RECLAMATION

Managing Water in the West

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Value Planning

Final Report

North Central Arizona Pipeline

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Conducted for the Bureau of Reclamation, Lower Colorado Region

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U.S. Department of the Interior
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Executive Summary

The Value Study Team (Team) met on Monday, April 22, 2013 for a five-day Value Planning study of the North Central Arizona Pipeline (NCAP) Project. Costs were not developed during this study because of limited time and the large-scale changes proposed. Therefore, costs/savings/additions for the Proposals are not included in this report. The estimated cost of the Value Planning study is approximately $57,000. The Team developed nine proposals, which are summarized below.

Dependent Proposals: Proposals 2A and 2B are closely related. Acceptance of one proposal would preclude full rejection of the other. The same applies to Proposals 7A and 7B.

Combinations: Proposal 3 can be combined with Proposals 2A or 2B.

Proposal 1: **Mussel Mitigation.** Mussels are present in Lake Powell and the Project must plan for mitigation.

Proposal 2A: **Centralized Water Treatment.** Consider centralization of treatment facilities at the beginning of the pipeline to provide a cost comparison with Proposal 2B.

Proposal 2B: **Water Treatment at Delivery Points.** Consider treatment at tribal delivery points to provide a cost comparison with Proposal 2A.

Proposal 3: **Utilize Slow Sand Filtration in Lieu of Rapid Sand Filtration.** Consider a slow sand filtration process instead of rapid sand filtration process to reduce cost.

Proposal 4: **Utilize Canals in Lieu of Piped Conveyance.** Consider lined canals in appropriate reaches to convey flow instead of a pressurized pipeline to reduce cost.

Proposal 5: **Phased Construction of Project.** Consider optimizing pumping equipment, water treatment, storage tanks, and conveyance pipe size in conjunction with phased build-out to meet final demands and reduce operation, maintenance, and replacement (OM&R) costs.

Proposal 6: **Reduce Number of Pumping Plants by Increasing Total Dynamic Head.** This proposal is to consider increasing the pump total dynamic head (lift) from 400 feet (typical Reclamation practice) to 530 feet. Increasing pump lift will result in increased pipeline pressure class and cost as well as some increased mechanical and electrical equipment pumping plant costs, but will reduce the number and costs of pumping plants.

Proposal 7A: **Inclined Intake.** Consider an inclined constant angle intake system to access a select depth of Lake Powell in conjunction with a reservoir-side pumping plant feature. This proposal needs to be compared to Proposal 7B.

Proposal 7B: **Vertical Shaft(s) with Horizontal Lake Tap Intake(s).** Consider constructing a vertical shaft with horizontal lake tap lateral intake system to access select depth(s) of Lake Powell. This proposal needs to be compared to Proposal 7A.

Other Ideas: The Team identified six additional ideas for further consideration and development that are listed in the "Disposition of Ideas" table near the end of this report.

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Acknowledgement of Consultation Assistance

The Value Study Team wishes to express thanks and appreciation to Rodney Barthel (TSC Design Team Lead), Jeff Riley (PXAO Client Contact), and those listed on the List of Consultants section of this report. Their cooperation and help contributed significantly to the technical foundation and scope of the Team's investigation and final proposals.

Value Method Process

The goal of the Value Method is to achieve the most appropriate and highest value solution for the project. It is only through the effort of a diverse, high-performing Team, including all those involved, that this goal can be achieved. This study is the product of such an effort. The purpose of the study is to make good projects better by focusing on improving value and striving to achieve a return on investment exceeding 5:1.

The Value Method is a decision-making process, originally developed in 1943 by Larry Miles, to creatively develop alternatives that satisfy essential functions at the highest value. It has many applications, but is most often used as a management or problem-solving tool.

The study process follows a job plan that provides a reliable, structured approach to the conclusion. Initially, the Team examined the component features of the program, project, or activity to define the critical functions (performed or desired), governing criteria, and associated costs. During the Creativity Phase, the Team suggested alternative ideas and solutions to perform those functions, consistent with the identified criteria, at a lower cost or with an increase in long-term value. The ideas were evaluated, analyzed, and prioritized, and the best ideas were developed to a level suitable for comparison, decision-making, and adoption.

This report is the result of a formal Value Study by a Team comprised of people with the diversity, expertise, and independence needed to creatively attack the issues. The Team members bring a depth of experience and understanding of the discipline they represent and an open and independent inquiry of the issues under study, to creatively solve the problems at hand. The Team applied the Value Method to the issues and supporting information, and took a "fresh look" at the problems to create alternatives that fulfill the client's needs at the greatest value.

The Team is a diverse group from Reclamation and the Navajo Nation in the project. Further policy and/or design evaluations will be required prior to acceptance of any proposal developed during the Value Study. Proposals from this study, in and of themselves, do not indicate the technological, administrative, or policy approval of the agencies represented by the Team. Decisions on acceptance or rejection of individual proposals will be made through a combined effort between Reclamation Designers and Managers, and Project Stakeholders.

Baseline Design Description

North Central Arizona (Coconino Plateau Region) water supply and demand needs have been the subject of numerous studies in the region. The studies include the Reclamation October 2006 "North Central Arizona Water Supply Study Report of Findings," which identified three alternatives that addressed unmet demands and described Federal objectives. The baseline design used in this Value Planning Study is based on alternatives from the Reclamation report, which built upon previous studies by private parties as well as Federal, County, State, and Tribal governments who have conducted investigations to identify potential water sources to meet future water demands in this region.

Water supply availability is an issue for all participants in the planning area. A Navajo Nation Department of Water Resources (NNDWR) White Paper identified the need for an increased water supply to help support needed basic services on the reservation (NNDWR, 2002). The tribe has investigated or is investigating the viability of transporting water by pipeline to several areas.

Resolution of Indian water rights settlements is a critical issue in the planning area. The Navajo Nation filed a lawsuit in April 2003 against the Secretary of the Interior over the operation of the Colorado River. A Federal judge has entered a stay in that case to allow negotiations with the State of Arizona and non-Indian water users about Navajo Nation claims to the mainstem Colorado River. In addition, the Navajo Nation had been negotiating for several years with non-Indian water users in the Little Colorado River Plateau Basin, the State of Arizona and the federal government under the direction of the Little Colorado River Adjudication Court 1979. (Arizona Department of Water Resources website).

Currently, groundwater is the primary source of public water in the study area. These groundwater sources are not considered to be sustainable for the next 50 years. The three major aquifers are briefly described as follows.

The N aquifer, named for the water bearing Navajo sandstone, overlays the other two aquifers. The N aquifer contains excellent quality water, but is east of the project area.

The C aquifer underlies the N aquifer and much of northeastern Arizona and parts of northwestern New Mexico. The C aquifer is an important source of water for many users. It is named for the primary water-bearing rock unit of the aquifer, the Coconino Sandstone. The aquifer is the most productive aquifer in the Little Colorado River Basin. Industrial users, individual homeowners, agriculture, and the municipalities of Flagstaff, Holbrook, Leupp, Show Low, St. Johns, Joseph City, Snowflake, Taylor, and Winslow, Arizona, depend upon water drawn from wells completed in the aquifer. (USGS in Cooperation with Bureau of Reclamation, Scientific Investigations Report 2005–5277, Numerical Ground-Water Change Model of the C Aquifer and Effects of Ground-Water Withdrawals on Stream Depletion in Selected Reaches of Clear Creek, Chevelon Creek, and the Little Colorado River, Northeastern Arizona).

The C aquifer discharges into the Verde River Basin and the Salt River Basin to the south, to underlying formations, and to the lower Little Colorado River Basin. The western boundary of the C aquifer is west of the Little Colorado River (USGS Scientific Investigations Report 2005–5277).

Water from the C aquifer generally is of poorer quality than the N aquifer, particularly near the Lower Colorado River where total dissolved salts (TDS) levels lie outside secondary water quality standards. Because the aquifer lies beneath the Navajo and Hopi Indian Reservations, it represents an important present and future source of water. (USGS Scientific Investigations Report 2005–5277).

The base flow of parts of some streams, including Chevelon and Clear Creeks, and of the Little Colorado River is sustained by discharge from the C aquifer, and in some cases, these streams support threatened and endangered fish species. (USGS Scientific Investigations Report 2005–5277).

The R-M aquifer is the deepest of these water-bearing units, and feeds springs at Havasu and the south wall of the Grand Canyon. Because of its depth, the aquifer is relatively undeveloped.

An annual average of about 170,500 acre-feet of water per year was used during the period 2001-2005 in the planning area for agricultural, municipal, and industrial uses. The water supplies utilized to meet these demands include primarily groundwater (104,800 acre-feet), surface water from the Colorado River and other streams (50,800 acre-feet) and effluent (14,900 acre-feet). The planning area has a large industrial water use sector due to the presence of several electrical generating stations, large coal mining operations, and a paper mill. Industrial water use is currently about 83,100 acre-feet per year. Municipal sector average annual demand is approximately 45,000 acre-feet. Agricultural demand is relatively small-scale with an estimated annual demand of 42,400 acre-feet. (Arizona Department of Water Resources website).

There are concerns that long-term pumping from the N, C, and R-M aquifers will not provide a sustainable water supply. Eventually, the total water demands from all users would result in excessive drawdown.

Water chemistry varies in the C aquifer. Samples were taken for a USGS study and chloride concentrations at one site ranged from 121 to 129 mg/ L and sodium concentrations ranged from 72.9 to 115 mg/L. Samples also indicated nutrient concentrations (ammonia, nitrite, nitrate, orthophosphate, and phosphorous), arsenic and other trace metals. Sulfate concentrations ranged from 250 mg/L to about 385 mg/L, which is above the Secondary Maximum Contaminant Levels of the Safe Drinking Water Act. There is a likelihood that groundwater has interacted with radioactive material, as uranium has been detected in some groundwater. Many wells require more than disinfection to provide safe drinking water. (Hoffmann, J.P., Phillips, J.V., Bills, D.J., and Halford, K.J., in press, Geologic, hydrologic, and chemical data from the C aquifer, near Leupp, Arizona: U.S. Geological Survey Scientific Investigations Report 2005–5280).

There are also Threatened and Endangered Species issues:
A number of listed threatened and endangered species may be present in the Eastern Plateau Planning Area. Those listed by the U.S. Fish and Wildlife Service as of 2008 are shown in Table 1. Presence of a listed species may be a critical consideration in water resource management and supply development in a particular area (Arizona Department of Water Resources website).

Table 1 - Threatened and Endangered Species in the Eastern Plateau Planning Area

Common Name	Threatened	Endangered	Elevation/Habitat
Apache Trout	X		>5000 ft./cold mountain streams
Bald Eagle	X		Varies/large trees or cliffs near water
Black-footed ferret		X	<10,500 ft./grassland plains
California Brown Pelican		X	Varies/lakes and rivers
California Condor		X	Varies/high desert canyon lands and plateaus
Chiricahua Leopard Frog	X		3,300-8,900ft./streams, rivers, backwaters, ponds stock tanks
Little Colorado Spinedace	X		4,000-8,000 ft./moderate to small streams in pools & riffles
Loach Minnow	X		<8,000ft./benthic species of small to large perennial streams
Mexican Gray Wolf		X	4,000-12,000 ft. /chapparal, woodland, forests
Mexican Spotted Owl	X		4,100-9,000 ft./canyons, dense forests with multi-layered foliage structure
Navajo Sedge	X		5,700-6,000ft./silty soils at shady seeps and springs
Peebles Navajo Cactus		X	5,400-5,600 ft/gravely soils of the Shinarump conglomerate
San Francisco Peaks Groundsel	X		10,900ft+/Alpine tundra
Southwestern Willow Flycatcher		X	<8,500 ft./cottonwood-willow and tamarisk along rivers and streams
Zuni Fleabane	X		7,300-8,000 ft./selenium-rich red

For these reasons, the sustainable water supply from Lake Powell is the best source to meet the existing and future water demands (domestic, commercial, municipal, and industrial) for the Navajo Nation.

The NCAP Project, formerly referred to as the Western Navajo Pipeline (WNP), would deliver approximately 40 million gallons per day (currently being evaluated) of water from Glen Canyon Dam Reservoir (Lake Powell) to serve the city of Flagstaff and Navajo Communities (Copper Mine, Bitter Springs, Cedar Ridge, Bodaway Gap, Tuba City, Cameron, and Gray Mountain). The project would allow participating communities to use their water allocations and plan for drought conditions within the Coconino Plateau. This water supply is necessary to supplement or replace poor quality water and to meet a portion of the NCAP participants' projected water demands through 2050.

Paragraph 12.1.1 of the 2010 proposed settlement agreement approved by the Navajo Nation Council states the following:
12.1.1 Capacity and Configuration – The Western Navajo Pipeline shall be capable of delivering from Lake Powell at least 10,906 acre-feet per year (AFY) of potable water to the Navajo Nation and at least 4,048 AFY of potable water to the Hopi Tribe for municipal, domestic, commercial and industrial uses. The Western Navajo Pipeline shall be constructed to serve the

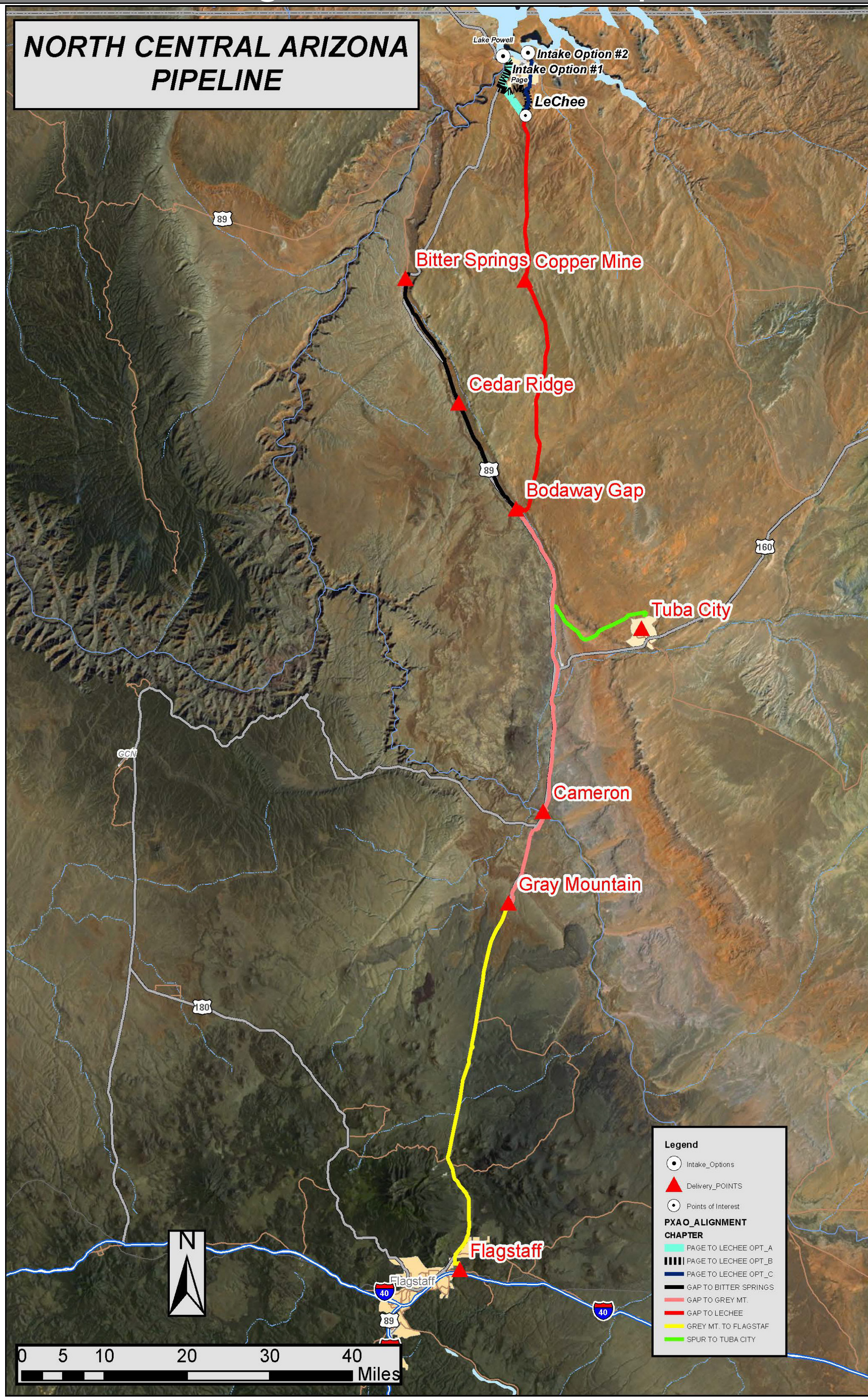
communities depicted on Exhibit 12.1.1, including LeChee, Coppermine, Bitter Springs, Cedar Ridge, Bodaway/Gap, Cameron, and Tuba City on the western portion of the Navajo Reservation and including Moenkopi, Third Mesa and Second Mesa on the Hopi Reservation. The Western Navajo Pipeline shall be configured, generally, as provided in the Western Navajo-Hopi Pipeline Project Cost Firming Report (Oct. 20, 2008). It shall include a raw water intake, water treatment plant, pipelines, storage tanks, pumping stations, pressure reducing valves, electrical transmission facilities and the other appurtenant items including real property and easements necessary to deliver potable water to the areas served.

The baseline design of NCAP (based on the 2006 Report of Findings) includes construction of buried pipelines and spurs, reservoir-side (Lake Powell) intake and pumping plant, water storage tanks, regulating tanks, pumping plants, air chambers, valves, valve vaults, meter vaults, delivery turnouts that will tie to existing tribal utilities, Supervisory Control and Data Acquisition (SCADA), network, and other related facilities. Generally, the NCAP route would be from Lake Powell to Bodaway Gap to Cameron terminating at the City of Flagstaff, Arizona, with laterals to Bitter Springs and Tuba City. Refer to Figure 1 for a map of NCAP Project. The approximate pipeline size would range between 48 inches and 4 inches in diameter. The combined main pipeline and two Navajo Nation spur lengths would be approximately 170 miles. The 2006 Report of Findings did not consider water treatment in the system or at the current delivery points. Changes and lessons from the NGWSP should be considered for this project also.

During the feasibility level planning phase, it is anticipated that additional entities will show interest in becoming NCAP participants. There are current negotiations taking place with the Phoenix Area Office regarding the potential addition of a Grand Canyon National Park and Tusayan Spur (~58 miles); including the Hopi (Moenkopi, Hotevilla/Bacavi, Kykotsmovi, Third Mesa, Second Mesa, First Mesa, and Keams Canyon) Spur (~85 miles). This Value Planning study does not include them at this time since those participants have not signed cost share agreements.

Non-tribal participants will provide funding mechanisms separate from tribal participants. These separate funding mechanisms will be for design and construction of their components, and for obtaining and securing water supplies.

Figure 1 – NCAP Map



Owner, Users, and Stakeholders List	
Owner	**Owner Issues**
Bureau of Reclamation	Meet government obligations to tribes, minimize costs (capital and OM&R), meet water quality regulations/requirements of multiple jurisdictions, comply with the NEPA process, and coordinate with all entities.
Non-Tribal Participants	Meet existing and future water demands, minimize capital and OM&R costs, improve economic growth and development, and blended water issues.
Tribal Participants	Meet existing and future domestic, commercial, municipal, and industrial water demands; minimize OM&R costs, improve water quality, and improve economic growth and development.
User	**User Issues**
Coconino County	Improve water quality, meet existing and future water demands, minimize costs (capital and OM&R), and improve economic growth and development.
City of Flagstaff	Meet existing and future water demands, minimize costs (capital and OM&R), and improve economic growth and development.
Navajo Nation	Improve water quality, meet existing and future water demands, minimize OM&R costs, improve economic growth and development, and provide a sustainable water supply.
Stakeholder	**Stakeholder Issues**
Arizona Department of Water Resources	Project complies with state regulations.
Arizona Department of Environmental Quality	Project complies with state regulations.
Arizona Department of Transportation	Right-of-way easement acquisition and major road crossings comply with state regulations.
Private Landowners	Minimize disturbance to property and width of easement.
National Forest Service	Minimize disturbance to property and width of easement.
Utilities	Impact to existing infrastructure.
Power Providers	Impact to existing infrastructure, and upgrades to existing system and possibly new infrastructure (distribution lines, sub-stations, etc.).
Arizona State Historic Preservation Office	Impacts to cultural resources and possible dinosaur fossils.

Owner, Users, and Stakeholders List Continued	
Stakeholder	**Stakeholder Issues**
Indian Health Services	Connection to existing infrastructure at delivery locations, and quality of water.
Colorado River Compact	Water rights.
Local Cities	Right-of-way easement acquisition, road crossings comply with local regulations, and impacts to existing infrastructure (water, sewer, etc.).
National Park Service	Minimize disturbance to property and width of easement.
US Fish and Wildlife	Threatened and endangered species.
Bureau of Land Management	Minimize disturbance to property and width of easement.
US Army Corps of Engineers	Rivers and streambed crossings.

Function Analysis

The Value Study Team developed basic functions for the key elements of the project. These functions generally are a two word pair consisting of an active verb and a measurable noun. The Team determined which functions are basic functions necessary to meet the purpose of the project. The basic functions (as shown in the list below) were determined by answering the questions "Which functions must the project satisfy?" All the other functions are secondary functions that support achieving the basic functions.

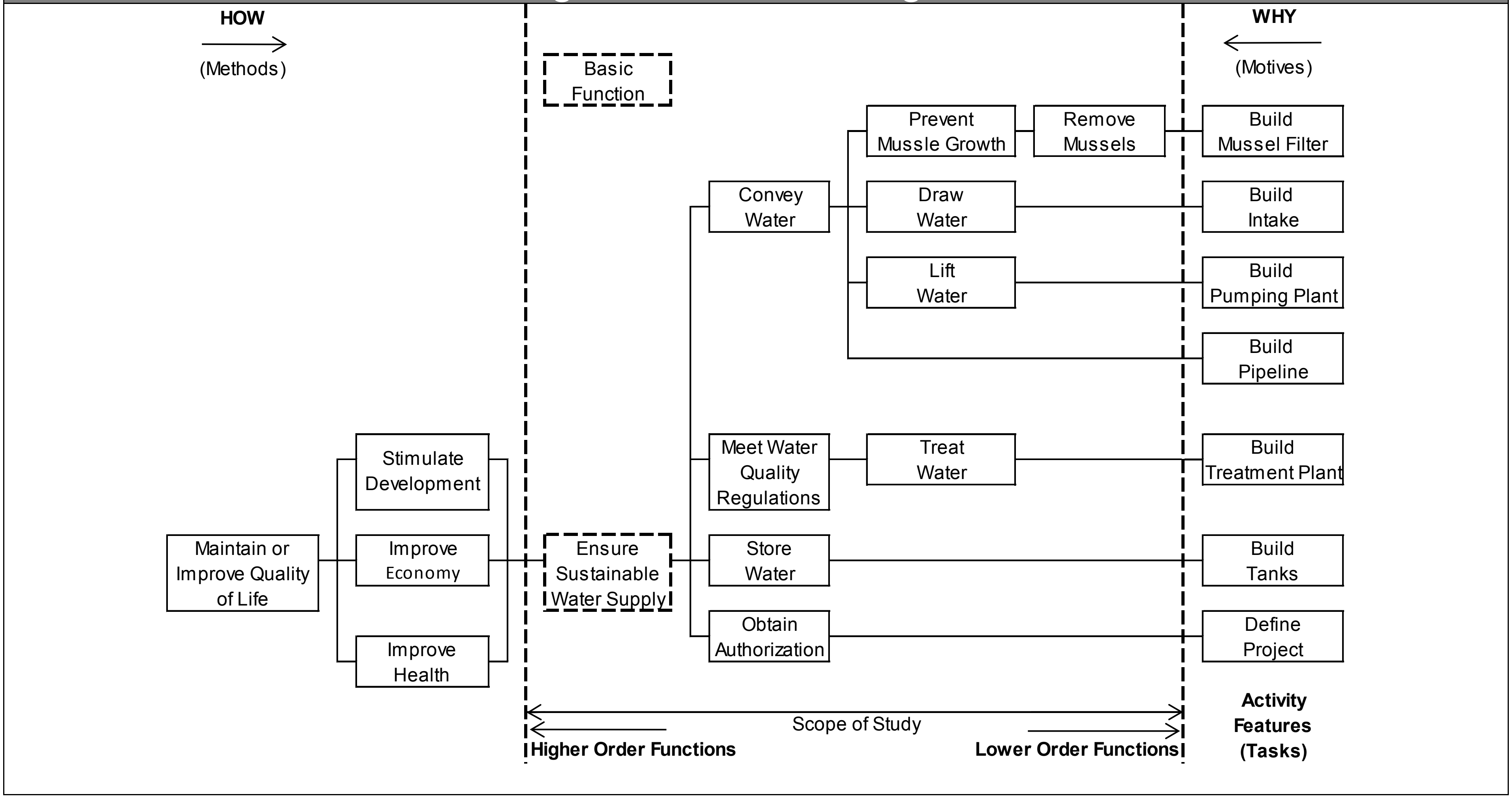
Component	Active Verb	Measurable Noun
Project		
	Convey	Water
	Improve	Economy
	Meet	Demands
	Comply with	Potential Authorization
	Deliver	Sustainable Water Supply
Intake / Trashrack		
	Draw	Water
	Lift	Water
	Protect	Pumps
	Screen	Water
	Protect	Fish
Pumping Plants		
	Lift	Water
Transmission Lines (Trunk and Spurs)		
	Convey	Water
	Meet	Demands
	Resist	Pressure
	Protect	Water Quality
	Contain	Water
Storage Tanks		
	Store	Water
	Control	Pressure
	Provide	Fire Protection
	Ensure	Reliability
	Reduce	Pipe Size
	Protect	Water Quality
Mussel Treatment		
	Remove	Mussels
	Prevent	Growth
	Kill	Veligers

Component	Active Verb	Measurable Noun
Water Treatment Plant		
	Treat	Water
	Filter	Water
	Protect	Health
	Disinfect	Water
	Meet	Regulations
	Improve	Water Quality
	Store	Water
Forebay Tanks		
	Provide	Suction Head
	Prevent	Cavitation
	Provide	Minimum Run-Time
	Provide	Hydraulic Boundary
Regulation Tanks (Surge Tanks)		
	Regulate	Flow
	Control	Pressure
	Separate	Reaches of Pipe
	Provide	Hydraulic Boundary
Air Chamber (Hydraulic Transient Facility)		
	Mitigate	Transients
	Protect	Pumps and Pipelines

Function Analysis System Technique (FAST)

The Value Study Team used the functions listed above to generate a Function Analysis System Technique (FAST) diagram (Figure 2), designed to describe the present solution from a function point of view. The FAST diagram helped the Team identify those design features that support critical functions and those that satisfy noncritical objectives. The FAST diagram also helped the Team focus on potential value mismatches and develop a common understanding of how project objectives are met by the present solution. Some of the functions listed above are not in the FAST diagram and some functions in the FAST diagram are not listed above. Some of the functions listed above were not considered to be critical functions during creation of the FAST diagram. As the FAST diagram was developed, other critical functions were identified that were not previously identified in the list above.

Figure 2 – FAST Diagram



Proposal 1: Mussel Mitigation

Proposal Description: According to recent information posted on the Glen Canyon National Recreational Area's website (http://www.nps.gov/glca/parknews/zebramussel1.htm), invasive species of mussels were found in Lake Powell. With known water quality conditions being ideal for mussel growth, Lake Powell is at a high risk for infestation.

The Team recommends that mussel mitigation be addressed early on in this project, and adult mussels and associated debris should be prevented, as much as possible, from entering any portion of the intake, pumping and transmission systems (Figure 3). Juvenile mussels, known as veligers, cannot be allowed to establish and thrive in any part of the system.

Critical Items to Consider: The strategies for dealing with mussels are multifaceted. Equipment that is in constant contact with water in Lake Powell is at risk for overgrowth. A combination of specialized materials, coatings, chemical injections, and cleaning strategies are highly advised.

As early in the conveyance as possible, the veligers should be removed to the greatest degree practical. Veligers are between 40 – 200 microns in size and sand filters generally have far smaller effective pore sizes and considered protective of downstream equipment. A slow or rapid sand filter would serve the purpose for the control of veliger infestation and transport downstream (See Proposal 3 for more detail on slow sand filtration). Post-filter UV or chemical treatment should be investigated as well for additional safety.

Further water treatment can be independent of the mussel consideration. However, in the event that chemical means are employed for control of mussels, additional treatment near the intake may be necessary to prevent or remove by-products of the chemical treatment. Since Lake Powell is a surface water supply, it must comply with the Safe Drinking Water Act, the Surface Water Treatment Rule, and must be filtered prior to delivery as potable. It would therefore make sense to consider the combination of the functions of mussel mitigation and microorganism removal as required by the SWTR.

Ways to Implement: Mussel mitigation should be included in Feasibility Level Planning Phase Design and Cost Estimates. For more information about mussels, see Reclamation's web site: http://www.usbr.gov/mussels/.

Changes from the Baseline: It is an increase from previous baseline studies and estimates and will add significant cost to the project. The 2006 Report of Findings did not include mussel mitigation.

Advantages	Disadvantages
• Reliable delivery of water. • Protects infrastructure. • Reduces inherent risk to the Project.	• Adds capital and OM&R costs.

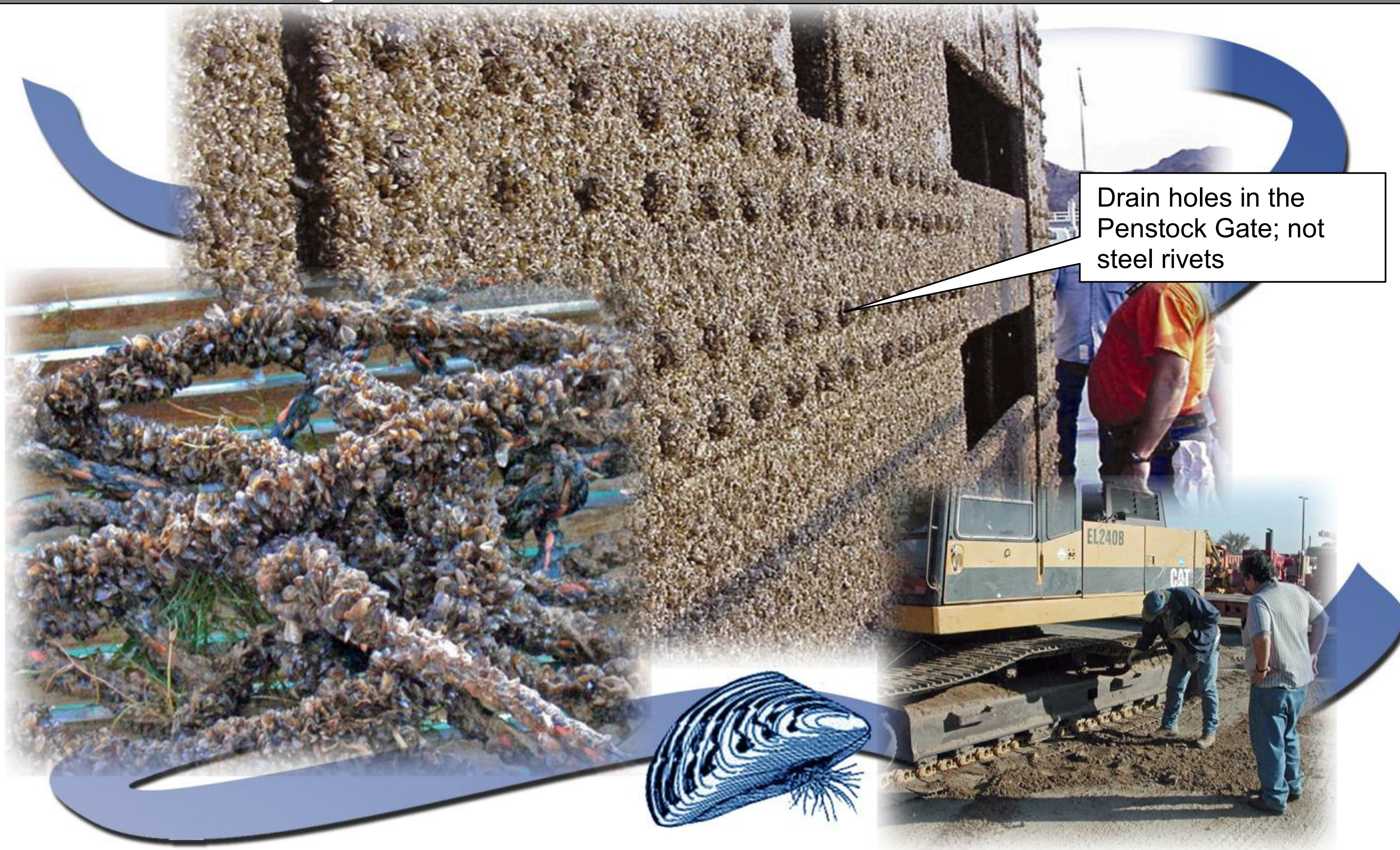
Potential Risks

The risk of not considering mussel infestation may have big consequences and increased OM&R costs. Intakes can become completely clogged and/or fouled with growth and debris. Pumps and valves can be damaged by shell material. Pipe capacity can be reduced resulting in large increases in frictional energy losses, rendering pumps unable to deliver the required amounts of water or increasing the power required to do so. The water quality can be compromised due to mussel presence.

Costs

Costs were not calculated for this Value Planning study.

Figure 3 – Photos of Mussels at Davis Dam



The figure above (from Inspection and Cleaning Manual for Equipment and Vehicles to Prevent the Spread of Invasive Species, Reclamation, 2012) is a composite of Reclamation experiences with mussel infestation. The bulkhead gate shown is from Davis Dam. The drain holes were completely plugged, greatly increasing the weight of the gate as it was drawn from Lake Mohave. The lower left portion of the photo shows a rope that was in contact with the lake water. The tracked vehicle shown above is included to show that the equipment has to be cleaned to prevent the spread of mussels.

Proposal 2A: Centralized Water Treatment

Proposal Description: This proposal would consider constructing a water treatment plant near the intake at Lake Powell. Centralized water treatment generally will require less capital and O&M costs than de-centralized water treatment due to economy of scale.

Another advantage of centralized water treatment is the opportunity to remove adult and juvenile mussels at the head of the conveyance facility, thereby preventing mussel colonies in the downstream reaches.

Critical Items to Consider: Mussel screening and veliger treatment should be considered at the point of water withdrawal at Lake Powell so that mussel clogging is minimized at the intake, Lake Pumping Plant, and discharge piping to the WTP. More extensive mussel mitigation can occur at the WTP. Multi Environmental Protection Agency jurisdictions.

Ways to Implement: Centralized water treatment should be included in Feasibility Level Planning Phase Design and Cost Estimates, unless Proposal 2B is selected.

Changes from the Baseline: The 2006 Report of Findings did not consider water treatment in the system or at the current delivery points. Therefore, this is an addition to the baseline design; however, the advantages and disadvantages are relative to Proposal 2B.

Advantages	Disadvantages
• Lower capital O&M costs. • Removal of adult and juvenile mussels at the head of the conveyance system. • Less number of staff for OM&R.	• A higher level of treatment is required to maintain water quality in a longer conveyance system. • Additional chlorination may be required in the downstream reaches to maintain acceptable chlorine concentrations. • Introduction of other water sources downstream of the WTP would require treatment before or after blending with project water.

Potential Risks

Disinfection byproducts could exceed standards in the downstream reaches of the facility. This risk would be mitigated by proper design and operation of the central WTP. Emergency or unplanned outage could reduce flows to downstream users.

Costs

Costs were not calculated for this Value Planning study.

Proposal 2B: Water Treatment at Delivery Points

Proposal Description: This proposal is to consider constructing water treatment plants at tribal delivery points. Although de-centralized water treatment will increase capital and O&M costs, project value may be added due to the advantages of water treatment closer to each of the individual delivery/distribution systems, therefore allowing localized control and treatment flexibility.

Regardless of the level of treatment performed at the turnouts, mussel mitigation through some form of treatment (See Proposal 3 for Slow Sand Filtration treatment) must be performed close to the project intake to prevent mussels from clogging or reducing the capacity of the conveyance facilities.

De-centralized treatment would provide value to the project with localized control over the desired level and methods of treatment, easily separable costs for each locality and treatment flexibility when encountering changing source water quality. For instance, if a locality introduced a local auxiliary supply, they would be able to tailor the treatment for the blended supply.

Another consideration with de-centralized treatment is the maintenance of sanitary conditions in the transmission line. If raw water is conveyed, the operators will need to monitor the condition of the pipeline regarding the formation of biofilms, which could pose health and maintenance issues.

Critical Items to Consider: Mussel removal, adults and veligers, is required at the head of the project to prevent system wide colonization. Multi Environmental Protection Agency jurisdictions.

Ways to Implement: De-centralized water treatment should be included in Feasibility Level Planning Phase Design and Cost Estimates, unless Proposal 2A is selected.

Changes from the Baseline: The 2006 Report of Findings did not consider water treatment in the system or at the current delivery points. Therefore, this is an addition to the baseline design; however, the advantages and disadvantages are relative to Proposal 2A.

Advantages	Disadvantages
• Local control of WTPs. • Treatment flexibility for each participant. • Ability to blend local ground water with central source water.	• A larger number of treatment staff may be required. • A larger capital investment is required. • A larger O&M budget is required.

Potential Risks

More WTPs increase the risk of treatment violations due to statistical increase in errors and equipment failure.

Costs

Costs were not calculated for this Value Planning study.

Proposal 3: Utilize Slow Sand Filtration In Lieu of Rapid Sand Filtration

Proposal Description: Consider constructing a slow sand filtration (SSF) process instead of rapid sand filtration. SSF is a low power, low cost, and low maintenance filtration technique that has been utilized in the United States since 1872 (Figures 4 and 5). SSF is a biologically active filter, which provides removal of particles, organic material, microorganisms, and mussels. SSF is still frequently employed in applications where ample land area is available and/or power availability is limited. SSF is also generally approved by State agencies.

SSF has the advantages of performing essentially the same water quality improvement as typical high-rate filtration with no backwash system, less mechanical equipment, less instrumentation and controls and less operator intervention. Its disadvantages are that it requires much larger land area, requires a "ripening" time for optimal performance and is less able to handle rapid changes in influent water quality. In applications where the water quality is consistently of low turbidity and land is available, it can be more economical.

Slow sand filters require greater land area, as they are loaded at 0.02 to 0.15 gallons/minute/square feet, whereas high-rate or rapid sand filters are loaded from 3-10 gallons/minute/square feet. Rapid sand filters are backwashed every 24-60 hours as headloss increases. Slow sand filters are not backwashed. They build up a helpful organic layer known as a "schmutzdecke" which provides good particle filtration and organic material removal. The layer is scraped manually by rake or skid steer equipment such as a Bobcat on the average of once every six months, followed by a ripening period when the filter is brought back into service. The level of staffing for slow sand is dramatically lower than conventional water treatment.

Critical Items to Consider: The area required for 60 cubic feet per second is approximately 6.2 acres. Considerations necessary to adopt this technology are available land, topography and view, vulnerability to sand/dust, freezing conditions and redundancy. Schmutzhdecke disposal.

Ways to Implement: SSF should be evaluated in Feasibility Level Planning Phase Design and Cost Estimates. Once a design decision is made to adopt, it is a part of the overall treatment process design.

Changes from the Baseline: The 2006 Report of Findings did not consider water treatment in the system or at the current delivery points. Therefore, this is an addition to the baseline design; however, the advantages and disadvantages given below are relative to rapid sand filtration.

Advantages	Disadvantages
• Same water quality as rapid sand. • Low energy cost. • Low O&M cost. • No backwash discharge – no water loss.	• Large land area required. • Not adaptable to changing water quality. • Will not handle high solids loading.

Potential Risks

Slow sand filters are not a risk to public health, however they could have operational risk if they are in an area prone to blowing debris. They rarely experience plugging prematurely due to biofouling. Mussel colonization on surface.

Costs

Costs were not calculated for this Value Planning study.

Figure 4 – Typical Slow Sand Filter System

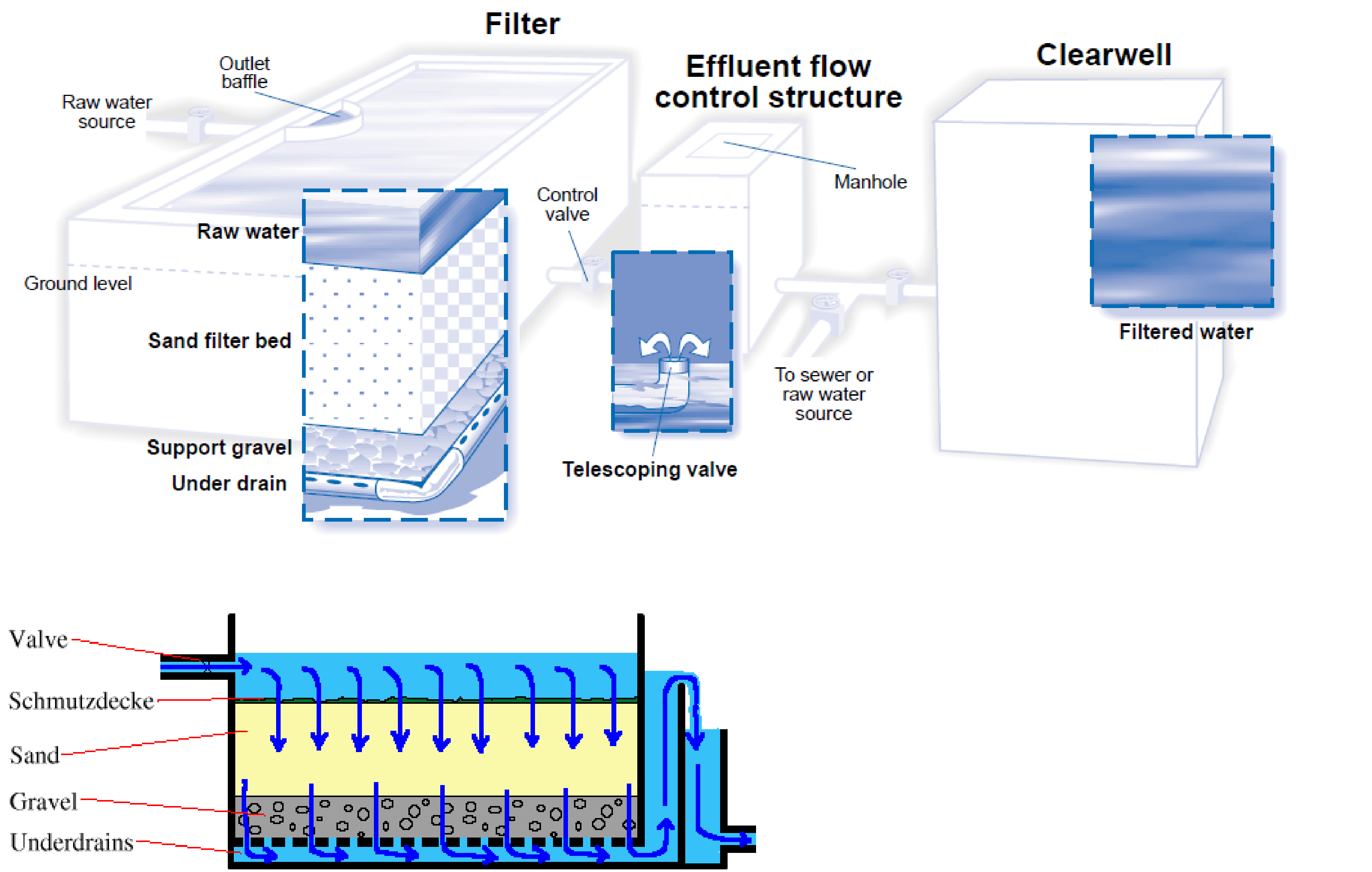


Figure 5 – Photo of a SSF Facility in Portsmouth

Proposal 4: Utilize Canals in Lieu of Piped Conveyance

Proposal Description: Consider open canals (Figure 6) to convey the flow to the desired locations in the system in areas where the topography is favorable. Open channels cost less than pipelines to construct. Review of the topography and additional design evaluation is needed to determine if this is a viable option.

Open channel flow would preclude the option of full-centralized water treatment (Proposal 2A) at the upper end of the system. Canals would convey raw water, which has been treated only to mitigate for mussels, so water would require treatment at demand centers and/or storage tanks (Proposal 2B).

Possible locations to construct canals are shown in Figure 7. Preliminary evaluations indicate that slopes approaching 0.5 percent will result in super critical velocities, which introduces additional concerns and requirements such as reinforced concrete linings, hydraulic effects at lining joints, and energy dissipation structures. In order to maintain sub-critical flow, periodic drop structures would likely be necessary.

The local conditions will require evaluating the effects of freezing temperatures, blowing sand and vegetative debris.

Critical Items to Consider:

- Before proceeding, evaluate Proposal 2A first.
- Additional design and hydraulic modeling would be required to determine whether this proposal is a viable option.
- Topographic and contour data should be reviewed to determine canal alignment and grades. Canal alignment would be the same as the pipeline alignment to minimize length, but this may result in steeper slopes than conventional canal design.
- Coordinating hydraulics between closed conduits and open channel flow may require intermediate operating reservoirs and automated control.
- Operating reservoirs, drop structures, energy dissipation may be necessary.
- Super critical flow will necessitate the need for reinforced lining of the canal.
- Canals will be lined to prevent seepage. Lining materials will need to be determined. Most likely concrete lining would be the preferred option.
- Windblown sand and debris may increase the sediment loading and clog trashracks at the downstream intakes requiring additional maintenance.
- Determine if freezing temperatures would be problematic.
- Geological site conditions will influence the design and maintenance of the canals.
- Cross drainage and vehicular access needs to be considered.
- Considerations to prevent livestock access.
- Safety concerns for children.

Ways to Implement: The following items would be considered in the Feasibility Planning Level designs and cost estimates:

- Perform hydraulic modeling and calculations to determine flow velocities, flow regime, canal cross-sections, need for possible operating reservoirs, possible alignments, and energy dissipation.
- Determine how the canal hydraulics will interface with the pumping plant flow and whether operating reservoirs will be required to regulate flows.

Changes from the Baseline: This proposal replaces portions of the pipeline with open channel canals.

Advantages	**Disadvantages**
• Cost savings associated with replacing pipe with open channel. • Simplifies OM&R effort. • Reduces excavation.	• Complex hydraulics to coordinate with pumping plants, closed conduit reaches, and daily demand fluctuations; complicates operation and control of the system. • Increases water loss (seepage and evaporation). • Provide crossings over canal. • Public safety concerns. • Tendency to leak. • Blowing debris such as tumbleweeds in canal.

Potential Risks

Problems associated with coordinating hydraulics to function with pumping plants and daily demand fluctuations.

Costs

Costs were not calculated for this Value Planning study, but a general rule of thumb approximates canals and ditches to cost roughly half of pipelines. The hydraulic complexities associated with switching from pipelines to open channels, along with steep canal grades, may reduce or eliminate potential cost savings.

Figure 6 – Cross Section of Proposal Canal

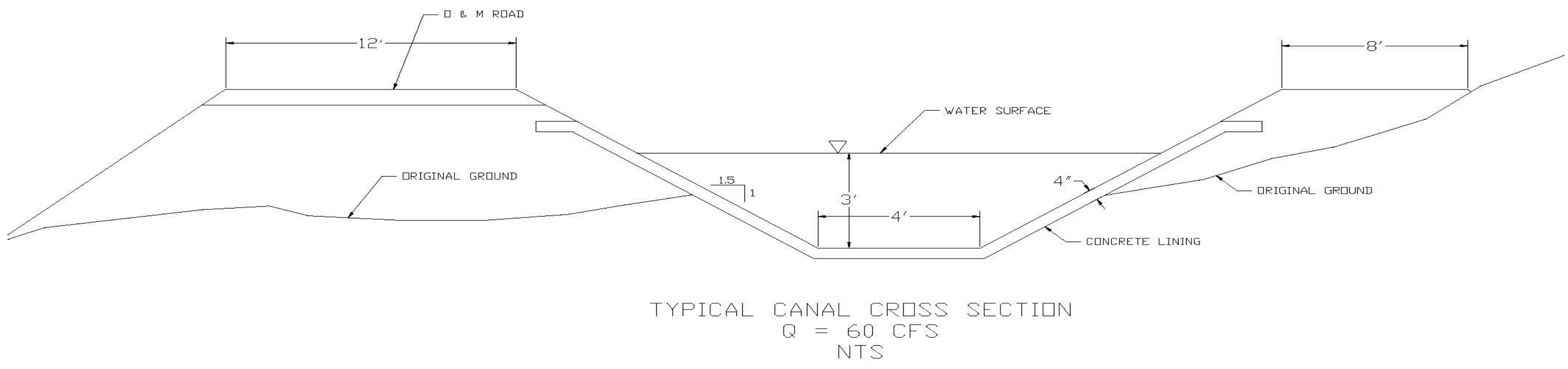
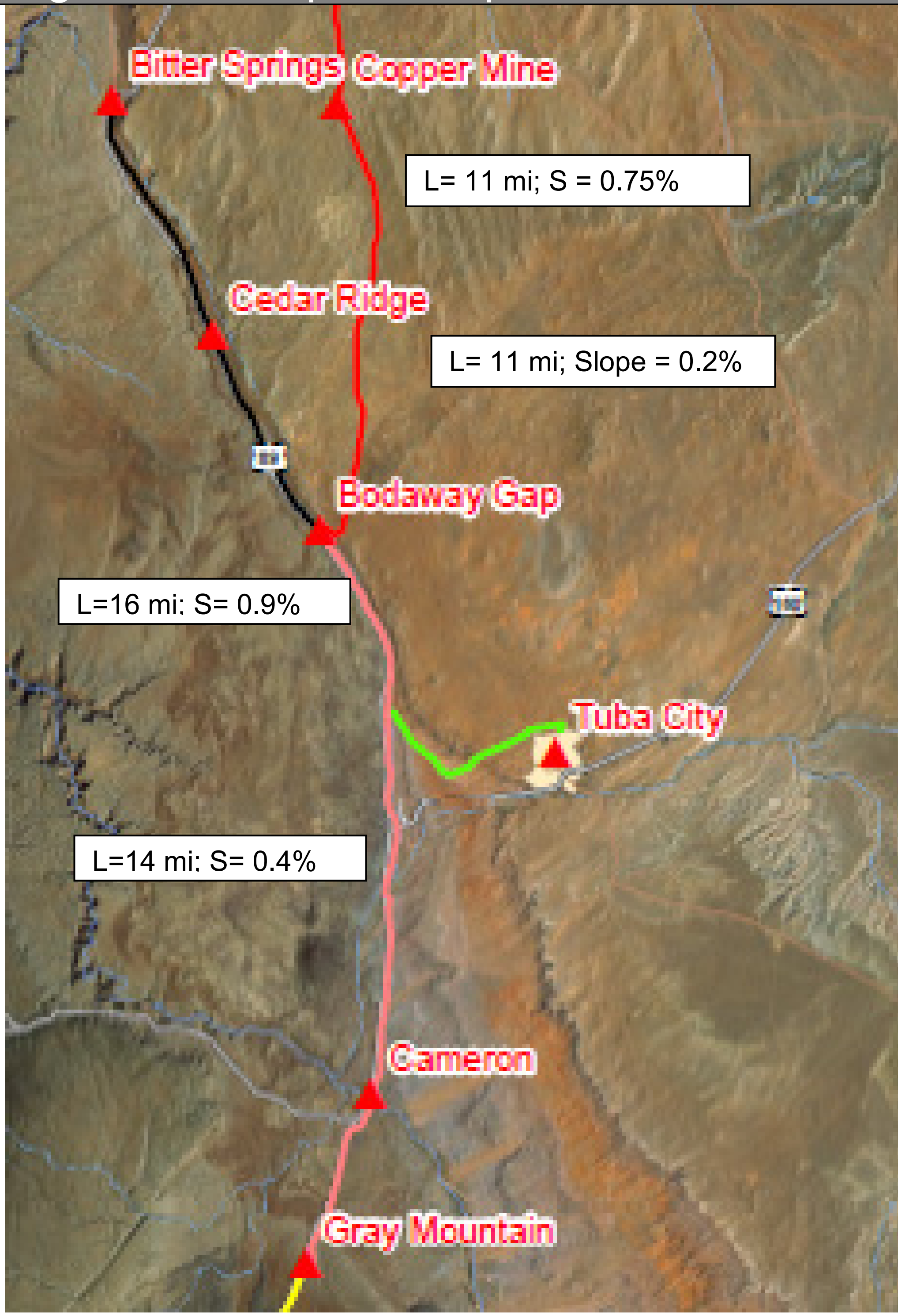


Figure 7 – Proposed Open Canal Locations



Proposal 5: Phased Construction of Project

Proposal Description: Consider optimizing pumping equipment, water treatment, storage tanks, and conveyance pipe size in conjunction with phased build-out to final demands. This may involve delayed construction of pumping, treatment or storage features. The system can be initially designed for current demands with the capability to be incrementally constructed for increased flow.

Pumping plants and water treatment plants can be designed to be expanded to coincide with increases in demand. Delaying the installation of pumping equipment or ultimate treatment plant sizing until the capacity is needed lowers OM&R costs, allows evaluation of actual demands to maintain an appropriately sized system.

Construction of storage tanks may be phased to meet increased water demands. Existing water storage tanks and storage in the conveyance pipeline itself may be adequate for current reliability storage requirements. Storage tank O&M is costly and by delaying or reducing tanks, maintenance costs can be reduced.

Conveyance pipe size may be able to be reduced if storage tanks at the demand centers are utilized for peaking demand flows. The tanks would provide the additional flows during the daily peak demand periods, then be refilled during low demand times. Reducing pipe diameters would lower capital costs, and reduce the water travel time in the pipe potentially improving water quality at end-use points.

Critical Items to Consider:

- Population projections and updated demand projections
- Storage criteria
- Peaking factors
- Pumping equipment ratings
- Appropriate water treatment expansion increments
- Integrate existing & proposed water supply systems (this is being done currently and future coordination with Navajo Nation, Navajo Tribal Utility Authority, Indian Health Service, etc. should continue)

Ways to Implement: These concepts will be evaluated during final design.

Changes from the Baseline: The design process is not far enough along at this time for these components to have been thoroughly evaluated. Therefore, this does not change the baseline.

Advantages	Disadvantages
• Capital and OM&R cost savings. • Future innovations with equipment.	• Additional construction required through full build-out.

Potential Risks

Future incremental construction build-out may not receive future funding allocations unless a deferred cost account is set up. Interest from funds set aside for future installations may not offset the effects of inflation. Equipment and materials may vary among phased construction contracts.

Costs

Costs were not calculated for this Value Planning study.

Proposal 6: Reduce Number of Pumping Plants by Increasing Total Dynamic Head

Proposal Description: This proposal would increase the pump total dynamic head (lift) from 400 feet (typical Reclamation practice) to 530 feet. Reduced capital and periodic costs may be achieved by reducing the number of pumping plants and by increasing individual pump lift. Increasing pump lift will result in increased pipeline pressure class and cost as well as some increased mechanical and electrical equipment pumping plant costs. Therefore, there will be a trade-off of cost savings for eliminating pumping plants against added costs for increased pipeline pressures.

Typical Reclamation practice has been to limit pump lift to approximately 400 feet. Transient head of 1.3 times the pump lift is an approximation for the maximum design head of the pipeline and associated mechanical features. This results in a maximum design head of approximately 520 feet (226 psi) (t_{wall} = 0.25 inch). Mechanical equipment is reportedly available for pressures up to 300 psi (690 ft) for municipal water systems. The pump lift for this situation would be approximately 530 ft (t_{wall} = 0.3125 inch) to accommodate transient head.

Critical Items to Consider: System transient analysis will determine design pressures. Confirmation of the availability of 300-psi pipeline mechanical equipment is necessary. Other agencies have constructed systems with higher lifts in the order of 580- 900 feet. A life-cycle cost comparison needs to be performed for lifts of 400 feet and 530 feet. Evaluate how this system will be integrated into Navajo Tribal Utility Authority systems.

Ways to Implement: This proposal should be evaluated in Feasibility Level Planning Phase Design and Cost Estimates.

Changes from the Baseline: Re-evaluate number of pumping plants and pipeline pressure class.

Advantages	Disadvantages
• Reduces number of pumping plants. • Potentially reduces OM&R costs due to smaller number of plants. • Simplifies control of the system. • Reduces design costs.	• Increases capital costs of pipeline and equipment. • Higher-pressure equipment reduces number of manufacturers.

Potential Risks

Design assumptions made during Feasibility Level Planning may impact the results of a cost comparison between the 400-foot and 530-foot lift.

Costs

Costs were not calculated for this Value Planning study.

Proposal 7A: Inclined Intake

Proposal Description: Consider an inclined constant angle intake system to access a select depth of Lake Powell in conjunction with a reservoir-side pumping plant feature (Figure 8).

Critical Items to Consider:

- Geologic stability of the proposed site.
- Underwater topography of the lake cliff.
- Drilling techniques suitable for the site and construction conditions.
- The elevation of the intake needs to be determined.

Ways to Implement: This concept will be evaluated during the Feasibility Planning Level phase and/or separate studies. The following is a description of a potential construction method:

Using a conventional inclined drilling method, drill several large-diameter boreholes along a constant angle to the lake cliff face. Each inclined intake tunnel would be completed by first drilling a pilot borehole to a target elevation to within a few feet of the lake cliff face but not penetrating the cliff face. After drilling is completed, a steel liner would be installed and grouted in each drill hole to the full depth of the reamed hole. The inclined drill holes would be completed by lowering a drill down the cased hole and drilling the last few feet to break through the cliff and connect to the lake. A vertical turbine submersible pump would be installed in each well and these pumps would discharge into a common sump where vertical booster pumping units would pump water from the sump to the pipeline.

This intake style was successfully implemented for the existing Salt River Project Reservoir-Side Pumping Plant (1970's) used to supply cooling water for the Navajo Generating Station located at Lake Powell. This intake type was also considered for the proposed Page-LeChee Reservoir Side Pumping Plant at Lake Powell.

Changes from the Baseline: In the 2006 Report of Findings, Lake Powell was identified as a water source and this style of intake was included. The advantages and disadvantages given below are compared to Proposal 7B.

Advantages	Disadvantages
• A deep withdrawal level would ensure access to the water source if site conditions are favorable to accommodate the inclined angle and distance to drill. • Potentially a lower cost alternative when compared to vertical shaft drilling with horizontal laterals to tap the lake.	• Drilling methods have technical limitations. • Concern for the potential release of drilling fluids to enter Lake Powell for each intake. • Inclined holes can deviate in alignment. • If there were a cliff haunch feature at the base of the cliff face, the desired lake penetration would be in jeopardy. An underwater survey would be required. • If the boreholes have a curvature, the steel linings would be difficult or possibly impossible to install. • Single level withdrawal limits source to water quality and temperature found at hole-penetration elevation. • The National Park Service rejected this method on another project at Lake Powell.

Potential Risks
Unforeseen site geological condition during drilling operations could hamper construction and increase costs. Debris slide may occur during construction.
Costs
Costs were not calculated for this Value Planning study.

Proposal 7B: Vertical Shaft(s) with Horizontal Lake Tap Intake(s)

Proposal Description: Consider constructing a vertical shaft(s) with horizontal "lake tap" intake systems to access select depth(s) of Lake Powell in conjunction with a reservoir-side pumping plant feature.

Critical Items to Consider:

- Geologic stability of the proposed site.
- Underwater topography of the lake cliff.
- Drilling techniques suitable for the site and construction conditions.
- The elevation(s) of the intake(s) needs to be determined.

Ways to Implement: This concept will be evaluated during the Feasibility Planning Level phase and/or separate studies. The following is a description of a potential construction method:

Construction could include drilling a pilot hole followed by reaming to create the vertical shaft and then installing a liner in the vertical tunnel shaft.

Lateral (horizontal) connection of the shaft to the lake tap can be made using a variety of tunneling methods. The tunnels would be lined, sealed, and ready for pump installation from inside the vertical shaft. Several laterals could be excavated at various elevations to provide a multilevel withdrawal capability. This capability allows withdrawals at different levels to select water quality and temperature at different lake elevations.

The vertical shaft would eventually become a common sump capable of accommodating all vertical turbine pumps.

This is an established construction method that has been successfully implemented for several water supply projects including those in Lake Havasu City, Arizona, and Las Vegas, Nevada. Additionally, in July 2005 this intake style has been approved per the Findings of No Significant Impact (FONSI) for the proposed *Navajo Generating Station Water Intake Project* by both the Glen Canyon National Recreational Area and the National Park Service based on the March 2005 Environmental Assessment.

Changes from the Baseline: In the 2006 Report of Findings, Lake Powell was identified as a water source and this style of intake was not included. The advantages and disadvantages given below are compared to Proposal 7A.

Advantages	Disadvantages
• Vertical shaft would potentially have multi-level intakes to maximize water availability, water quality and temperature. • Preferred by pump designers.	• This alternative is perceived to have a higher capital cost than the inclined lake tap design.

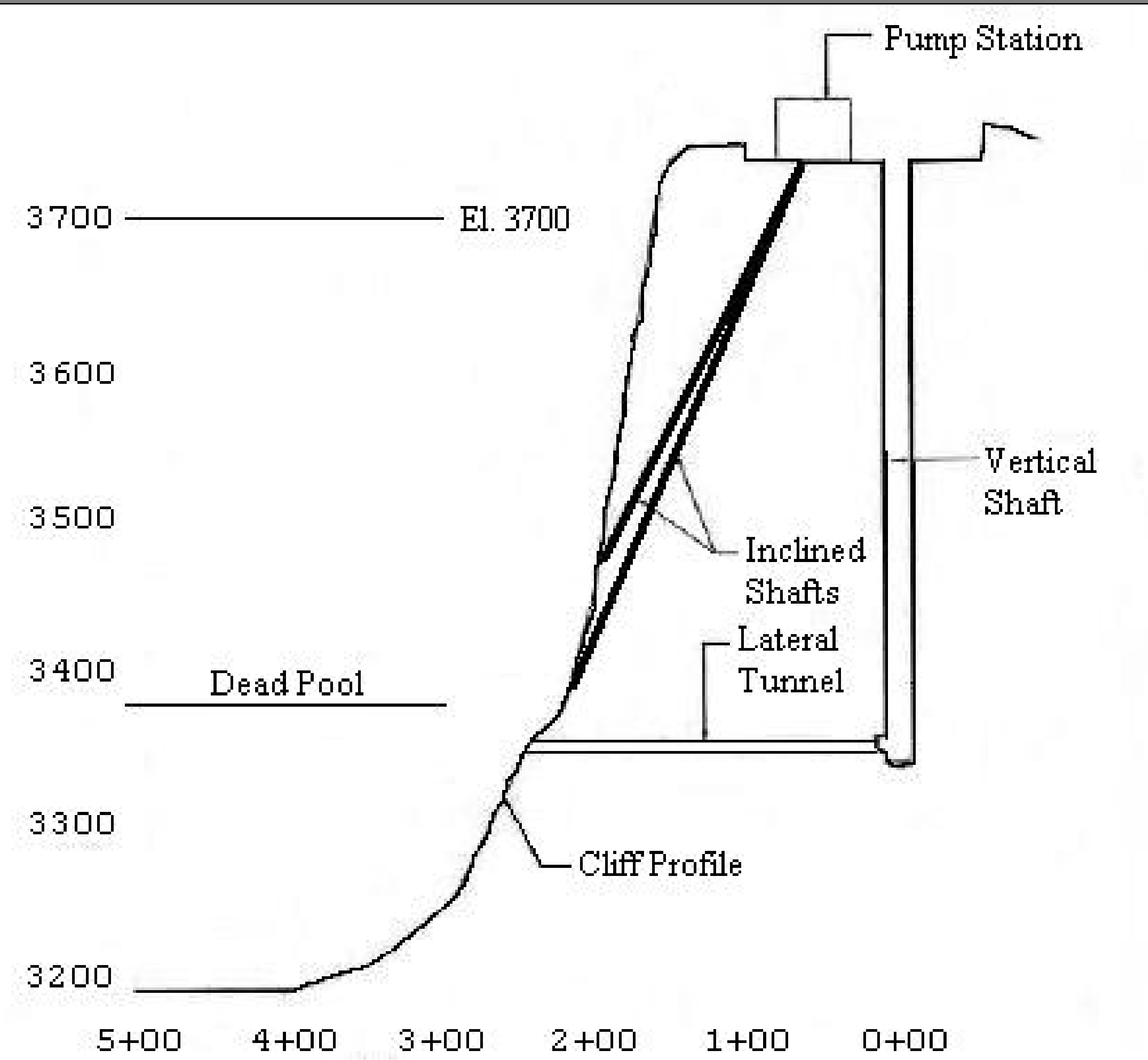
Potential Risks

An unforeseen geological condition during drilling operations could hamper construction and increase costs. Debris slide may occur during construction.

Costs

Costs were not calculated for this Value Planning study.

Figure 8 – Sketch of Inclined Intake and Vertical Shaft Intake



Disposition of Ideas

During the Creativity Phase of the Study, the Team is encouraged to offer any and all ideas, including wild ideas to solve the problem. Criticism is prohibited during this Phase so that everyone will feel comfortable in offering thoughts and ideas. It has been demonstrated that one person's extreme idea can often be the spark for someone else's 'brilliant' idea. Ideas are not evaluated during this phase of the study. A full listing of the ideas is presented to demonstrate the openness of the environment in which the ideas were offered. The table below is a list of all the ideas, the function that the idea addressed and the disposition of that idea. The best ideas were developed as proposals and some ideas did not rise to the level of Proposal and were put in the Appendix

Idea	Function	Disposition
1. Install pipe (Steel, PVC, HDPE, DIP, Wood, Concrete, Clay, Pre-stressed, Bronze, Corrugated Metal, Asbestos Cement)	Convey Water	Team determined this is addressed in baseline design and will be optimized during the Feasibility Planning Level phase and/or during final design.
2. Canal (Lined with concrete, clay, riprap, plastic, HDPE, brick, gabion baskets, pavers or unlined with earth or rock)	Convey Water	Refer to Proposal 4. Lining would be determined during the Feasibility Planning Level phase.
3. Truck Haul	Convey Water	Team determined this is impractical for this project.
4. Helicopter	Convey Water	Team determined this is impractical for this project.
5. Through natural channels / streambeds / rivers	Convey Water	Team determined this is not applicable to this project due to topography.
6. Wells	Convey Water	Team determined this does not meet the goals of the project.
7. Pump Water	Convey Water	Team determined this is addressed in baseline design.
8. Wheeling water (Water exchanges)	Convey Water	Team determined this is impractical for this project.
9. Carry in buckets	Convey Water	Team determined this is impractical for this project.
10. Horses / Mules	Convey Water	Team determined this is impractical for this project.
11. Atmospheric Moisture	Convey Water	Team determined this is impractical for this project.
12. Tunnel	Convey Water	Team determined this is cost-prohibitive for this project.
13. Water wheel	Lift Water	Team determined this is impractical for this project.
14. Pumps with pressure	Lift Water	Team determined this is addressed in baseline design.
15. Pull with suction	Lift Water	Team determined this is addressed in baseline design.
16. Trucking or helicopter	Lift Water	Team determined this is impractical for this project.

Idea	Function	Disposition
17. Conveyor	Lift Water	Team determined this is impractical for this project.
18. Elevator	Lift Water	Team determined this is impractical for this project.
19. Copper / Bronze Metalwork	Prevent Mussel Growth	Incorporated into Proposal 1.
20. Zequanox Pesticide	Remove Mussels	Team determined this is a pesticide and associated public health concerns.
21. Non Adherence Coating	Prevent Mussel Growth	Incorporated into Proposal 1.
22. Toxic chemicals	Remove Mussels	Team determined this raises public health concerns.
23. Predators	Remove Mussels	Team determined this solution may cause more problems than it solves.
24. Sterilization method	Prevent Mussel Growth	Team determined this does not exist.
25. Mechanical methods	Remove Mussels	Incorporated into Proposal 1.
26. Change water quality	Prevent Mussel Growth	Team determined it is impractical to change the water quality in Lake Powell.
27. Remove calcium in waste water treatment processes	Prevent Mussel Growth	Team determined this was beyond the scope of the project.
28. Resource Management	Remove Mussels	Team determined this is not an effective solution.
29. Clean boats	Remove Mussels	Team determined this is already being done and is not an effective strategy.
30. Increase velocity of water	Prevent Mussel Growth	Team determined this option by itself will not adequately prevent mussel growth.
31. Aquifer	Store Water	Team determined this is cost prohibitive.
32. Tanks (steel, fiber, concrete, pre-stressed)	Store Water	Team determined this is addressed in baseline design. Tank materials will be determined during the Feasibility Planning Level phase.
33. Ponds / Reservoirs (lined and unlined)	Store Water	Team determined this is impractical for this project. May be used in conjunction with open canals (See Proposal 4).
34. Bigger Pipe	Store Water	The Team determined this is not cost-effective.
35. Cisterns	Store Water	Team determined this is impractical for this project.
36. Unsaturated Zone	Store Water	Team determined this is impractical for this project.

Idea	Function	Disposition
37. Bladder Storage	Store Water	Team determined this is impractical for this project.
38. Natural features	Store Water	Team determined this is not applicable to this project due to topography.
39. Increase pipe class to reduce number of pumping plants	Miscellaneous Ideas	Incorporated into Proposal 6.
40. Soften water in Lake Powell to remove calcium	Miscellaneous Ideas	Team determined this is impractical for this project.
41. Evaluate renewable energy to provide energy for pumping plants	Miscellaneous Ideas	Team determined that this does not appear to be a viable option.
42. Use open channel flow in low grade areas	Miscellaneous Ideas	Incorporated into Proposal 4.
43. Optimize pipe types	Miscellaneous Ideas	Team determined this would be done during Feasibility Planning Level phase and/or final design.
44. Generate power at low points (PRV's)	**Miscellaneous Ideas**	**Refer to Project Management to determine if this should be evaluated.**
45. Slow sand filtration	Miscellaneous Ideas	Refer to Proposal 3.
46. Increase storage to use solar energy to pump during the day	Miscellaneous Ideas	Team determined that this does not appear to be a viable option at this time.
47. Use process water to cool pumping plant buildings	Miscellaneous Ideas	Team determined that this does not appear to be a viable option at this time.
48. Put first pumping plant downstream of dam	Miscellaneous Ideas	Refer to the Appendix for more information.
49. Cyclone separator to remove debris at the first pumping plant	Miscellaneous Ideas	Team determined this is impractical for this project.
50. Lay pipe on the ground and backfill on top of it	Miscellaneous Ideas	Team determined this is impractical for this project due to freezing and other site constraints.
51. Blend project water with treated groundwater or surface water	Miscellaneous Ideas	Team determined this would not meet project goals.
52. Optimize build out with future water demands / phased construction	Miscellaneous Ideas	Incorporated into Proposal 5.
53. Recycling water	Miscellaneous Ideas	Team determined this was beyond the scope of the project.
54. Combine water treatment plant and storage tanks	**Miscellaneous Ideas**	**Refer to the Design Team to consider.**
55. Increase total dynamic head to 692 feet	Miscellaneous Ideas	Incorporated into Proposal 6.

Idea	Function	Disposition
56. Do not allow any more participants	Miscellaneous Ideas	Team determined this was beyond the scope of the project.
57. Reduce the flow rate	Miscellaneous Ideas	Team determined this would not meet project goals.
58. Reduce number of delivery points	Miscellaneous Ideas	Team determined this would not meet project goals.
59. Install pipe on top of the ground	Miscellaneous Ideas	Team determined this is impractical for this project.
60. Siphon	Miscellaneous Ideas	Team determined this is impractical for this project.
61. Intentionally deleted		
62. Revise pipeline alignment to Bitter Springs	Miscellaneous Ideas	Team determined this would add cost for no increase in value.
63. Combine pumping water from Lake Powell with surface and/or groundwater	Miscellaneous Ideas	Team determined this would add cost for no increase in value.
64. Optimize water storage and the size of pipes	Miscellaneous Ideas	Incorporated into Proposal 5 and 6. This will be completed during the Feasibility Planning Level phase and/or final design.
65. Water conservation	Miscellaneous Ideas	Team determined this was beyond the scope of the project.
66. Build pumping plant on top of water storage	**Miscellaneous Ideas**	**Refer to the Design Team to consider.**
67. Vertical shaft intake at Lake Powell	Miscellaneous Ideas	Incorporated into Proposals 7A.
68. Passive withdrawal screens	Miscellaneous Ideas	Incorporated into Proposals 7B.
69. Filter water with chlorine to kill veligers and remove chlorine before by-products are formed	Miscellaneous Ideas	Team determined this is impractical for this project.
70. Break pipeline into segments for hydraulic transients	Miscellaneous Ideas	Refer to the Appendix for more information.
71. Locate pumping plants at locations based on engineering criteria and land availability	**Miscellaneous Ideas**	**Refer to the Design Team to consider.**
72. Divide air chamber into multiple tanks for reliability	**Miscellaneous Ideas**	**Refer to the Design Team to consider.**
73. Centralize treatment versus treat at the delivery points	Miscellaneous Ideas	Incorporated into Proposals 2A and 2B.
74. Movable intake (vertically)	Miscellaneous Ideas	Team determined this is impractical for this project.
75. Coordinate & integrate tie-ins to existing systems	**Miscellaneous Ideas**	**Refer to the Project Management Team to consider.**
76. Increase pipe size for mussels	Miscellaneous Ideas	Team determined this is impractical for this project.

List of Consultants

Consultant or Contact	Topic or Information
Chris Holdren, Ph.D., Bureau of Reclamation Manager, Environmental Applications & Research 303-445-2178	Information about zebra and quagga mussels in Lake Powell and treatment options for removing mussels.
Allen Skaja, Ph.D. Bureau of Reclamation Chemist 303-445-2396	Information about coating systems that prevent the growth of mussels.

Data and Documents Consulted

Title, Author, and Date	Information
North Central Arizona Water Supply Study, Report of Findings; Bureau of Reclamation; October 2006	Appraisal level design alternatives.
Lake Powell Reservoir-Side Pumping Plant Site, Geology Report; Bureau of Reclamation; November 2007	Geologic information for the project.
Draft North Central Arizona Water Supply Feasibility Study, Test Pit Investigations 2012; Bureau of Reclamation; November 2007	Geologic test pit data along a portion of the alignment.
Page-LeChee Water Supply – Part 1, Concept Design Study – Report of Findings; Bureau of Reclamation; June 2004	Data description regarding intakes.
Navajo Generating Station Water Intake Project Environmental Assessment; National Park Service; March 2005	Data description regarding intakes and methods of drilling.
Lake Powell Reservoir-Side Pumping Plant Site, Geology Report, November 2007	Reviewed potential geological hazards of constructing a pumping plant on the rim of the canyon.
Inspection and Cleaning Manual for Equipment and Vehicles to Prevent the Spread of Invasive Species, Technical Memorandum No. 86-68220-07-05; Bureau of Reclamation; 2012	Information about preventing the spread of mussels.
Colorado Springs Utility	Pump and hydraulic data on the Southern Delivery System project (Pueblo Dam to Colorado Springs, approx. 60 miles).

Design and Value Study Teams' Presentation Attendance List

Name	Organization / Phone Number / Email Address	Design Team Presentation 4/22/13 – 9 am	Value Study Team Presentation 4/26/13 – 9 am
Jeffrey Riley	Reclamation, PXAO-2200 / 623-773-6457 / jriley@usbr.gov	X	X
Katherine Strozinski	Reclamation, TSC / 303-445-3266 / kstrozinski@usbr.gov	X	X
Michael Miller	Reclamation, LC-6030 / 623-773-6455 / mmiller@usbr.gov	X	X
Ray Benally	Navajo Nation Water Resources / 928-729-4003	X	X
Jerry Waugh	Reclamation, TSC / 303-445-3192 / jwaugh@usbr.gov	X	X
Rodney Barthel	Reclamation, TSC / 303-445-3221 / rbarthel@usbr.gov	X	X
Ronald LeBlanc	Reclamation, TSC / 303-445-3230 / rleblanc@usbr.gov	X	X
Steven Robertson	Reclamation, TSC / 303-445-3123 / srobertson@usbr.gov	X	X
Jeff Morris	Reclamation, TR / 303-445-3373 / jmorris@usbr.gov	X	X
Bob Davis	Reclamation, TR / 303-445-2964 / rdavis@usbr.gov	X	X
John Peterson	Reclamation, Native American Affairs / 303-445-2122 / jepeterson@usbr.gov		X
Dick LaFond	Reclamation, TSC / 303-445-3226 / rlafond@usbr.gov		X
Al Bernstein	Reclamation, TSC / 303-445-3275 / abernstein@usbr.gov		X
John Leeper	Navajo Nation Consultant		Via Phone
Rich Dent	Reclamation, LC Region / 623-773-6430 / rdent@usbr.gov		Via Phone
Randy Chander	Reclamation, LC Region / 623-773-6215 / rchandler@usbr.gov		Via Phone
Tim Brown	Reclamation, TSC / 303-445-3709 / tbrown@usbr.gov		X
Debra Tosline	Reclamation, LC Region / 623-773-6277 / dtosline@usbr.gov		X
Robert Kirk	Navajo Nation / 928-729-4004 /robertkirk@navajo-nsn.gov		X

Appendix

Disposition of Idea 48 – Put First Pumping Plant Downstream of Dam
Construct a pumping plant downstream of the Glen Canyon Dam. This concept would require constructing an intake into the lake or tapping into the existing outlet works or other penetration through the dam or abutments. The pumping plant would be constructed downstream of the dam and a penstock would be constructed from the pumping plant up the canyon walls to the pipeline alignment.

From further review of the topography and site constraints, a suitable location for the pumping plant would be difficult to locate due to the steep canyon walls. The lake spillway is located through the left abutment and would impact the locations the intake could be placed. Access to the pumping plant would be costly and difficult to construct. This option may not be cost effective due to site constraints.

Easements from the Park Service may be difficult to obtain. Environmental approval would be more difficult to obtain. Construction of the pumping plant would impact recreation and visual aesthetics of the canyon and surrounding area.

Disposition of Idea 70 – Hydraulic Transients
Divide pipeline into hydraulic segments that do not create high points close to the Hydraulic Grade Line (HGL). High points that are close to the hydraulic grade line in elevation are in danger of dropping to vacuum conditions during a hydraulic transient, which can result in a vapor cavity. As the hydraulic transient progresses, the vapor cavity collapses due to the arrival of a positive pressure wave and a damaging high-pressure spike may occur. The problem can be eliminated by locating the downstream end of the pipeline segment and next pumping plant at the troublesome high point. Alternately, terminate the hydraulic segment sufficiently downstream and uphill of the troublesome high point so that the high point has sufficient vertical clearance from the HGL. This concern is already addressed in the design process and requires no further evaluation.

<u>Review Comments from the Navajo Nation Department of Water Resources:</u>

Mr. Ray Benally, Director, Navajo Nation Department of Water Resources, submitted his comments to Mr. Jeff Morris in a letter regarding the North Central Arizona Pipeline Value Planning Study Presentation. A copy of the letter follows:

THE NAVAJO NATION
DEPARTMENT OF WATER RESOURCES
P.O. BOX 678 • FORT DEFIANCE, ARIZONA 86504 • (928)729-4003/4004 • FAX (928)729-4029 /4126

BEN SHELLY
PRESIDENT

REX LEE JIM
VICE PRESIDENT

April 29, 2013

Jeff Morris, P.E.
CVS Value Program Manager Team Facilitator
U.S. Bureau of Reclamation
DEC Oversight and Value Program Office
PO Box 25007
Denver, CO 80225

RE: **Comments on the North Central Arizona Pipeline Draft Value Planning Report, April 2013**

Mr. Morris,

The Navajo Nation Department of Water Resources (NNDWR) is providing the following comments to the *Value Planning Draft Report for Presentation North Central Arizona Pipeline* conducted the week of April 22:

1. The NCAWSP needs to convey water to the supply points of the NTUA systems.
As we have moved forward with the construction of the Navajo Gallup Water Supply Project (NGWSP), we have incorporated the regional water systems to integrate with the NTUA systems. Some viewed the NGWSP as the main trunk line and only component with little consideration given to effectively connecting to the NTUA systems. The NTUA turnouts were nothing more than conceptual tanks and booster stations, which failed to meet the overall purpose of the project.
Throughout the NGWSP planning process, we emphasized that the NGWSP needs to convey water to the supply points of the NTUA public water systems. The failure to do so will result in a water project that is unable to immediately provide water to the communities and the people that desperately need it. For the NGWSP, the statutory authorization included the connections to the public water systems, and the NNDWR had developed a connection plan to do that. With that recent experience in mind, we want to continue to emphasize that consideration needs to be given to conveying water to the supply points of the NTUA systems. This increased the value of the project and the same result can be obtained for the North Central Arizona Pipeline.
Conveying water to the supply points implicates the hydraulics and the hydraulic optimization of the trunk line and pumping stations. For the NGWSP, consideration has been given to using either the static or dynamic head in a manner that can help convey water to the supply points. Conveying water to the supply points can create project benefits if the existing NTUA storage or existing NTUA chlorination facilities can be utilized toward meeting some of the Project's purpose and need. It also helps to ensure that project benefits are realized much sooner and a greater number of potential customers can start to fund a portion of the OM&R expenses. These are all conditions that substantially increase the project's value.

2. Integration of the NCAWSP with the existing and planned NTUA infrastructure

This concept was peripherally addressed in: 1) Under disposition of Ideas #75 and 2) Proposal 5: Phased Construction of Project "Existing and Proposed water supply systems". However, this concept should receive more attention as effective integration has the potential to significantly reduce the overall cost of the NCAWSP and also has the potential to greatly increase the value of the project.

The Navajo Nation (Nation) has a number of important programmatic efforts to meet the water supply needs within the footprint of the NCAWSP service area. The NCAWSP feasibility level study authority and resources could result in technical products that could leverage funding from other programmatic sources and the programmatic resources could contribute to both the feasibility level investigation, which may reduce the ultimate capital cost of the NCAWSP. For instance, the proposed Page LeChee Water Supply Project would clearly serve a portion of the NCAWSP service area. The Nation has been aggressively pursuing a new intake on Lake Powell for that purpose and Reclamation has been a very active partner in that effort. The Reclamation studies support the programmatic efforts and the NCAWSP. The Page LeChee Intake may secure the intake footprint for the NCAWSP which will save time and money.

The NCAWSP will need to establish rights of way through the Nation's trust lands. However, NTUA already has rights of way throughout much of this corridor and the utilization of these corridors may result in less time and expense for securing rights of way. It will reduce the lengths of corridors that NTUA will need to maintain in the future. Utilizing the existing NTUA storage where possible may also result in a reduction in the additional storage needed and expenses for the NCAWSP.

3. Sequencing the construction of the NCAWSP

Proposal 5 considers the phased of construction of the NCAWSP but it primarily refers to deferring the construction of facilities that may not be needed at the current time. That is a good concept but it should also consider assessing the sequencing of construction from the perspective of the NTUA water systems needs. One could conceptualize three municipal subareas being served by the NCAWSP: 1) Bodway Cameron, 2) Page Lechee, and 3) Tuba City. There are a number of infrastructure improvements that could be made in these sub-areas that would have enormous short term benefits as well as help meet the NCAWSP purpose. Instead of just viewing the NCAWSP as a trunk line that serves these demands, we can look at the NCAWSP as a series of NTUA systems that will one day be conveying water to a broader range of stakeholders. The programmatic resources could be utilized to help meet current short term needs while creating the building blocks that will one day become the NCAWSP. The sequencing is not just delaying construction of NCAWSP portions until water demands mature but it also includes partnering today with different existing authorities that will increase the number of NCAWPS customers in the short term and buy down the ultimate cost of the NCAWSP in the long term. This approach is more complicated and it will not result in a perfect interface among the various agencies and facilities involved but the benefits are enormous. It will help the Nation and other stake holders get real water to real people in real time.

4. Options for the Water Treatment

The options for water treatment are complicated. Proposal 2a is a centralized water treatment plant and Proposal 2b is water treatment at the delivery points. Based on the recent NGWSP discussions, the NCAWSP may use a combination of the two. Several issues have merged: 1. There is concern with mussels infecting the project 2. There is concern with maintaining chlorine residuals in pipelines that have long conveyance times. 3. There is concern of the byproducts produced by the various treatments. 4. There are also regulatory restrictions. Some level of treatment will be required at the intake of the NCAWSP and final treatment near the delivery points.

There were some questions about the water treatment efforts at Page. HKM prepared a preliminary engineering report that includes a modest increase in the capacity of the City's water treatment plant to address the near term demands of LeChee. This PER will be submitted to USDA for funding. This portion will serve part of the NCAWSP purpose.

In the future, it could be anticipated that the pre-treatment system developed for the NCAWSP would benefit both Page and LeChee. Like the NTUA systems that will be served by the NCAWSP, the pre-treated water would be conveyed to the existing Page water treatment plant for further treatment (if necessary) and distributed to the Page and LeChee communities.

The Nation is looking forward to this study addressing significant water needs for the Navajo people.

Sincerely,

Ray Benally, PE, RLS
Director

cc: NNDWR chrono
Jason John, NNDWR – Water Management Branch

Response from Reclamation's Lower Colorado Region Phoenix Area Office (PXAO) to the Review Comments from the Navajo Nation Department of Water Resources (above):

A copy of the letter follows:

United States Department of the Interior

BUREAU OF RECLAMATION
Lower Colorado Region
Phoenix Area Office
6150 West Thunderbird Road
Glendale, AZ 85306-4001

IN REPLY REFER TO:
PXAO-2000
PRJ-28.00

JUN 13 2013

Ray Benally, PE, RLS
Director, Navajo Nation Department of Water Resources
P.O. Box 678
Fort Defiance, Arizona 86504

Subject: Comments on the North Central Arizona Pipeline Value Planning Draft Report (your letter dated April 29, 2013) – North Central Arizona Water Supply Study Feasibility Study

Dear Mr. Benally:

Thank you for your comments on the subject value planning draft report. Your letter will be made an amendment to the report, along with this response letter. Our responses are numbered to coincide with your comments:

1. We agree that the North Central Arizona Pipeline needs to connect at the appropriate locations to Navajo Tribal Utility Authority (NTUA) water systems. Reclamation has been coordinating this effort with Navajo Nation Department of Water Resources (NNDWR) for the last year during the development of pipeline alignments. Several alignment decisions have already been made based on NTUA connection points.

Reclamation will continue seeking connection-point information from NTUA and NNDWR during feasibility and design phases, and would appreciate any updated information as it becomes available.

We appreciate any history and input regarding issues encountered during the design and construction of the Navajo Gallup Water Supply Project. The lessons learned on similar projects can benefit our process.

2. Reclamation supports the concepts described regarding integration of the North Central Arizona Pipeline with existing and planned NTUA infrastructure. Regarding the rights-of-way, we will need to discuss this further to determine if the existing NTUA right-of-way widths are adequate for the addition of a large pipeline and whether the existing infrastructure within those rights-of-way can be, or needs to be, maintained during construction.

3. Reclamation is certainly willing to explore sequencing construction activities at locations that could potentially maximize benefits to water users, although decisions regarding phasing of the project would be made in the design process, after completion of the feasibility study. Please keep in mind that this VP study is just one element of the overall feasibility study. Feasibility

requires specific deliverables, namely a detailed cost estimate and environmental impact statement. In our opinion, sequencing would have little effect on the approach, engineering, cost estimate, and conclusions of the feasibility project.

4. Your comments regarding water treatment are noted and appreciated. Reclamation will continue working with Page and LeChee to develop cost effective intake, water treatment, and pipeline alignment alternatives that provide the most benefit to these communities and the overall project.

If you have questions or need additional information, please contact me at 623-773-6430.

Sincerely,

Acting For

Richard E. Dent, P.E.
Chief, Engineering Division

cc: Jason Johns, Navajo Nation Department of Water Resources, Water Management Branch, P.O. Box 678, Fort Defiance, Arizona 86504