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EXECUTIVE SUMMARY

Big Wind River Drainage Level II, Phase 1, Storage Feasibility Study

Contract NO. RN052814/F

Prepared for:

Wyoming Water Development Commission

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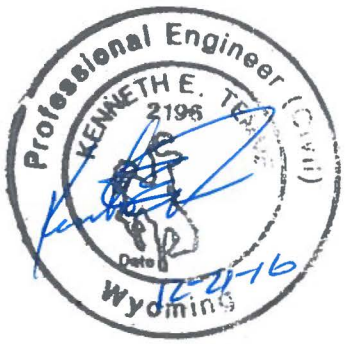
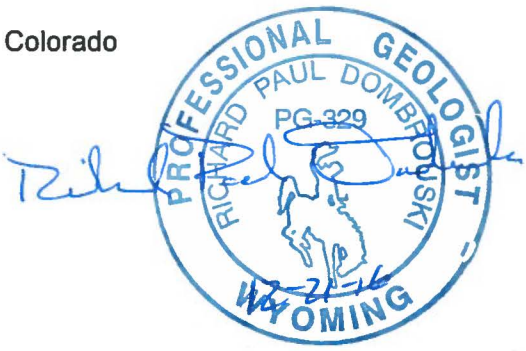


December, 2016

In association with
Riverside Technology, Inc, Fort Collins, Colorado
DOWL, Lander, Wyoming
Harvey Economics, Denver, Colorado



Introduction

Irrigation shortages have long been documented in the Wind River Basin upstream of Boysen Reservoir. In 2014, the Eastern Shoshone and Northern Arapaho Tribes (Sponsor) received Wyoming Water Development Commission (WWDC) funding to conduct a Level II, Phase I, Storage Feasibility Study for the Big Wind River Drainage (Project) for evaluation and conceptual design for constructing new or enlarging existing dams and reservoirs to offset the documented irrigation shortages. The "StateMod" modeling platform was used for simulating water availability, rights and shorted demands for the project. Using data from this modeling, conceptual designs, economic evaluations, and cost estimates were developed for constructing new or enlarging existing dams and reservoirs within the Big Wind River Basin.

This Executive Summary presents the Project purpose, findings, cost estimates and recommendations. More detail on the Project is available in the Big Wind River Drainage Level II, Phase 1, Storage Feasibility Study, which was also conducted by Tetra Tech, Inc. in association with Riverside Technology, Inc., DOWL, and Harvey Economics, dated December 2016.

Purpose and Need

The purpose of the study was to develop a "StateMod" modeling platform for simulating water availability and shorted water demands in the Big Wind River Basin. Currently the timing of runoff through the drainage does not match irrigation demand timing. Without additional water storage, the timing of runoff and subsequent availability hinders supply capabilities for required irrigation demands.

In addition to meeting current shortage and projected demand for irrigation water, the project will provide several associated benefits, including increased recreation opportunities and enhancement of late season stream flows.

Temporary Stream Gaging

Temporary stream gages were installed at nine locations, three in the Big Wind River basin and six in the Little Wind River basin where data was considered to be lacking due to the absence of previously installed stream gages. The data obtained from the stream gages can be used to supplement data in the hydrologic analysis for this study and future studies. The installation and operation of these gages were a combined effort for the Big Wind River Storage Study and the Little Wind River Storage Study.

Hydrologic Analysis

The StateMod model was used to simulate current hydrologic conditions throughout the Big Wind River basin for the period 1990 through 2013. The model used historical records of streamflow, diversions, and reservoir levels; current water rights; and estimates of ditch transmission losses, crop application efficiencies, and return flows to simulate current administration practices in the basin. This Current Demand Model Scenario run of the model identified water supply shortages throughout the basin as well as the legally available free water supply at potential reservoir locations. Legally available flows at a point in the river are defined as that portion of the physical supply that is available to be diverted or stored under a new (current day priority) water right and is not subject to a call from a senior water right downstream. The model was also run under a Total Water Righted Acreage scenario in which the demand for water in the model was assumed to be the total allocated amount of water for each right, regardless of whether that much water

had been taken historically. This scenario includes the water rights for the Tribal Futures lands. In order to identify the true system-wide impacts of an additional storage project, the StateMod models for the Big and Little Wind basins were combined into a single model.

The Current Demand Model Scenario indicates that the Big Wind River watershed's average annual shortage is estimated to be approximately 12,202 ac-ft. In the extremes, the model estimates a maximum shortage of 24,100 ac-ft for a single year and a minimum shortage of 7,757 ac-ft for a single year. Under the Total Water Righted Acreage Scenario, the average annual shortage is estimated to be approximately 55,200 ac-ft, with individual years ranging from less than 500 ac-ft shortage to more than 195,000 ac-ft. The model's results substantiate the claim that there are seasonal water shortages in the Big Wind River Watershed.

Conservation

There are approximately 134,847 acres of land currently being irrigated in the Big Wind River basin, based upon mapping analyses performed as part of this study. The complexity of water diversions range from small farming practices to extensive irrigation ditch systems within Irrigation Districts. The types of irrigation applications include a mix of sprinkler and gravity fed flood irrigation practices. Irrigation ditches throughout the basin often consist of several miles of open dirt canals with multiple turnouts. Increasing the application efficiency or conveyance efficiency in the ditches will decrease the amount of diverted water needed to meet field requirements, potentially reducing shortages in the system as more water may become available if less water is diverted.

Diversion efficiencies in StateMod include both conveyance and on-farm application efficiencies in a single, monthly number. Adjustments were made to these values by making assumptions about changes that could be made to improve the one value. The modeling suggests that conservation measures could reduce shortages by more than 50% (6,665 ac-ft) but that a substantial amount of shortage still exists within the Big Wind River basin, particularly later in the irrigation season. Thus, the need for additional storage for late season supplementation flows is still justified.

Screening

A screening matrix was developed to assist in evaluating each potential storage site through five sequential levels of screening in accordance with guidelines provided by the Wyoming Water Development Office (WWDO). The five levels of screening included the following:

1. Water Supply/Demand Estimates - provided a quantitative analysis of how much water was available at the potential sites and how much of that water could be utilized by shorted water rights.

2. Technical Feasibility - compared the technical constraints at the potential reservoir site locations that would make a reservoir more difficult to construct.

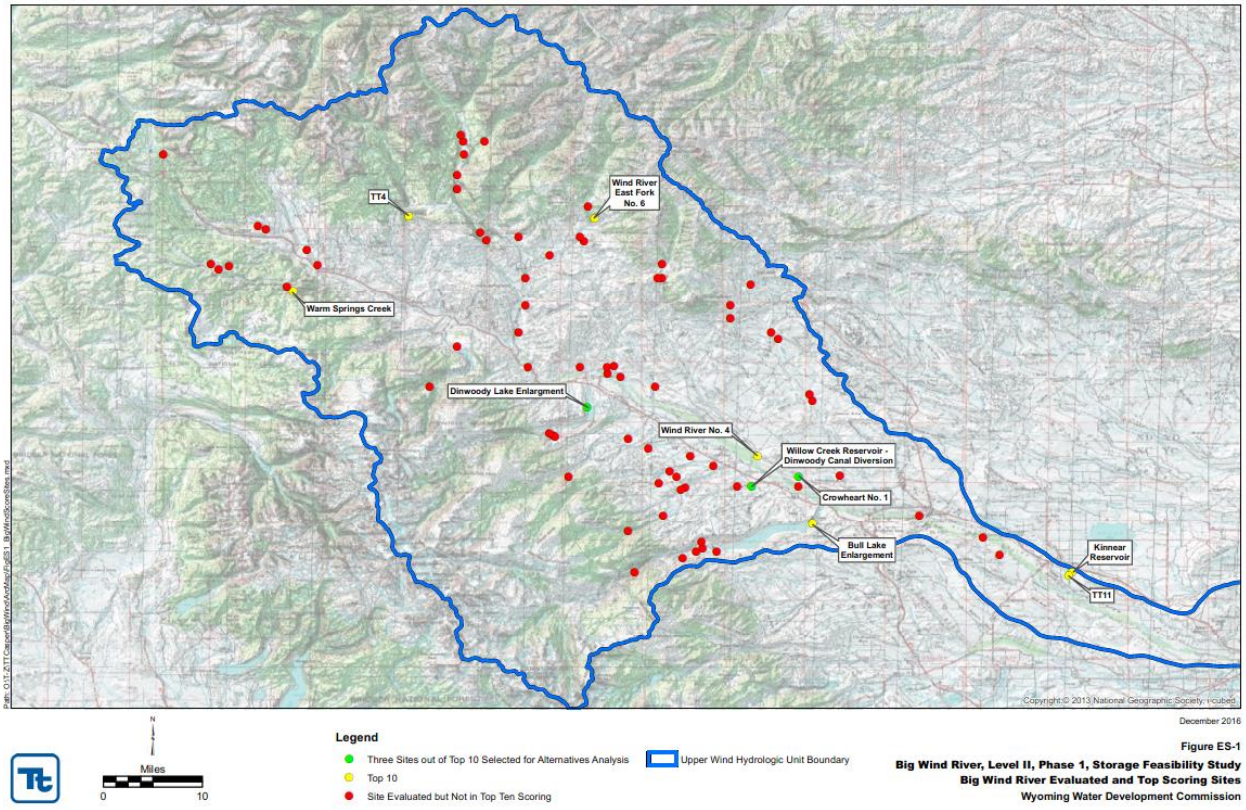
3. Environmental Analysis - qualitative screening of data that would potentially make a site less desirable to develop due to the increased risk of impacts to various environmental considerations and present an increased level of permitting or could prevent sites from being developed at all.

4. Cost/Economics - provided a quantitative analysis of the cost efficiency of the sites for comparison purposes.

5. Stakeholder Acceptance – presentation of the top ten scoring sites to the Wind River Indian Reservation Water Resources Control Board (Water Resources Control Board) for screening.

Eighty-one sites were evaluated for the screening task. The majority of the sites were developed from a previous study by SEH (SEH, 2001) however twelve additional sites were identified by Tetra Tech based on a desktop analysis of topographic mapping.

Each site was comparatively scored under selected screening criterion. A weighting factor was applied to the screening criteria to arrive at a value for each respective storage site for each screening criterion. Screening criteria values were summed to arrive at a cumulative score for each potential storage site. The top ten scoring sites (including the three selected by the Water Resources Control Board for advancement) were as noted on Figure ES-1 below.



The hydrologic analysis modeling and potential reservoir site screening results were presented to the Water Resources Control Board on September 19, 2016. Discussion following presentation of the modeling and potential reservoir site data, included an exchange of information on site specific reservoir data to consider in final selection of the preferred reservoir sites. After a lengthy discussion the following sites were determined to be preferred and were approved by the Water Resources Control Board as the top three sites for further consideration and study in the Alternatives Analysis.

- Dinwoody Lake Enlargement
- Crowheart No 1 (Crowheart)
- Willow Creek Reservoir – Dinwoody Canal Diversion (Willow Creek)

Alternatives Analysis

The proposed Dinwoody Lake Enlargement, Crowheart No. 1, and Willow Creek Reservoir – Dinwoody Canal Diversion sites were evaluated for the Alternatives Analysis. This level of evaluation included purchasing topography of the sites and developing conceptual layouts of the reservoir and its appurtenances. The conceptual layouts and site locations were used to simulate the water supply and balance of the reservoirs in the StateMod model. The physical area and location of the sites were used to determine archeological, land ownership, probable maximum flood (PMF), geotechnical and geologic, wetlands disturbance, and construction cost estimating data. The cost estimate includes upfront costs such as land acquisition, engineering, permitting, legal fees, wetland mitigation and a 15% construction contingency.

The PMF hydrographs were estimated for each of these sites based on previous studies and available data. Conceptual layouts were developed for each reservoir site using this data in conjunction with data from the hydrologic analysis and modeling. This included structure sizing and cost estimates for spillways, outlet works, embankments, diversions, and conveyance systems.

A geotechnical and geological assessment was performed to develop site specific information associated with the three selected candidate reservoir sites. This assessment included a desktop review of existing reports and published geologic maps along with a cursory site investigation to verify published data and to investigate hazards and geologic conditions that may impact the three selected reservoir sites. Site specific information included identifying fatal flaws, borrow sources, and potential geologic/geotechnical risks/impacts to overall project cost estimates. The surveys indicated the following hazards/conditions should be considered: landslides, wind-blown soil deposits, high permeability soils (seepage), bedrock outcrops, soluble bedrock, bentonitic beds and faults and seismicity. Geotechnical investigations of the foundation soils and borrow soils will be necessary to advance the design and to evaluate borrow site suitability and development of each of the three candidate reservoir sites.

Using ESRI's ArcMap software, the wetlands dataset (downloaded from the National Wetlands Inventory) was intersected with the potential reservoir dataset to identify wetland types occurring within conceptual reservoir location. Tetra Tech also compared the conceptual reservoir footprint with aerial imagery from Google Earth and performed field reconnaissance (not actual surveys) to quantify wetlands impact.

Cultural and archeological reviews were performed for each site based on available data. The Class I cultural resource review included information obtained from the BLM's historic trails dataset to identify historic roads and features that existed or still may exist within the potential reservoir locations. In addition, a meeting was held with Tribal Historical Preservation Office (THPO) representatives, Yufna Soldier Wolf (Northern Arapaho) and Will Ferris, (Eastern Shoshone), and Mitch Cottenoir (OTWE) on October 20, 2016 to discuss the potential reservoir locations and the status of inventoried cultural resources. THPO indicated about 80% of the Dinwoody Lake reservoir location has been inventoried for cultural resources; the reservoir locations for Crowheart No 1 and Willow Creek Reservoir – Dinwoody Canal Diversion have not been subjected to any cultural resource survey. For the Dinwoody Lake reservoir area, none of the identified cultural resources have been evaluated for cultural significance. THPO indicated any future cultural resource inventory would be conducted by THPO staff members, and not a third party consultant. Project development costs as presented below do not include THPO costs associated with identification of cultural issues. Length of time and costs to evaluate eligibility and mitigation cannot be estimated without the cultural inventory.

Any dam or reservoir project in the Big Wind River Watershed will require a number of environmental permits and environmental clearances. The land ownership and jurisdiction affects the permits required. None of the sites are on National Forest or Public Lands, therefore neither the USDA Forest Service nor Bureau of Land Management will have any decisions, approvals, or permits. Similarly, there are no wilderness areas affected. No Wyoming State Trust Lands would be affected, consequently the Wyoming Office of State Lands and Investments would not have to issue any permits or approvals. Land managed by the Bureau of Reclamation occurs downstream of all the projects, but is not likely to be affected and the Bureau of Reclamation does not have any permitting approvals required for the project. A small portion of the area at the south end of the Dinwoody Lake Enlargement site is privately owned land.

Specifically, the Army Corps of Engineers (USACE), Environmental Protection Agency (EPA) and the Bureau of Indian Affairs (BIA) are the federal agencies who must make decisions. Because of the federal approvals and permits required from the USACE, EPA, and BIA, the requirements of the National Environmental Policy Act (NEPA), Clean Water Act (CWA), Clean Air Act (CAA), National Historic Preservation Act (NHPA) and the Endangered Species Act (ESA) apply.

Dinwoody Lake Enlargement: The Dinwoody Lake Enlargement site would enlarge the existing lake with the new dam being located 1,000 feet downstream from the existing dam structure as recommended in the SEH, 2001 Level 1 Study due to bedrock faulting in the vicinity of the existing dam. The lake is the source for Dinwoody Canal and feeds the Big Wind River.

The Dinwoody Lake expansion will have the ability to satisfy an average of approximately 2,350 acre feet per year (ac-ft/yr) of shortages for the Current Demand Scenario and 1,800 ac-ft/yr of shortages for the Total Water Righted Acreage Scenario. These volumes apply to those shortages downstream that can be met directly by releases from the reservoir. Additional shortages in the system could possibly be met through exchanges, but these scenarios were not explicitly modeled.

No significant geologic risks were identified at the new dam location, however it is anticipated that foundation preparations will require removal of loose surficial materials and will likely require the construction of a cutoff trench and drainage collection system beneath the embankment and up the abutments to address potential seepage.

No improvements to the water conveyance into Dinwoody Lake are necessary. The current conveyance out of the existing lake is through a weir into the Dinwoody Canal or through the natural channel. The proposed dam could duplicate this system however the Dinwoody Canal can only operate when the lake is at high levels which is primarily in the spring and early summer when irrigation shortages are not as prevalent. The existing reservoir operations could be modified to supply more water to Dinwoody Canal by putting in a pump to Dinwoody Canal or flattening Dinwoody Canal.

Development of the Dinwoody Lake Enlargement project is estimated to cost $16,407,000.

Crowheart No. 1: The Crowheart No. 1 site consists of an off-channel storage facility utilizing existing natural depressions east of Crowheart Butte located on a bench north of the Big Wind River. The site could be developed to only fill the natural depression or additional storage is possible through construction of a partial embankment along the northeast, east, and southwest sides. At this location, there are two successive U-shaped depressions with the eastern most depression having natural containment whereas both depressions plus the surrounding area would be inundated by the larger reservoir. The natural depression would contain 6,000 ac-ft of water whereas the larger reservoir alternative evaluated for the Project would contain 15,555 ac-

ft. The water conveyance system includes an inlet canal originating upstream 5± miles at the Big Wind River and an outlet pipe discharging back to the Big Wind River. Previous studies include the nearby Steamboat site located approximately 3 miles to the east (SEH, 2001).

The Crowheart No. 1 reservoir will have the ability to satisfy an average of approximately 2,900 ac-ft/yr of shortages for the Current Demand Scenario and 11,900 ac-ft/yr of shortages for the Total Water Righted Acreage Scenario. These volumes apply to those shortages downstream that can be met directly by releases from the reservoir. Additional shortages in the system could possibly be met through exchanges, but these scenarios were not explicitly modeled.

The proposed site appears suitable for construction of an earthen embankment dam. It is anticipated that foundation preparations will require removal of loose surficial materials and will likely require the construction of a cutoff trench cutoff trench and drainage collection system beneath the embankment and up the abutments to address potential seepage. A natural spillway is located at the northeast corner of the depression and can still be utilized with the proposed embankment dam spillway. Construction of the proposed reservoir would result in the need to relocate Burris Lenore Road to the south in the vicinity of the reservoir. There are borrow sources on site, particularly the hills that separate the natural depressions. These soils will likely require on-site processing to remove gravel and cobbles.

Development of the Crowheart No. 1 project is estimated to cost $74,666,000.

Willow Creek Reservoir – Dinwoody Canal Diversion: The Willow Creek site would consist of a new reservoir located on the Sand Draw drainage near the Dinwoody Canal termination point. The site would consist of constructing an earthen embankment across Sand Draw. The Willow Creek Reservoir – Dinwoody Canal Diversion would capture water from the Dinwoody Canal at a point located approximately 675 ft north of the proposed dam location and water from the existing drainage into a newly constructed reservoir. Final alignment and profile will need to be determined through additional studies.

The Willow Creek Reservoir will have the ability to satisfy an average of approximately 1,590 ac-ft/yr of shortages for the Current Demand Scenario and 2,200 ac-ft/yr of shortages for the Total Water Righted Acreage Scenario. These volumes apply to those shortages downstream that can be met directly by releases from the reservoir. Additional shortages in the system could possibly be met through exchanges, but these scenarios were not explicitly modeled.

The proposed site appears suitable for construction of an earthen embankment dam. It is anticipated that foundation preparations will require removal of loose surficial materials and will likely require the construction of a cutoff trench beneath the embankment.

Development of the Willow Creek Reservoir – Dinwoody Canal Diversion project is estimated to cost $41,563,000.

Summary: Crowheart No. 1 produces the largest yield (15,555 ac-ft) followed by Dinwoody Lake Enlargement (4,228 ac-ft) and then Willow Creek Reservoir (2,655 ac-ft). Crowheart No. 1 represents the largest capitol cost of $74.7 million followed by Willow Creek Reservoir ($41.6 million) and Dinwoody Lake Enlargement ($16.4 million). Dinwoody Lake Enlargement offers the lowest capitol cost per yield ($3,881/ac-ft) followed closely by Crowheart No. 1 at $4,800/ac-ft. The capitol cost per yield for Willow Creek Reservoir at a rate of $15,655/ac-ft is over three times greater than the other two sites.

Dinwoody Lake Enlargement satisfies 3% (1,800 ac-ft) of the annual shortage in the system for the Total Water Righted Acreage Scenario and 40% (2,350 ac-ft) of the annual shortage in the system for the Current Demand Scenario. Crowheart satisfies 21% (11,900 ac-ft) of the annual shortage in the system for the Total Water Righted Acreage Scenario (from 1990-2012) and 22% (2,900 ac-ft) of the annual shortage in the system for the Current Demand Scenario. Willow Creek satisfies 4% (2,200 ac-ft) of the annual shortage in the system for the Total Water Righted Acreage Scenario (from 1990-2012) and 13% (1,590 ac-ft) of the annual shortage in the system for the Current Demand Scenario. The Crowheart project satisfies the greatest percentage of shortage for the Total Water Righted acreage Scenario by over five times the percentage of Dinwoody and Willow Creek. Meanwhile Dinwoody satisfies the greatest percentage of shortage for the Current Demand Scenario by about twice as much as Crowheart and over three times as much as Willow Creek.

Economic Analysis

The economic analysis determined whether the three Alternatives Analysis sites bring economic benefits to the region and the State which justify the costs, and secondly, how the project might be funded. Additionally, a Current Shorted Demand scenario and a Total Water Righted Acreage shorted demand scenario were examined for each of the potential reservoir sites. The Total Water Righted Acreage shorted demand scenario is an estimate of the future demand for irrigation water assuming that all current water rights in the books are called to irrigate currently non-irrigated land.

All three sites evaluated in the economic analysis would generate a variety of local benefits, including increased agricultural production and potential stream enhancements to support fish populations and the environment downstream of the dam. Construction related benefits would be more widespread. Only the benefits related to agricultural production were considered in the benefit-cost analysis and construction benefits were not included as a benefit when calculating the benefit-cost ratio. The benefit-cost analysis results are presented in Table 1:

Table 1. Benefits, Costs, Net Benefits and Benefit-Cost Ratio for the Big Wind River Sites

	Dinwoody Lake Enlargement		Crowheart No 1		Willow Creek Reservoir - Dinwoody Canal Diversion	
	Current Shortage Demand Scenario	Total Water Righted Acreage Shorted Demand Scenario	Current Shortage Demand Scenario	Total Water Righted Acreage Shorted Demand Scenario	Current Shortage Demand Scenario	Total Water Righted Acreage Shorted Demand Scenario
Total Benefits (PV)	$8,823,976	$15,782,298	$9,124,968	$47,240,919	$4,726,397	$22,200,498
Total Costs (PV)	$16,129,731	$16,129,731	$71,390,736	$71,390,736	$40,014,053	$40,014,053
Net Benefits (PV)	($7,305,755)	($347,433)	($62,265,768)	($24,149,817)	($35,287,656)	($17,813,555)
Benefit-Cost Ratio	0.55 : 1	0.98 : 1	0.13 : 1	0.66 : 1	0.12 : 1	0.55 : 1

While the projects may be of benefit to the economy as a whole, the costs are generally borne by those willing to fund it. Payment for the chosen site could come from multiple sources, including both the WWDC and the beneficiaries or other sources. The Northern Arapaho and Eastern Shoshone Tribes (Tribes) could apply for a WWDC grant through the Water Development Program to cover the majority of the costs following recommendations by the WWDC and approval by the Governor and the Wyoming Legislature. The remainder of the capital costs are assumed to be covered through a loan to the Tribes or the Tribes would find other grant sources. The Tribes could also pursue additional funding from other sources to reduce this loan amount, and may be eligible for funding specifically targeted to Native American irrigation projects.

A typical WWDC Grant could cover 67 percent of the proposed Level III project costs. The remaining balance is assumed to be through a loan to be paid off over a period of 50 years at an interest rate of four percent. The financing picture for the Big Wind alternatives under these assumptions is as noted in Table 2:

Table 2. Costs and Payment Amount for the Big Wind River Sites with a 67 Percent Grant

	Dinwoody Lake Enlargement	Crowheart No 1	Willow Creek Reservoir - Dinwoody Canal Diversion
Capital Cost	$16,407,000	$74,667,000	$41,563,000
WWDC Grant (67%)	$10,993,000	$50,027,000	$27,848,000
Remaining Balance	$5,414,000	$24,640,000	$13,715,000
Annual Loan Payment[1]	$252,044	$1,146,999	$638,479
Annual O&M Costs	$14,750	$14,750	$14,750
Total Annual Costs	$266,794	$1,161,749	$653,229
Note: Assumes a Loan at 4 percent for 50 years.			
The costs are the same under both the current and total water righted acreage scenarios.			

Recognizing that the remaining annual costs beyond the State contribution are substantial, a 75 percent WWDC grant was also evaluated. Under a 75 percent State contribution level, the annual costs to be made up by non-State sources decreased by about 24 percent from those costs at the 67 percent contribution level.

The annual costs to be borne by the beneficiaries, their net financial benefit from the additional irrigation and the cost per acre foot are noted in Table 3 for the Current Demand and the Total Water Righted Acreage shorted demand scenarios.

In the Current Demand scenario the projects' annual net benefits account for less than 5 percent of the annual costs of building and running the project (4 to 8 percent for the Total Water Righted Acreage scenario). The remaining possible sources of meeting these costs are other monies from the beneficiaries or other funding sources.

Table 3. Total and per Acre Payment Required for the Big Wind River Sites

	Dinwoody Lake Enlargement		Crowheart No 1		Willow Creek Reservoir - Dinwoody Canal Diversion	
	Current	**TWRA**	**Current**	**TWRA**	**Current**	**TWRA**
Total Annual Costs	$266,794	$266,794	$1,161,749	$1,161,749	$653,229	$653,229
Annual Net Benefits to Beneficiaries	$11,665	$20,864	$12,434	$64,370	$6,248	$29,349
Additional Annual Funding Required	$255,128	$245,930	$1,149,315	$1,097,378	$646,981	$623,880
Acre Feet Supplied	2,350	4,228	2,900	15,555	1,590	2,655
Total Annual Costs per Acre Foot	$114	$63	$401	$75	$411	$246
Annual Net Benefits to Beneficiaries per Acre Foot	$4.96	$4.93	$4.29	$4.14	$3.93	$11.05
Additional Assessment per Acre Foot Required	$109	$58	$396	$71	$407	$235

Note: The annual net benefits to beneficiaries are the net benefits from increased agricultural production, after production expenses that are available to pay off the annual costs.

Other monies from Tribal sources or from individual Tribal members were not identifiable from publicly available sources. Tribal budgets are not published and regardless, budgets typically are supported by public sources. Taxing or assessment mechanisms for individual land owners or irrigation districts do not exist, and land is not held in private hands. For these reasons, the calculation for the ability to pay could not be completed. No financial support for this project should be assumed from existing Tribal or Tribal member coffers.

Thus, the only realistic prospect for funding this project is other public funding sources. These sources could include a variety of federal programs which can be pursued from the U.S. Bureau of Indian Affairs, the U.S. Bureau of Reclamation, or directly from the U.S. Congress.

Recommendations

Project development costs do not include THPO costs associated with identification of cultural issues. Length of time and costs to evaluate eligibility and mitigation cannot be estimated without the cultural inventory. For each of the three potential reservoir sites, cultural inventories performed by THPO should be given a high priority to identify cultural resources which will impact each respective reservoir site.

The StateMod model should be used to review and optimize the conceptual reservoir storage capacities with respect to the ability to meet Current Demand and the Total Water Righted Acreage shorted demand scenarios. Additional modeling could be performed to simulate exchanges to alleviate the shorted demand of upstream users and downstream users beyond this study.

Feasibility level geotechnical and geological investigations should be performed to further refine the conceptual designs for the reservoir sites. Specific items to review include foundation soil/bedrock profiles and conditions, seepage collection/control, and borrow source materials. The conceptual alignment for the delivery canal for the Crowheart No. 1 site should be reviewed and additional geotechnical/geologic studies performed to provide feasibility level information on seepage and final alignment.

A more detailed review of the wetlands and potential acres to be mitigated should be performed. As part of this work, the schedule required to accomplish the associated permitting and mitigation must be reviewed and the impacts added to the project schedule and costs.

Future conservation measures should be considered during future studies to help optimize the ability to meet projected water shortage demands.

Additional grants and water users should be identified to reduce the financial burden of the Tribes and future water users. Consideration of the construction revenue circulating within the state of Wyoming would increase the benefit-cost ratio above one for all projects.