the north bank of the Pedernales, the bank owned and administered by LYJO, has been altered for agricultural purposes. Until recently, cattle have been allowed to graze on the north bank with little restriction. Consequently, natural regeneration of riparian species has been suppressed. By contrast, the south bank of the Pedernales across from LYJO, which is owned and administered by the Texas Parks and Wildlife system, supports a thin but well established riparian corridor with mature trees and understory vegetation.

While many natural resource benefits could be achieved by restoring a fully functional, extensive riparian corridor on the north bank, one of the primary goals of the park is to re-create the historic scene that existed during the Core Ranch Period of 1963-1973. Examination of a small number of photographs from that period suggests the riparian vegetation was not completely absent from the north bank of the Pedernales as it practically is today. Consequently, we believe it is possible to restore a thin strip of the riparian corridor and still maintain the historic scene.

The whole suite of riparian benefits would not be achieved with the restoration of only a thin strip; however, the very important benefit of bank stabilization may be accomplished or at least increased. Presently, long reaches of the north bank of the river within LYJO are unvegetated and near vertical, periodically experiencing erosion during high flows (**Figure 2**). Because even a thin corridor of woody and herbaceous riparian vegetation could realize benefits of streambank stabilization and improve the overall appearance of the bank, we recommend considering restoring the riparian corridor, at least within the context of the Core Period.

Figure 2 – View of the Pedernales River looking upstream and contrasting the north bank (foreground) and the south bank (upper left). Note the thin yet well developed riparian corridor on the south bank and the almost total lack of vegetation on the north bank.

Several approaches to restoring the riparian could be considered. The most simple would be to encourage natural re-vegetation by eliminating any activities that could inhibit growth, such as mowing, grazing, and/or herbicide application. Of course, exotic species, like the castor bean, would need to be managed. During the site visit, we observed some woody species on the river bank, suggesting natural re-establishment may be possible (**Figure 3**).

Figure 3 – Two views of some of the sparse woody vegetation present on the north bank. The presence of these naturally occurring stands suggests restoration of a more extensive corridor is possible.

A more pro-active approach to restoration would be to propagate and plant the species of interest. While this approach would have a much greater chance of success, planting the entire reach of the river that fronts LYJO would be a sizable task. However, this may be the necessary approach if natural regeneration is ineffective. Perhaps a reasonably sized test plot could be established to evaluate the effectiveness and ultimate cost of plantings while the rest of the bank is allowed to vegetate naturally. Regardless of which approach (if any) is adopted, an important first step would be consultation with an expert in local riparian systems to identify desired species and community structure, as well as evaluate the overall likelihood of re-establishment given the present conditions.

Procedures for establishing a riparian test plot:

The first step in restoring the riparian system is to determine the assemblage of riparian species that either would occur naturally, or, are at least restorable in this particular environment. To accomplish this, a local expert with particular knowledge of Texas Hill Country riparian systems could assess existing conditions and develop a list of appropriate species for restoration. Local Federal and State agencies may likely employ such riparian experts. Additionally, databases may contain general species lists for riparian systems in this part of Texas. Another restoration tool that could be of great value is the identification of a "reference section," or a reach of stream nearby with the desired conditions. Considering the goal of maintaining the Core Ranch Period appearance, a completely analogous reference section may be difficult to identify, however, any nearby, well developed riparian system could provide insight regarding species assemblage and community structure.

A comprehensive review of available historical photographs should be conducted by park staff to determine the extent of riparian vegetation that would be commensurate with the Core Ranch Period. From a natural resource perspective, the greater the extent of the riparian, and the greater species diversity within the riparian, the better the system functions. With that, our goal would be to maximize the extent of bank available for restoration while still maintaining the historic scene.

When a species list is developed, the environmental requirements for the individual species may be assessed with reference to the existing conditions and the available area for restoration. For example, species requiring constant or near constant soil saturation would not likely survive on the upper terrace, while some of the larger woody species may be well adapted for infrequent inundation at that level, but may not fit in the historical context. With these considerations a list of target species may be developed.

When a list of target species is developed a section of bank should be selected to establish a test plot. This bank section should have a morphology that would support the target species and be large enough to establish a viable stand of riparian vegetation. Additionally, it should be small enough to be easily managed by available park staff. It may be necessary to examine the environmental conditions of the test plot in greater detail, for instance, piezometers may be necessary to determine depth to water table and detailed soil properties may need to be assessed. However, these investigations would be dictated by the target species. With the size and configuration of the test plot established, a planting plan, possibly accompanied with an

irrigation plan, should be developed. Some of the stock for the target species may be acquired from nearby cuttings, however, it is likely that a local greenhouse will need to be contracted to propagate some or all of the individuals planned for the test plot. Local volunteer labor may be utilized in the planting.

Standard engineering stabilization

An additional treatment that should be mentioned is the more classic riverbank stabilization with structural means. While not truly a "restoration," hydraulic structures may be very effective in controlling bank erosion. Gabion baskets, backfilled with stone have been used at LYJO in the past, apparently with good success. Topsoil was placed over the structures after construction and vegetation has been established making the structures almost indistinguishable from other reaches of the bank. There are two drawbacks to this approach, the first is the cost, which could be substantial for the entire north bank within LYJO, and the second is limited habitat value often associated with such structures.

Flood hazard

Numerous floods have occurred on the Pedernales River in the last century. The first recorded high flow event was in 1869 with additional events in 1900, 1929, 1952, 1978, 1991, two in 1997 (February and June), and 2002. Most recently, park staff observed two out of bank flows in 2007. The flood of record occurred in 1952 with a discharge of 441,000 cfs at Johnson City.

The Pedernales watershed is located in a hydrologic province that may experience tropical and sub-tropical storms producing some of the highest rainfall rates in the United States. In addition to high rainfall, the river basin itself contributes to flooding with shallow bedrock and a relatively steep gradient channel of about 10.5 feet per mile (ACOE, 1979).

Design flood magnitudes developed by the ACOE for LYJO reflect the floodprone nature of the Pedernales in this area with values ranging from 16,400 cfs for the 2-year flood to 320,000 for the 500-year flood. A complete list of design floods are presented in Table 1.

Table 1 – Estimated flood discharge with associated recurrence intervals (ACOE, 1979). The technique used to derive these estimates was a synthetic unit hydrograph with published standard design storm inputs.

Frequency (Recurrence Interval)	Discharge (cfs)
2-year	16,400
10-year	86,000
25 – year	139,000
50 – year	179,700
100-year	220,200
500-year	320,000

Floodplains and historical structures

Due to the proximity of LYJO to the Pedernales River and the propensity of high flows, many of the historic structures and features are within the 100- and 500-year floodplains. These "at risk" structures include the Junction School, the LBJ Birthplace, the Johnson Family Cemetery, the Sam E. Johnson Sr. Farmhouse (Grandparents House), and the Cedar Guest House. The Texas White House is outside of the 100-year floodplain but within the mapped 500-year floodplain.

Based on the hydraulic analysis conducted by the ACOE, the depth of flooding for some of these locations may be substantial. Table 2 presents calculated depths of the 100-year flood at the location of historic structures within the park. As mentioned, the Texas White House is outside of the 100-year floodplain. In the event of a 500-year flood, flow depth at this historic structure would likely be in the range of about 2 feet.

Table 2 – Estimated depth of the 100-year flood at historic structures of interest within the park. Estimations were made by comparing modeled flood depth to corresponding land surface elevations.

Location	Estimated depth of flow (feet)
Cedar Guest House	6
Sam E. Johnson Sr. Farmhouse	6
Johnson Family Cemetery	10-14
LBJ Birthplace	5
Junction School	8-10

In terms of floodplain compliance and NPS policy, historic structures are exempt from floodplain regulations, and therefore, there is no need to prepare a Floodplain Statement of Findings for continued use of these structures. However, any mitigative actions adopted on the part of park staff to lessen potential damage during extreme flows must be viewed as a positive action.

Often times, buildings and other features that cannot be located outside of a floodplain are protected from flood hazard using structural means, such as levees or ring dikes. While these measures may reduce the flood hazard up to a certain level, they generally have an upward limit of protection. In the case of the LBJ Ranch, any type of protective structure that would substantially add to the flood safety would also likely violate the cultural scene. Consequently, structural mitigation is probably not appropriate in this setting.

Fortunately, the flooding conditions associated with the locations of the historic structures do not appear to be extremely hazardous. This supposition is based on previous floodplain analysis and past experience with multiple episodes of flooding. The most floodprone features in the park are the Johnson Family Cemetery and the Junction School. Both of these sites have experience high water at several times in the past but apparently have suffered no severe damage. Irreplaceable items within the structures should either be stored well above the expected level of flooding or included in an evacuation plan.

As a side note, the conditions that determine the depth of flooding for any given reach of a river are the amount of water in the stream and the physical characteristics of the stream channel and its associated floodplain, namely slope, configuration, roughness, and possibly permeability of the floodplain/channel. The question has been raised that the upstream Hodges Dam may be contributing to the frequency of flooding in LYJO. With the exception of controlled releases supplementing ambient flow or failure of a structure, an upstream impoundment does not increase the magnitude of downstream floods.

Stability of historic impoundment structures

As mentioned, two historic dams exist within LYJO. Given the historic significance of these structures and the resource values associated with them, their overall stability is of great concern to park staff. Recently, the Bureau of Reclamation in cooperation with the National Park Service completed a Safety Evaluation of Existing Dams (SEED) examination of the two structures within the park and the one located upstream of the park boundary (Faris, 2008).

In addition to the general conclusions that will be described in following paragraphs, the report provides two recommendations worth highlighting immediately:

1) "Make periodic visual observations and document whether seepage flow conditions are worsening at the right abutment of Jordan Dam (i.e., higher seepage flow over time). Make repairs if needed to limit seepage from the abutment."

2) "Repair the void in the concrete just downstream from the right abutment of State Park Dam to prevent further deterioration from occurring."

During the inspection, minor to moderate deficiencies were identified for all three structures, although none were viewed as serious by the inspector. The greatest deficiency was at the Jordan Dam where water was observed seeping under the left embankment. Recommendation 1) suggests continued observation and documentation of the seepage; however, it is our opinion that this condition will not improve, so preventative maintenance should be considered.

The Johnson Dam also had a couple of deficiencies, although they may be more cosmetic than structural. Specifically, some deterioration of the concrete on the low-water crossing deck was noted and there was some minor seepage near the toe of the dam at the left abutment, but neither of these conditions posed a serious concern to the inspector.

It is noteworthy that no structural deficiencies were recorded during the site visit, however, the inspector also stated for all three dams that flow over the structures during this site visit did not allow for an adequate examination of the structures. Consequently, we believe it is premature to assume that there is no structural deficiency associated with these impoundments and we recommend every effort be made to reschedule an inspection during low-water conditions to obtain a more comprehensive inspection report.

As a side note, park staff may be considering re-establishing the low water crossing associated with the Johnson Dam for some type of limited access. While WRD has no technical input

regarding general park management, we recommend approaching decisions that would put visitors or park staff directly in the flowfield of a large river with caution.

Erosion and channel migration

The concern that erosion and potential channel migration of the Pedernales could dramatically alter the cultural landscape and compromise resources has been present in the park for some time. This concern arises largely from the observation of bank erosion subsequent to high water events. WRD staff conducted an assessment of this observed bank erosion in 1999 and concluded that the loss of bank material is associated with hydraulic conditions that develop during high flows over the impoundment structures, and is primarily a localized condition and not expected to become widespread. Furthermore, the assessment concluded that the channel had a very low probability of migrating due to shallow bedrock exerting morphological control of the river form.

Subsequent to this assessment, John Middleton (a student at Texas A&M) conducted a more rigorous analysis of historical channel migration using a series of aerial photographs from 1955, 1963, 1970, 1974, 1983, 1990, and 1995. Spatial analysis of the geo-referenced photos indicated that the alignment and sinuosity of the Pedernales had remained constant since 1955. The analysis did detect a widening of the channel in some reaches; however, this observation was associated with emplacement of the low head impoundment structures and is not a result of any kind of natural channel evolution.

Other Issues

Deposition of sediment on floodplain

During some of the out of bank flows, fine grained sediment is deposited on the adjoining floodplain. The question was raised whether or not park staff should consider removing this material. Floodplain aggradation during a flood is a natural process and, in fact, is one of the reasons that floodplains provide such rich agricultural land. Eventually, these new deposits will become vegetated and blend in with the terrain. Consequently, we would recommend against expending any resources to remove this material.

Removal of trees and sediment across from Junction School

Another issue related to floodflows and riparian management that has been considered in the past is the removal of trees and sediment on the right (south) bank, across from the Junction School. The idea is that “opening up” the entire channel to floodflows would reduce the velocity in the vicinity of the Junction School. This short reach of the river is fairly complex from a hydraulic standpoint. Not only is there a well developed stand of trees, which serves as a substantial resistance to flow, but there is a dipping bedrock outcrop in the channel, which creates a channel slope in the direction of the school (**Figure 4**). Additionally complicating the hydraulics is a highway bridge downstream of the school that likely creates a substantial backwater effect during larger flows. We would suggest that prior to endorsing the removal of relatively rare

riparian habitat, a more comprehensive hydraulic analyses be conducted. If this is ever seriously considered, WRD would be able to undertake such an analysis on behalf of the park.

Figure 4 – Bedrock outcrops in the channel just upstream from the Junction School. Note how the configuration of the bedrock creates a "cross-channel" slope towards the left bank, the one supporting the school.

References

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