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Funding for WRDS and the creation of this electronic document was provided by the Wyoming Water Development Commission (http://wwdc.state.wy.us)

Executive Summary

Viva Naughton Enlargement Study
Level II, Phase II

Prepared for:

Wyoming Water Development Commission
Cheyenne, Wyoming

Prepared by:

States West Water Resources Corporation – Cheyenne, Wyoming

In Association with:

RJH Consultants, Inc. – Englewood, Colorado
Western EcoSystems Technology, Inc. – Cheyenne, Wyoming

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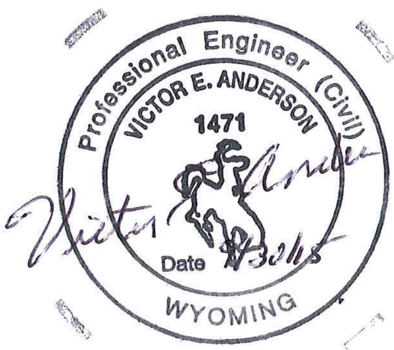

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EXECUTIVE SUMMARY

1 INTRODUCTION

Water shortages are well documented on this stretch of the Hams Fork River. A Level II, Phase I project was completed by ECI Consultants in 2004. This report considered several alternatives for providing additional storage to users in the Hams Fork Basin including raising the existing Viva Naughton Dam, a new reservoir on Dempsey Basin, and a new reservoir on Willow Creek.

For the Level II, Phase II portion of the project, the Wyoming Water Development Commission (WWDC) contracted with Gannett Fleming, Incorporated in 2005 to complete the conceptual design of these three alternatives. Gannett Fleming made several recommendations as a part of this project. This includes the enlargement or new reservoir size be limited to 24,180 acre-feet and Willow Creek be eliminated due to the presence of a large underground coalmine in the vicinity. Subsurface core drilling and test pit exploration at the Viva Naughton and Dempsey Basin was scheduled for the project but was postponed until a BLM Temporary Use Permit could be secured. In June 2007, WWDC executed a contract with States West Water Resources Corporation to complete the Level II, Phase II project. This report is the product of that project.

1.1 PROJECT LOCATION

Viva Naughton Dam is located on the Hams Fork River approximately 15 miles northwest of Kemmerer, Wyoming. The general location within the State of Wyoming is shown on Figure 1. A USGS topographical quad map of the area is shown on Figure 2.

Lower Dempsey Basin Dam and Upper Dempsey Basin Dam would be located on Dempsey Creek, which is a tributary to Viva Naughton Reservoir. The centerlines of both of these proposed dams (shown in relation to Viva Naughton Reservoir) are shown on Figure 2.

Figure 1
Project Location Map

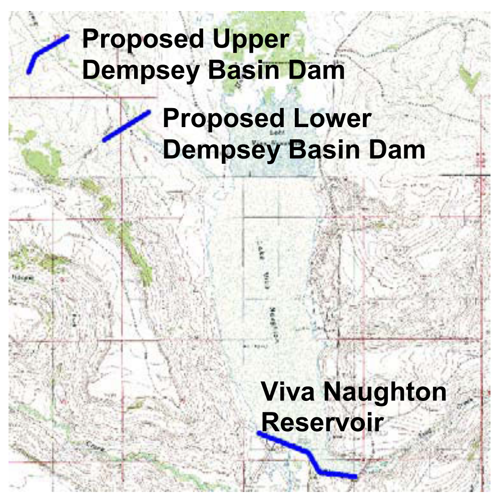

Figure 2
USGS Topographical Map

1.2 PERMIT HISTORY

The original storage permit (P6418R) for Viva Naughton Reservoir has a priority date of August 1, 1957. This permit allows PacifiCorp to store 42,393 acre-feet water for industrial use. An enlargement permit (P7476R) with a priority date of August 20, 1971 allows an additional 27,252 acre-feet to be stored in Viva Naughton for industrial and irrigation uses. Currently, 3,072 acre-feet of this permit is being utilized for storage, meaning that 24,180 acre-feet is still available for storage. A second enlargement permit (P7599R) with a priority date of August 20, 1973 also exists that would allow Viva Naughton to store an additional 12,250 acre-feet of water for industrial use. This permit is not currently being utilized.

1.3 RESERVOIR STORAGE VOLUME

The Level II, Phase II interim report issued by Gannett Fleming made several recommendations regarding the appropriate storage volume for an enlarged Viva Naughton Reservoir or a new Dempsey Basin Reservoir. This report concluded that an active storage volume of 24,180 acre-feet would meet the needs of all users. This volume would utilize the remainder of 1971 right (P7476R) of 27,252 acre-feet, of which 3,072 acre-feet are already available in the existing storage capacity of the reservoir. Fully utilized the 1971 water right would be allocated as follows:

1. A volume of 10,250 acre-feet would be available to PacifiCorp to meet the supply needs of future expansion at the Naughton Power Plant. A minimum reserve pool storage of 16,000 acre-feet in Viva Naughton Reservoir was also included in the modeling.

2. A volume of 4,750 acre-feet would provide firm future supply to the municipalities of Kemmerer/Diamondville, Opal, and Granger/Little America. Demands for these municipalities were projected to the year 2050.

3. The remaining 12,252 acre-feet would be allocated for irrigation supplemental supply. This supply would reduce serious shortages of currently irrigated acreages to 12 percent of the time in future years (i.e. 88 percent reliability).

1.4 RECOMMENDED STORAGE VOLUMES

The minimum active storage volume considered in this report is 24,180 acre-feet. In addition, States West considered the storage right of Kemmerer Reservoir (P5302R for 1,058 acre-feet) to be consolidated into the new project for a total of 25,238 acre-feet of active storage. This report also identified alternatives incorporating a dead pool of 10,000 acre-feet (35,238 acre-feet total) be added to a new reservoir to meet fishery and hydropower head requirements. This report also investigated a short term increase of normal high water level at Viva Naughton Reservoir. This investigation considered a short term, three foot water level raise which would store approximately 4,535 acre-feet.

This study investigated four storage alternatives:

1. Viva Naughton Enlargement
2. Viva Naughton Reservoir Shor Term Storage Increase
3. Lower Dempsey Basin Reservoir
4. Upper Dempsey Basin Reservoir

2 VIVA NAUGHTON ENLARGEMENT

The first site investigated involved the raising of the existing Viva Naughton Reservoir to contain the new storage. Enlarging Viva Naughton Reservoir by 24,180 acre-feet would require the dam be raised by approximately 13 feet. Enlarging the reservoir by 25,238 acre-feet would require the dam be raised by approximately 14 feet. This alternative has several critical issues that would need to be investigated further such as: subsurface geotechnical investigation, wetland impacts, crucial moose winter habitat impacts, greater sage-grouse habitat impacts, cultural impacts to the Dempsey-Hockaday trail.

2.1 GEOLOGICAL AND GEOTECHNICAL INVESTIGATION

Geological and geotechnical investigations included review of published and unpublished geotechnical and geological data at and near the dam and reservoir, photogeologic interpretation and field geologic mapping, subsurface investigations in the area of the proposed emergency spillway, laboratory testing, and engineering evaluations to develop a preliminary interpretation of the subsurface conditions that are likely to impact emergency spillway construction and raising the embankment. Conceptual design of the enlargement was developed and a downstream raise concept was recommended to raise the crest from an elevation of 7,249 feet to an elevation of 7,265 feet. The existing spillway would be removed to accommodate the downstream raise of the embankment. The new principal spillway would be located further west in order to found the structure on solid material. The new structure would be similar in function and capacity as the existing structure. The enlargement of Viva Naughton Reservoir would require modifications to the outlet works as the toe of the enlarged embankment would inundate the existing outlet works control building. This structure (and the existing control valves within the structure) would have to be moved beyond the limits of the enlarged dam toe as shown. The design of the new control building would be similar to that of the existing control building. The existing 66-inch diameter outlet pipe would also have to be extended by approximately 175 feet. The current diameter of the outlet pipe is sufficient to discharge increased outlet flows. The existing emergency spillway would be abandoned and the raised embankment extended across to the west. The design of the new emergency spillway would be similar to that of the existing emergency spillway and would be designed to pass the PMF safely. The width of the new spillway would remain at 300 feet. Additional subsurface geotechnical investigation and borings through the embankment's core is recommended to help determine the existing dam's internal structure.

2.2 WETLAND AND RIPARIAN MITIGATION INVESTIGATION

A wetland and riparian mitigation investigation was conducted to determine the feasibility of mitigating wetland and riparian losses associated with a Viva Naughton Reservoir enlargement. The area investigated was on lands owned by PacifiCorp upstream of Viva Naughton Reservoir. The wetland impacts associated with a 24,180 acre-foot enlargement would be approximately 175 acres. The ratio for mitigation of new wetlands was assumed to be 2:1 for a mitigation requirement of 350 acres. The total area upstream of the normal high water level of the enlargement on PacifiCorp property was approximately 312 acres and primarily focused on the irrigated lands on the property. The irrigated lands that were targeted for this study could possibly be enhanced; however, the ratio for enhancement is 4:1, which would require 700 acres of mitigation. This would involve removing substantial irrigated lands for wetland creation. This presents a severe permitting problem and is likely not a feasible option for wetland mitigation.

The area that would be inundated by a reservoir raise at Viva Naughton Reservoir is included in an area classified as critical moose habitat. The area is composed primarily of wetland (175 acres) and riparian areas (250 acres). In addition to mitigating wetlands, the riparian areas would also need to be mitigated at a ratio of at least 3:1 for a total of 750 acres of riparian habitat establishment would be required. This investigation did not result in the identification of adequate potential mitigation areas upstream of the reservoir. The potential to mitigate the impacts of the enlarged reservoir inundation does not appear feasible upstream of the reservoir.

2.3 HISTORIC TRAIL EFFECT INVESTIGATION

Enlarging Viva Naughton Reservoir would impact the Dempsey-Hockaday Trail. The length of trail inundated would be approximately 0.85 mile and would more than likely require mitigation in the form of protecting other segments of the trail and better public access and appreciation for the historical significance.

2.4 GREATER SAGE-GROUSE IMPACTS

Viva Naughton Reservoir is located within the greater sage-grouse Core Population Area. On June 2, 2011, Governor Mead issued Greater Sage-Grouse Executive Order (EO) 2011-5, which states that new development or land uses within Core Population Areas should be authorized or conducted only when it can be demonstrated that the activity will not cause declines in greater sage-grouse populations. A Density and Disturbance Calculation Tool (DDCT) was used to determine if the proposed new disturbance, combined with existing and permitted disturbances in the area, are below 5% of the DDCT area. Based on the results of this DDCT analysis, the enlargement of Viva Naughton Reservoir would not be in compliance with the Governor's EO because total surface disturbance is greater than 5%. Even without the new disturbance, the area of existing disturbance in the DDCT analysis area (5.78%) is already above the 5% threshold.

2.5 CONCEPTUAL COST ESTIMATE

Conceptual cost estimates were developed for a 24,180 acre-foot enlargement and were estimated to be $72.3 million in 2012 costs or $2,990 per acre-foot.

3 VIVA NAUGHTON RESERVOIR SHORT TERM STORAGE INCREASE

Due to the potential fatal flaws associated with a 24,180 acre-foot enlargement of Viva Naughton Reservoir, a smaller enlargement alternative was investigated. The investigation considered a short term, three foot water level raise of Viva Naughton which would store 4,535 acre-feet. This increase would raise the normal high water level from an elevation of 7,242 feet to an elevation of 7,245 feet. The issues investigated included the effects on wetlands, dam embankment modifications, emergency spillway modifications, greater sage-grouse effects, and historic trail effects.

3.1 WETLAND SHORT TERM IMPACTS

The high-water elevation associated with an approximate 3-foot raise of Viva Naughton Dam were reviewed in relation to wetland maps prepared from a delineation of the area previously conducted. The length of time that the water levels would have been increased was estimated using the hydrological model developed in previous work. The model indicates that the increased storage pool would have been filled approximately 75% of the years. The average fill date would be June 1. The estimated average reservoir levels and inundated wetlands would be:

Table 1 - Viva Naughton Reservoir Levels and Inundated Wetlands

Date	Reservoir Level	Additional Wetlands Inundated
June 1	7245	83.7 acres
July 1	7243.3	35.6 acres
Aug 1	7241.9	0 acres

The results indicate that 35.6 acres of wetlands would be inundated for 30 days, and zero acres of wetlands would be inundated for 60 days.

The short term increase of normal high water level could have the long term effect of increasing the wetlands acreages. The water level increase could increase the wetland acreage by an estimated 36.8 acres. These areas were mapped as upland species and currently are used primarily for hay production.

The conclusions are that short term inundation should not negatively impact the existing wetlands and could have the indirect benefit of creating additional acreages of wetlands; however, further investigation is recommended.

3.2 DAM EMBANKMENT EFFECTS

The proposed three foot increase in normal high water level was reviewed by RJH consultants, geotechnical specialists for the project. A preliminary static slope stability and a simplified seismic deformation analyses were performed to evaluate the feasibility of raising the maximum normal pool elevation of Viva Naughton Reservoir from Elevation (El.) 7242 to El. 7245. The results of the stability analyses are summarized in Table 2.

Table 2 - Stability Analysis Results

Loading Condition	Calculated Factor of Safety			Minimum Recommended Factor of Safety[(2)]
	Existing Conditions	Raised Pool	Dam Raise (2008)[(1)]	
Downstream Steady State Seepage with Peak Bedrock Strength	1.56	1.56	1.75	1.5
Downstream Steady State Seepage with Residual Bedrock Strength	1.22	1.20	1.50	1.0
Upstream Steady State Seepage with Peak Bedrock Strength	-	1.79	1.48	1.5
Upstream Steady State Seepage with Residual Bedrock Strength[(4)]	-	1.88	1.79	1.0
Upstream Rapid Drawdown with Peak Bedrock Strength	-	1.24	1.19	1.3
Upstream Rapid Drawdown with Residual Bedrock Strength	-	1.52	1.15	1.0

Notes:
1. Results for the dam raise are from RJH (2008).
2. Minimum required factor of safety according to the US Army Corps of Engineers, EM 1110-2-1902, 2003.
3. "-" means does not apply.
4. Failure surface forced through bedrock, not critical failure surface.

Based on the results of the seismic deformation analysis, the estimated crest deformation is predicted to vary from 0.2 to 4.0 feet. The analysis was performed for both the clay core material and the clayey silty gravel shell material. The wide range of estimated deformation values is a reflection of the uncertainty of the shear wave velocity of the embankment materials.

Based on the results of the analyses the following conclusions are offered:

- Raising the reservoir has a negligible impact on the computed static slope stability of the embankment.
- Raising the pool elevation to El. 7245 will raise the water about 1 foot above the top of the core, possibly causing water to flow over the core. The flow over the core could also overwhelm the capacity of the chimney drain.
- The maximum predicted seismic deformation is about 4 feet. The residual freeboard after a seismic event could be zero feet.

The existing embankment would be adequate for storing the additional three feet of storage. However, the remaining freeboard is insufficient to contain the probable maximum flood or normal wave action. The proposed solution is the construction of a parapet wall along the reservoir side of the dam crest. The parapet wall would be connected to the existing dam core to prevent piping. The retaining walls of the principal spillway as well as the walkway, gate operators and stems, electrical control panels, and conduits would have to be raised to the same level as the parapet wall.

3.3 GREATER SAGE-GROUSE IMPACTS

New disturbance associated with the proposed three foot short term water level raise would be approximately 65 acres. The additional disturbance areas would be within a core sage grouse habitat population, and the effects of the additional inundation would occur in June and July. The existing surface disturbances in the DDCT area are approximately 5,713.74 acres, which represents 8.61% of the DDCT analysis area and includes the existing Viva Naughton and Kemmerer Reservoirs as well as extensive irrigated hayfields located along the Hamsfork River upstream of Viva Naughton. The combined existing and proposed disturbance was approximately 5,778.74 acres, which represents approximately 8.7% of the DDCT analysis area. The additional disturbance caused by the proposed three foot short term water level raise is fairly insignificant and would occur in June and July only and would more than likely not cause any permanent removal of sage grouse habitat; however, even without the new disturbance, the area of existing disturbance in the DDCT analysis area (8.61%) is already substantially above the 5% threshold. The proposed three foot short term water level raise would more than likely not cause the permanent removal of sage grouse habitat, and would primarily inundate the wetland and riparian area north of Viva Naughton. Further investigation of sage grouse habitat impacts and potential mitigation efforts are recommended in future studies.

3.4 HISTORIC TRAIL EFFECTS

The potential short term three foot water level raise would inundate approximately 500 feet of a “contributing segment” of the Dempsey-Hockaday Trail along Dempsey Creek. The increased water level would parallel the contributing segment for approximately 2,500 feet.

3.5 CONCEPTUAL COST ESTIMATE

Conceptual cost estimates were developed for a three foot water level raise and were estimated to be $5.5 million in 2012 costs or $1,213 per acre-foot.

4 DEMPSEY BASIN DELIVERY SYSTEM

As off-channel sites, the Lower Dempsey Basin Reservoir and Upper Dempsey Basin Reservoir require a water delivery system. Alternative water delivery systems were analyzed and included:

1. Canal system
2. Pumping system
3. Pump/turbine combination unit system

A preliminary design was completed for each alternative and cost estimates were developed for a range of sizes for each alternative. The following trends and conclusions can be drawn from the water delivery system analysis:

1. The probable optimum size of Alternative 1: Canal System would be approximately 350 cfs. This size would be required to fill the reservoir on a dependable basis. The annual costs increase with time because of the high operation and maintenance costs. This alternative does not have a high dependability due to the difficulties of snow removal to open the canal.

2. The probable optimum size of Alternative 2: Pumping System would be approximately 150 cfs. This size range would require 50 days to deliver the average fill of 14,000 acre-feet and 81 days to deliver the maximum fill of 24,180 acre-feet. The annual costs increase with the system size and time so the smallest system that can reliably deliver the water would be optimum. The 150 cfs system was used for economic comparisons.

3. The probable optimum size of Alternative 3: Pumped Storage System Using Reversible Pumps/Turbines would also be approximately 150 cfs. The annual costs indicate larger sizes of systems are more costly. The potential value of the pumped storage to PacifiCorp may be higher than that determined by utilizing filed avoided rates. The generation capacity could be available nearly instantaneously to help meet peak demand periods. The 150 cfs system was used for economic analysis of the reservoirs.

4. The life cycle costs for the study period do not heavily favor any of the alternatives. Based on the potential benefits of revenue generation for the pumped storage alternative, we recommend pursuing Alternative 3: Pumped Storage System Using Reversible Pumps/Turbines. The optimum project size would be the 150 cfs system. Alternative 3 requires that the power/recreation pool be incorporated into the dam design

5 LOWER DEMPSEY BASIN RESERVOIR

The lower Dempsey Basin location is sited just inside the high water line of Viva Naughton Reservoir. It was moved slightly from the location identified in earlier reports to reduce material necessary to construct the dam. The minimum storage volume previously considered for Lower Dempsey Basin Reservoir was 24,180 acre-foot. This study also investigated the feasibility of a

25,238 acre-foot reservoir (which would incorporate the storage right from Kemmerer Reservoir) and a 35,238 acre-foot reservoir (which would incorporate both the storage right from Kemmerer Reservoir and a 10,000 acre-foot power/recreation pool).

5.1 GEOLOGICAL AND GEOTECHNICAL INVESTIGATION

Geological and geotechnical investigations included subsurface investigations, laboratory testing, and engineering evaluations to develop a preliminary interpretation of the subsurface conditions that are likely to impact dam and reservoir design and construction. The dam and reservoir are underlain by the Wasatch formation. Within the dam and reservoir site, the Wasatch formation locally includes a subunit known as the Tunp Member that intertongues with other members of the Wasatch and Green River formations. The Tunp Member is described as a red, conglomeratic, sandy mudstone. Due to the soft mudstone bedrock, slopes of the potential dam demanded flattening to absorb the potential stress and provide an adequate factor of safety. There is also potential for the mudstone to swell if the moisture content is increased or due to removal of the overburden materials. If the mudstone swells, it could impact the invert elevation of the spillway crest. Swelling properties of the mudstone should be evaluated in future phases of design. Mudstone bedrock is highly erodible material and significant erosion of the spillway channel will occur when the spillway operates. Erosion of the spillway should be evaluated in future phases of design. Another geotechnical issue is the potential for inundation of the dam toe by Viva Naughton Reservoir. Additional protection was planned to eliminate embankment damage from this occurrence. Based on the geotechnical investigation, conceptual design of the embankment, spillways and outlet works were developed. The existing emergency spillway at Viva Naughton Reservoir does not have sufficient capacity to pass flood flows created by a dam failure at Lower Dempsey Basin Reservoir. It is recommended that the spillway at Viva Naughton be widened 500 feet to a total emergency spillway width of 800 feet. The maximum flow through the emergency spillway would be approximately 75,000 cfs.

5.2 WETLAND AND RIPARIAN IMPACTS

A 24,180 acre-foot Lower Dempsey Basin Reservoir would only inundate 19 acres of wetlands due to the ephemeral nature of Dempsey Creek. A 35,238 acre-foot reservoir would inundate 21 acres. Based on standard Corps of Engineers ratio of 2:1, wetland mitigation requirements would be between 38 and 42 acres. The mitigation of this site could be achieved with rim wetlands above the high water line of the proposed reservoir.

5.3 HISTORIC TRAIL EFFECTS

Unfortunately, the high water line of a 24,180 acre-foot reservoir covers approximately 3.7 miles of the Dempsey-Hockaday Trail, and a 35,238 acre-foot reservoir would inundate approximately 3.8 miles of the trail. The potential mitigation for historic trail impacts would more than likely be in the form of protecting other segments of the trail and better public access and appreciation for the historical significance. Although over a mile of the Trail is on private property, the regional United States Bureau of Land Management (BLM) personnel have shown resistance to allowing any elimination.

5.4 GREATER SAGE-GROUSE IMPACTS

A DDCT analysis was completed to determine the impacts to greater sage-grouse habitat. Active leks were identified in the near vicinity of the proposed Lower Dempsey Basin Reservoir, and the total disturbance was estimated to be 5,103.42 acres or 7.69%. Even without the new disturbance, the area of existing disturbance in the DDCT analysis area (5.78%) is already above the 5% threshold.

5.5 CONCEPTUAL COST ESTIMATE

Conceptual cost estimates for a potential storage of 24,180 acre-feet were estimated to be $55.5 million in 2012 costs or $2,295 per acre/foot. The total project cost would be approximately $67.3 million in 2012 costs for the 35,238 acre-foot reservoir or $1,910 per acre/foot. The larger storage size was used to allow a fishery and head for hydropower.

6 UPPER DEMPSEY BASIN RESERVOIR

Upper Dempsey Basin Reservoir was previously identified in the Green River Groundwater Recharge and Alternate Storage, Level I Project. This site was originally not pursued in subsequent studies due to difficulties of delivering water through a canal. With the validity of pumped storage shown, it was possible to reintroduce the original Dempsey Basin reservoir located approximately 1 mile upstream from Dempsey Creek's inlet with Viva Naughton Reservoir. Table 3 illustrates the advantages and disadvantages the upper storage site has in comparison to the lower site.

Table 3 - Advantages and Disadvantages of Upper Dempsey Basin Reservoir

Advantages	Disadvantages
1. The upper site would be more efficient in that the embankment quantity would be less than the lower site for the equivalent amount of storage. 2. The upper reservoir is located at a higher elevation. Power generation revenues would increase. 3. The upper site would be upstream of identified landslides. 4. Viva Naughton Reservoir would not inundate the dam foundation and toe at the upper site. 5. The impacts on wetlands would be reduced from 21 acres to approximately 15 acres. 6. The impacts on the historic trails would be reduced from 3.8 miles to approximately 2.7 miles. 7. The dam would be located entirely on one property whose landowner has been receptive to the project. 8. Approximately 1 mile of Dempsey Creek could be developed with instream flows and riparian/wetland habitat.	1. The pipeline from the pump/turbine station to the reservoir would be increased by approximately 1 mile. 2. The upper reservoir is located at a higher elevation. Pumping heads to the reservoir would be higher, resulting in higher electricity costs.

6.1 GEOLOGICAL AND GEOTECHNICAL INVESTIGATION

Geological and geotechnical investigations included subsurface investigations, laboratory testing, and engineering evaluations to develop a preliminary interpretation of the subsurface conditions that are likely to impact dam and reservoir design and construction. A review of published and unpublished geotechnical and geological data, photogeologic interpretation and field geologic mapping was previously performed during evaluation of the Lower Dempsey site; some of this information is also relevant to the Upper Dempsey site because the sites are about a mile apart.

Seven exploratory bore holes and sixteen test pits were excavated. The bedrock proved to be stronger than the lower site allowing steeper slopes on the faces of the dam saving approximately 1 million cubic yards of material in the embankment. Areas of high hydraulic conductivity were identified in the subsurface investigation. The reasons for these areas of high hydraulic conductivity are currently unknown, but they could be caused by defects in the rock mass that could have been caused by stress relief, landsliding or other geologic phenomena. It is not currently known if these defect areas daylight in the reservoir or if they will result in excessive seepage losses or create seepage stability concerns. The conceptual design and cost estimates include a grout curtain to seal the zone.

As discussed in the previous section, the existing emergency spillway at Viva Naughton Reservoir does not have sufficient capacity to pass flood flows created by a dam failure at the Dempsey Basin reservoir sites. It is recommended that the spillway at Viva Naughton be widened 500 feet to a total emergency spillway width of 800 feet. The maximum flow through the emergency spillway would be approximately 75,000 cfs.

6.2 WETLAND AND RIPARIAN IMPACTS

A 24,180 acre-foot Upper Dempsey Basin Reservoir would only inundate 14 acres of wetlands due to the ephemeral nature of Dempsey Creek. A 35,238 acre-foot reservoir would inundate 15 acres. Based on standard Corps of Engineers ratio of 2:1, wetland mitigation requirements would be between 28 and 30 acres. The mitigation of this site could be achieved with rim wetlands above the high water line of the proposed reservoir or within the Dempsey Creek drainage located on upstream tributaries.

6.3 HISTORIC TRAIL EFFECTS

The Upper Dempsey Basin Reservoir would impact the Dempsey-Hockaday Trail. Approximately 2.6 miles of trail would be affected by a 24,180 acre-foot reservoir, and approximately 2.7 miles of trail would be affected by a 35,253 acre-foot reservoir. The potential mitigation for historic trail impacts would more than likely be in the form of protecting other segments of the trail and better public access and appreciation for the historical significance. However, the regional United States Bureau of Land Management (BLM) personnel have shown resistance to allowing any elimination.

6.4 GREATER SAGE-GROUSE IMPACTS

A DDCT analysis was completed to determine the impacts to greater sage-grouse habitat. Active leks were identified in the near vicinity of the proposed Upper Dempsey Basin Reservoir, and the total disturbance was estimated to be 5,319.52 acres or 6.65%. Even without the new disturbance, the area of existing disturbance in the DDCT analysis area (5.13%) is already above the 5% threshold.

6.5 CONCEPTUAL COST ESTIMATE

Conceptual cost estimates for a potential storage of 24,180 acre-feet were estimated to be $59.5 million in 2012 costs or $2,461 per acre/foot. The total project cost would be approximately

$66.7 million in 2012 costs for the 35,238 acre-foot reservoir or $1,893 per acre/foot. The larger storage size was used to allow a fishery and head for hydropower.

7 HAMS FORK RIVER IMPACTS

To demonstrate the impact of additional storage on downstream water users, a StateMod model was constructed as part of the previous study. The model simulates the river from 1946 through 2001; however, an extended drought struck the region in 1999. This drought would prove to be the drought of record for the area. Therefore, in order for the model to be accurate, the StateMod model was updated in the Level II, Phase II report completed by Gannett Fleming to include the years between 2002 and 2005. The model was then utilized to determine the impacts on flows at numerous locations below Viva Naughton Reservoir. The results indicate flows are reduced in the runoff months of April, May, and June as flow is stored. Appreciable increases in flow occur in the months of July, August, and September as releases are made for irrigation supplementary flows. The lower portions of the Hams Fork have historically dropped to very low flows in late summer. The percentage increases of flows are highest at these locations. The reduced flows during April, May and June cannot injure any existing water rights based on the legally available flows for storage. As Table 4 shows, the flows through Kemmerer/Diamondville are reduced in spring and early summer, but are significantly increased at summers end. The table also demonstrates the potential increased flows during periods of drought.

Table 4 - StateMod Modeling Results below PacifiCorp Diversion

AVERAGE FLOWS												
Existing	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
AF/Month	1,163	1,128	1,230	1,220	1,094	1,332	7,209	37,562	30,085	6,435	2,956	1,332
CFS	18.9	19.0	20.0	19.8	19.7	21.7	121.2	610.9	505.6	104.7	48.1	22.4
With Enl.												
AF/Month	1,163	1,128	1,230	1,220	1,094	1,332	3,973	27,804	29,465	8,134	4,728	2,364
CFS	18.9	19.0	20.0	19.8	19.7	21.7	66.8	452.2	495.2	132.3	76.9	39.7
Percent Change	0	0	0	0	0	0	-45%	-26%	-2%	+26%	+60%	+77%

DROUGHT FLOWS												
Existing	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
AF/Month	893	974	1,025	983	925	1,227	2,080	13,466	13,582	3,432	1,802	892
CFS	14.5	16.4	16.7	16.0	16.7	20.0	35.0	219.0	228.3	55.8	29.3	15.0
With Enl.												
AF/Month	893	974	1,025	983	925	1,227	2,080	6,635	10,543	3,165	2,116	1,201
CFS	14.5	16.4	16.7	16.0	16.7	20.0	35.0	107.9	177.2	51.5	34.4	20.2
Percent Change	0	0	0	0	0	0	0	-51%	-22%	-8%	+17%	+35%

8 DEMPSEY-HOCKADAY TRAIL IMPACTS

As discussed in previous sections all four alternatives impact the Dempsey-Hockaday Trail. The impacts range from the enlargement's 500 feet on private property to 3.8 miles for the Lower Dempsey Basin Reservoir. Since a significant impact on the trail for the Dempsey Basin reservoirs is located on BLM owned property, this agency has had a significant amount of control on accessing and investigating the sites. Any further progress for either Dempsey Basin site will involve the BLM cooperation and assistance.

9 ALTERNATIVE STORAGE SITE MATRIX

To compare the alternate storage sites, a matrix has been utilized to incorporate both monetary and non-monetary factors. The factors are summarized in Table 5.

Table 5 - Monetary and Non-Monetary Factors for Scoring Matrix

Monetary Factors	Non-Monetary Factors
Project Storage Reservoir size in acre-feet.	**Need** Project need based on shortages.
2012 Project Costs Total project costs updated to 2012.	**Water Availability** Availability of water to store.
Unit Storage Cost Project costs divided by project storage.	**Project Ability to Meet Need** Project location and size relative to needs.
Operation and Maintenance Operation and maintenance costs for 2012.	**Multiple Use Potential** Potential for uses such as recreation, municipal, power generation, hydropower production, irrigation, etcetera.
2012 Net Power Costs Annual net payment (or revenue) for power usage and hydropower production.	**Geotechnical Feasibility** Preliminary geotechnical evaluation completed.
Annualized Construction Costs Yearly payment for loan on total costs assuming no grant and 4 percent interest for 30 years.	**Land Ownership** Preliminary evaluation of impacts on wetlands, riparian habitat, wildlife, fisheries, etcetera.
Total Annual Costs Total costs for loan payment, operation and maintenance, and net power costs assuming no grant from WWDC.	**Ability to Permit** Comparative evaluation of potential for successful project permitting.
Annualized Construction Costs Yearly payment for loan on total costs assuming 67% grant and 4 percent interest for 30 years.	**Cultural** Potential impact to cultural resources.
Total Annual Costs Total costs for loan payment, operation and maintenance, and net power costs assuming 67% grant from WWDC.	**Species** Potential impact to threatened, endangered and sensitive wildlife and plants, migratory birds and big game habitats.
	Sage-Grouse Potential impact to sage-grouse habitat.

Each of the non-monetary factors were assigned a weighted value that reflects the importance of that factor feasibility. Each potential project was assigned a score from 0 to 10 for each factor.

Table 6 - Non-Monetary Scoring Matrix Factors

Factor	Weight	Viva Naughton	Viva Naughton Short Term Storage Increase	Lower Dempsey		Upper Dempsey	
Storage (Acre-feet)		24,180	4,535	24,180	35,238	24,180	35,238
Need	40	10	10	10	10	10	10
Water Availability	30	9	10	8	8	8	8
Ability to Serve Needs	30	10	2	8	10	8	10
Multiple Use	40	2	2	2	10	2	10
Geotechnical Feasibility	20	8	9	6	6	7	7
Land Ownership	20	9	9	5	5	5	5
Wetlands Impact	30	1	9	7	6	8	7
Sage-Grouse Impact	30	8	8	3	2	2	1
Moose Impact	30	1	8	9	9	9	9
Cultural Impact	30	6	9	2	1	3	2
Ability to Permit	40	1	8	2	2	2	2
Total		1910	2540	1890	2180	1940	2230

Table 7 - Monetary Scoring Matrix Factors

	Viva Naughton	Viva Naughton Short Term Increase	Lower Dempsey		Upper Dempsey	
Project Storage (Acre-feet)	24,180	4,535	24,180	35,238	24,180	35,238
2012 Project Cost	$72.3 M	$5.5 M	$55.5 M	$67.3 M	$59.5 M	$66.7 M
Unit Storage Costs ($/ac-ft)	$2,990	$1,213	$2,295	$1,910	$2,461	$1,893
Life Cycle O&M costs	$1.8 M	$0	$4.4 M	$6.5 M	$4.4 M	$6.4 M
Life Cycle Power Cost/Revenue	$0	$0	$1.9 M	$ -1.6 M	$2.7 M	$ -1.9 M
Costs w/ No Grant Life Cycle Costs	$74.1 M	$5.5 M	$61.8 M	$75.4 M	$66.6 M	$71.2 M
Costs w/ 67% Grant Life Cycle Costs	$24.7 M	$1.8 M	$24.6 M	$27.1 M	$26.7 M	$26.5 M

The scoring matrix results indicate the Viva Naughton Short Term Storage Increase alternative is the preferred alternative. The life cycle costs favor the Viva Naughton Short Term Storage Increase alternative. The Viva Naughton Enlargement has potential fatal flaws with wetland impacts and crucial moose winter habitat impacts. It is unknown if the Dempsey Basin Storage alternatives have fatal flaws with sage-grouse core area impacts and historical trail impacts.

10 RECOMMENDATIONS

Recommendations for further study of the Viva Naughton project, if the project is advanced, are detailed in this section.

10.1 GENERAL RECOMMENDATIONS

The following common items need to be addressed if any project near Viva Naughton Reservoir is to advance to the next phase:

1. PacifiCorp's willingness to participate must be determined for both cost sharing and ability to assist with O&M. The ability to use the power produced from the proposed turbines should be discussed with the power company.

2. The issues with the potential impacts on the Dempsey-Hockaday Trail must be addressed and solutions found to the BLM concerns.

3. Water needs and potential usage from irrigators and municipalities must be verified.

4. The potential to move the Kemmerer Reservoir water rights with the City, the Wyoming State Engineer's Office, and the Wyoming Game and Fish should be evaluated if the Viva Naughton Enlargement or Dempsey Basin Reservoir projects are advanced. This includes the actual moving of the right and the ability for the Wyoming Game and Fish to obtain and manage the existing Kemmerer Reservoir.

10.2 VIVA NAUGHTON ENLARGEMENT RECOMMENDATIONS

The following items should be addressed if the enlargement of Viva Naughton is advanced to the next phase of study:

General Issues:

1. Mitigation areas for wetland impacts and crucial moose winter habitat must be addressed. Adequate areas for mitigation have not been identified in previous work.

2. Potential impacts to greater sage-grouse core areas and active leaks must be investigated. Mitigation potential may have to be evaluated.

3. The mitigation of potential impacts to approximately 0.8 miles of the Dempsey-Hockaday trail must be addressed.

Geotechnical Issues:

1. Borings should be advanced through the existing dam to confirm the descriptions of the various embankment zones and to obtain samples for laboratory strength and index testing.

2. Additional borings should be advanced through the proposed emergency spillway to confirm the subsurface profile and to obtain samples for laboratory strength, deformability, erodibility, and index testing.

3. Borrow sources for general earthfill and filter materials should be investigated and proven.

4. The shear wave velocity of the existing and proposed embankment fill should be more accurately estimated.

10.3 VIVA NAUGHTON SHORT TERM STORAGE INCREASE RECOMMENDATIONS

The following items should be addressed if the Viva Naughton Short Term Storage Increase is advanced to the next phase of study:

General Issues:

1. The impacts to sage-grouse core areas and active leks should be investigated further. Specifically, whether or not the wetlands and riparian areas above Viva Naughton Reservoir are considered sage-grouse habitat and the effects the short term inundation would have on the habitat.

2. The mitigation of impacts to approximately 500 feet of the Dempsey-Hockaday Trail should be addressed.

3. Reservoir hydrology, flood hydrology and flood routing associated with the short term storage increase should be addressed as well as the capacity of the existing emergency spillway to pass a PMF.

4. Evaluate the effects of the recently completed PMP study has on the existing PMF.

Geotechnical Issues:

1. Complete a subsurface investigation to accomplish the following:
    a. Collect samples of the shell material and perform grain size analyses, strength testing, and permeability testing.
    b. Collect samples of the foundation bedrock and perform laboratory strength testing to establish residual strength.
    c. Confirm the elevation of the top of the core in multiple locations.
    d. Measure the shear wave velocities of the core and shell materials.

2. Reevaluate the stability of the embankment with strength properties developed from the results of the subsurface investigation.

3. Evaluate and design a method to extend the core to a higher elevation. These could include a concrete or soil-bentonite cutoff wall.

4. Re-evaluate the seismic deformation with site-specific shear wave velocity data and a more rigorous analysis method.

5. Evaluate the potential erodibility of the emergency spillway and the ability of the emergency spillway foundation to support a control structure.

10.4 Lower Dempsey Basin Recommendations

The following items should be addressed if the Lower Dempsey Basin Reservoir is advanced to the next phase of study:

General Issues:

1. The impacts to sage-grouse core areas and active leks must be investigated. The dam and reservoir area is located within the sage-grouse core area. Active leks are located in close proximity to the reservoir.

2. The mitigation of impacts to approximately 3.8 miles of the Dempsey-Hockaday Trail must be addressed.

Geotechnical Issues:

1. Site-specific topographic information should be obtained for the embankment footprint, reservoir, and surrounding area. This is required to evaluate further the concerns related to the Viva Naughton Reservoir encroaching on the toe of the dam, to refine the dam layout, and provide an adequate base map for design level geologic mapping and evaluation.

2. The extent and properties of the sandstone bed in the upper left abutment and along the left reservoir rim should be investigated and evaluated.

3. The gradation, consistency, and properties of the alluvial terrace materials should be investigated to confirm that these materials would be suitable for use in the manufacture of filter materials and to evaluate the extent of required processing and amount of unsuitable (excess) materials that would be generated as a result of processing.

4. Additional field investigations should be performed along the alternate dam alignment to further evaluate the properties of the bedrock, confirm the initial conclusions regarding the degree of fracturing, and to obtain samples for laboratory testing.

5. The shear strength of the embankment fill is the primary controlling factor in the external embankment configuration. Only samples of weathered bedrock were obtained and only one test was performed to estimate shear strength because of permitting access issues. Additional field and laboratory tests need to be conducted on weathered bedrock and alluvial clay materials in the valley bottom to confirm or revise the shear strength of the borrow material available for use as embankment fill.

6. The material properties and especially the shear wave velocity of the embankment fill should be more accurately estimated and a more rigorous seismic deformation analyses should be completed to determine if additional freeboard is required to prevent a breach of the dam during an earthquake.

10.5 UPPER DEMPSEY BASIN RESERVOIR RECOMMENDATIONS

The following items should be addressed if the Upper Dempsey Basin Reservoir is advanced to the next phase of study:

General Issues:

1. The impacts to sage-grouse core areas and active leks must be investigated. The dam and reservoir area is located within the sage-grouse core area. Active leks are located in close proximity to the reservoir.

2. The mitigation of impacts to approximately 3.8 miles of the Dempsey-Hockaday Trail must be addressed.

Geotechnical Issues:

1. Additional subsurface investigations and seepage analyses should be performed to evaluate areas of bedrock with high hydraulic conductivity and the effects of the high hydraulic conductivity on seepage losses and seepage stability. Additional investigations should also be performed to investigate why the areas of high hydraulic conductivity are present within bedrock at the Site.

2. Additional field and laboratory tests need to be conducted on borrow materials in the valley bottom to confirm or revise the shear strength of the borrow material available for use as embankment fill.

3. Additional laboratory tests need to be conducted on borrow materials to evaluate the consolidation characteristics of the material available for use as embankment fill and estimate the rate of consolidation and associated duration of shutdown required for a staged construction.

4. Additional laboratory tests need to be conducted on alluvial soils within the embankment footprint to better define the shear strength and deformation properties of the foundation soil. Additional stability analyses should also be performed using revised strength properties for the foundation soil. Removal of surficial soil beneath the entire embankment footprint may not be required if adequate safety factors are achieved with the soil in place and predicted settlements are not excessive.

5. The gradation, consistency, soundness, and properties of the alluvial terrace materials should be further investigated to confirm that these materials would be suitable for use in the manufacture of filter and riprap bedding materials and to evaluate the extent of required processing and amount of unsuitable (excess) materials that would be generated as a result of processing.

6. The material properties, and especially the shear wave velocity of the embankment fill, should be more accurately estimated and a more rigorous seismic deformation analyses should be completed to determine if additional freeboard is required to prevent a breach of the dam during an earthquake.

7. A more thorough geologic and geotechnical evaluation of the existing ancient landslides above the right reservoir rim should be conducted to evaluate the existing stability of the landslides and the effects of reservoir construction on stability.

8. Additional laboratory strength tests should be performed to evaluate the shear strength of the bedrock. Additional investigations and stability analyses should be performed to evaluate the stability of the reservoir slopes, and in particular, the area where the proposed inclined intake is proposed to identify if this concept is appropriate.

11 CONCLUSIONS

A draft copy of this report was made available to PacifiCorp, the owner of Viva Naughton Reservoir, in an effort to gauge PacifiCorp's willingness to participate in a project at Viva Naughton Reservoir or one of the alternative Dempsey Basin Reservoirs. In a letter dated September 20, 2013 addressed to Jason Mead with the Wyoming Water Development Office, PacifiCorp stated interest in pursuing further discussions with the Wyoming Water Development Commission on the development of a mutually agreeable arrangement that may facilitate the Viva Naughton Enlargement alternative (approximately 4,500 acre-feet). PacifiCorp was not interested in pursuing the development of the Dempsey Basin Reservoir alternatives. Currently, the WWDC and PacifiCorp are working to reach agreement on a memorandum of understanding that will guide further efforts to research the feasibility of a mutually agreeable arrangement to enlarge Viva Naughton Reservoir. The project team is currently investigating the technical feasibility of a nominal raise (approximately 4,500 acre-feet) of Viva Naughton Reservoir based on the recommendations presented in Section 10. Findings from this investigation will be included as an addendum to this report once completed. The height of the nominal raise will be based on several factors such as:

- Inundation tolerances of the wetlands and sage grouse habitat
- Subsurface geotechnical evaluation of Viva Naughton Dam
- Reservoir hydrology, flood hydrology and flood routing