8.0 NAVAJO-GALLUP PROJECT STRUCTURAL ALTERNATIVES

The principal objective of this technical memorandum is to describe Project configurations that may meet the Project's purpose and need, and that are acceptable to the participants. The configurations presented in this technical memorandum are the product of more than 40 years of progressively refined analysis. The location of the point of diversion has critical hydrologic implications for the endangered species in the San Juan River which have yet to be fully evaluated. Therefore, this technical memorandum presents two distinct configurations:

- The first alternative is the San Juan River Alternative. This alternative would divert water directly out of the San Juan River below the confluence of the La Plata and San Juan Rivers and then south along Highway 666 to Yah-ta-hey.

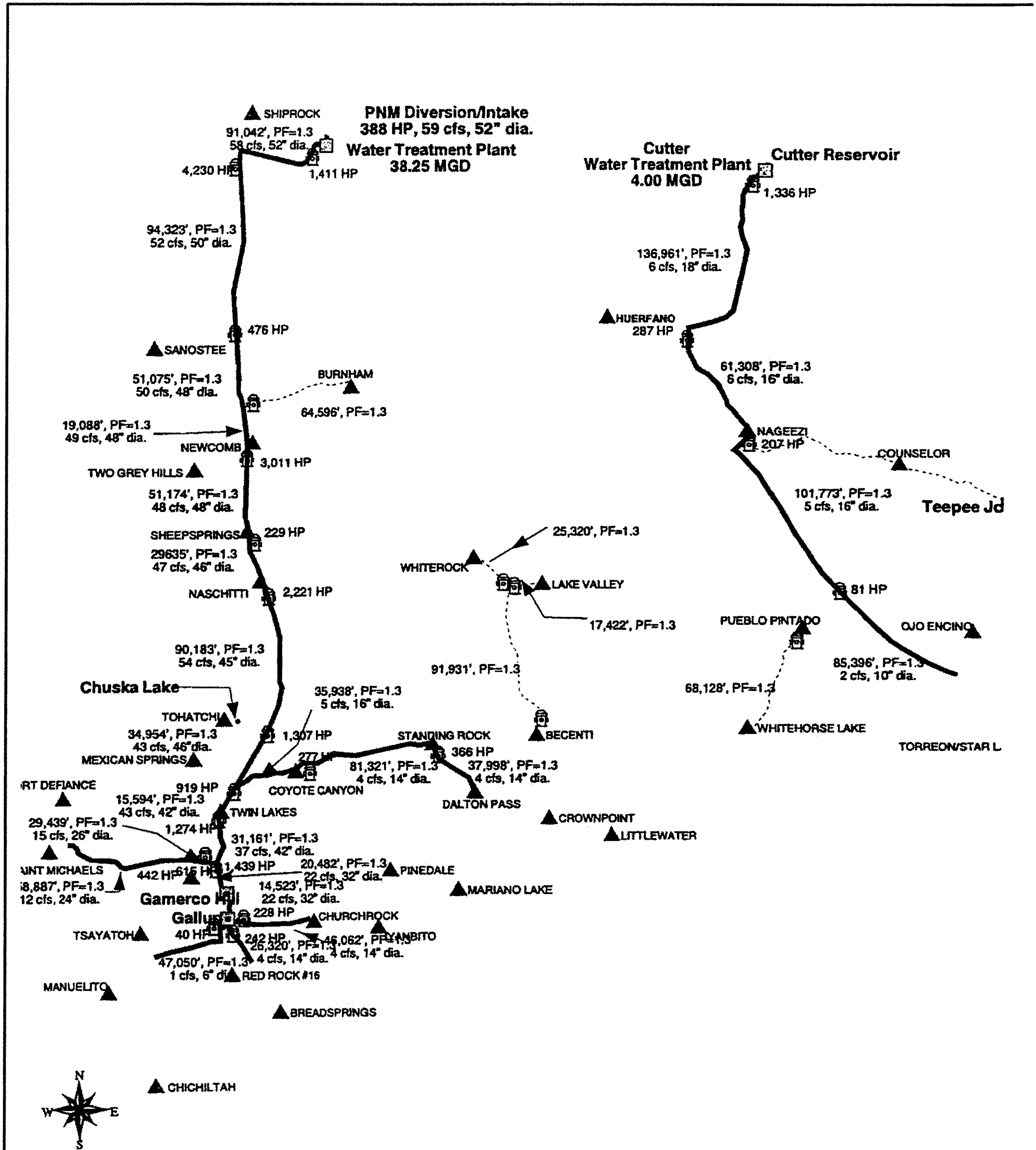
- The second alternative is the NIIP Alternative. This alternative would route water through the Navajo Indian Irrigation Project (NIIP) Main Gravity Canal to Moncisco Reservoir and then south along the Transwestern Pipeline corridor to Yah-ta-hey.

As proposed, both alternatives provide water to the same service area. These alternatives are shown in Figures 2.1, 2.2, 8.1 and 8.2. By the year 2040 the Project will divert 36,600 acre-feet and deplete 34,700 acre-feet from the San Juan River. The remaining municipal demand will be met with 4,680 acre-feet from the Animas La Plata Project, 3,200 acre-feet of groundwater production by the Navajo public water systems, and 1,400 acre-feet of groundwater production by the City of Gallup.

The NDWR investigated additional groundwater development for the Navajo communities in the Project area. One scenario is to provide the entire municipal demand with groundwater. In most cases this scenario is not viable at any cost because groundwater supplies are inadequate to provide a reliable, long-term water supply. The other preferred scenario is to develop a conjunctive water supply based on the sustainable yield of the groundwater. The conjunctive groundwater component reduces the cost of the surface water system and the required depletions from the San Juan River.

The major system elements are:

- The diversion from the San Juan River and conveyance along Highway 666 (The San Juan River Diversion Alternative)
- Routing water through the NIIP facilities and conveyance along the Transwestern Pipeline Corridor (The NIIP Alternative)
- Service to the municipal subareas
- Water treatment
- Wastewater treatment
- Terminus storage
- Project rights-of-way
- Other direct and indirect costs
- Operation and Maintenance



LEGEND

Required Pumping HP

Served Chapters

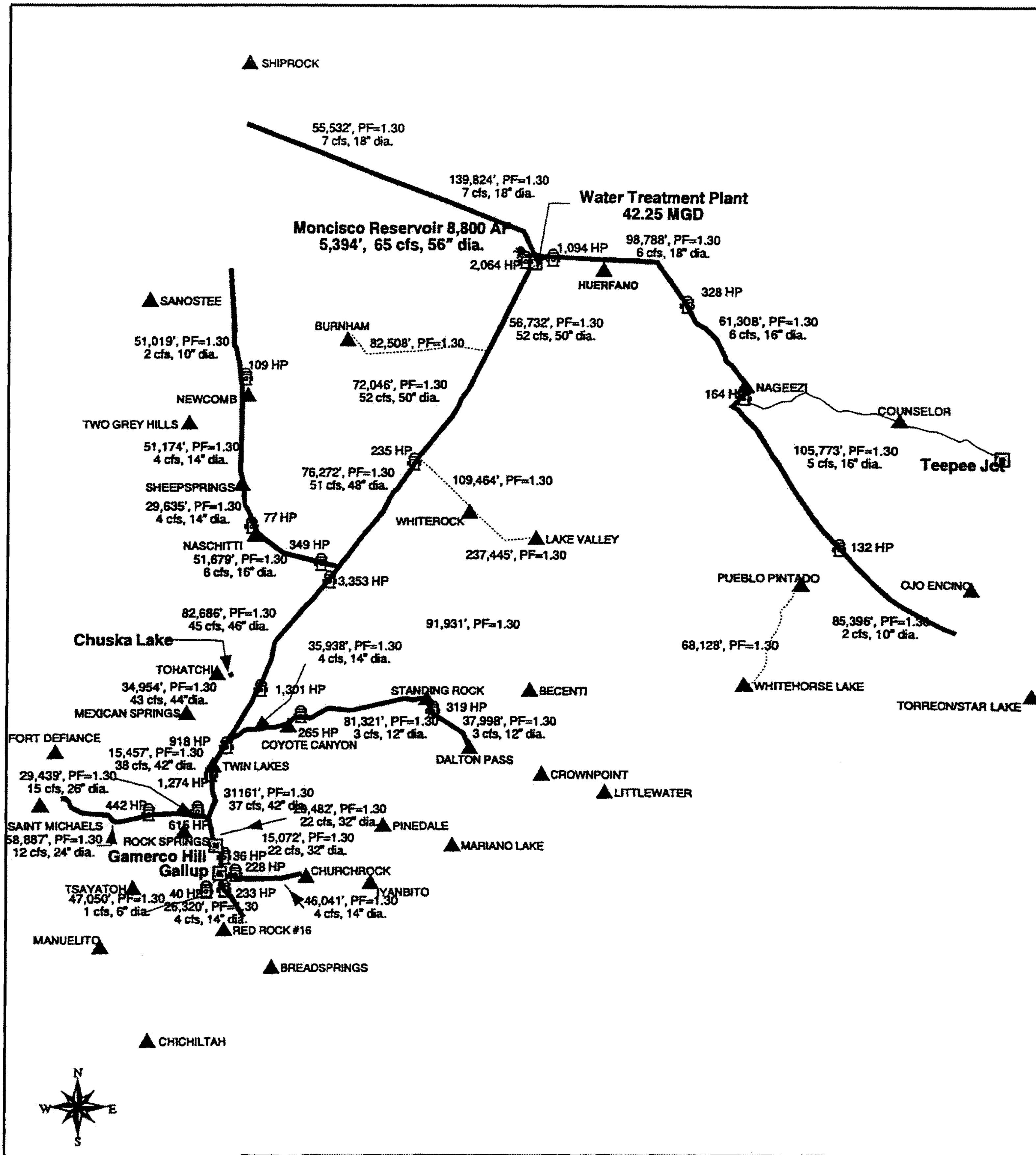
SJR Alternative

Figure 8.1
Navajo-Gallup Water Supply Project
Project Configuration Map

Navajo Department of Water Resources

proj1.apr

March 15, 2001
by: Robert L. Kirk



LEGEND

- Required Pumping HP
- Moncisco.shp
- Served Chapters
- Programmatic Lines
- NIIP Alternative

Figure 8.2
Navajo-Gallup Water Supply Project
Project Configuration Map

Navajo Department of Water Resources

nilpalt1_30.apr	March 16, 2001

Navajo-Gallup Water Supply Project

8.1 The San Juan River Diversion Alternative

The San Juan Diversion would divert approximately 33,000 acre-feet per year directly from the San Juan River. The average diversion is 46 cubic feet per second and the peak diversion is 60 cubic feet per second. A treatment plant, settling basin, and regulating reservoir would be constructed near the point of diversion. Compared to the water in the NIIP canals, the water quality of the San Juan River is lower and it may require additional treatment. From the treatment plant, the pipeline alignment proceeds south along Highway 666 to Yah-ta-hey. At Yah-ta-hey one lateral follows Highway 64 east to Window Rock and another lateral goes south along Highway 666 to the City of Gallup and surrounding areas. Another lateral from Twin Lakes goes east along Indian Route 9 to Dalton Pass. Storage tanks and re-chlorination facilities are included in the Project. This alternative is shown in Figures 2.1 and 8.1.

To service the eastern portion of the Navajo Reservation, a separate pipeline, referred to as the Cutter Lateral, will be constructed. This diversion would divert approximately 3,500 acre-feet per year with an average diversion of 4.6 cubic feet per second and a peak diversion of six cubic feet per second. This pipeline will originate at a treatment plant to be constructed at Cutter Reservoir. The Cutter Lateral will convey water from the treatment plant south to Huerfano, follow Highway 44 to Nageezi and then south to Torreon. Cutter Reservoir is a part of the NIIP canal system and it receives water from Navajo Reservoir. The Cutter Lateral may also be able to convey water to the Jicarilla Apache Nation. This lateral is shown in Figures 2.1 and 8.1.

There may be greater hydrologic flexibility if the main point of diversion is located on the San Juan River below the confluence of the La Plata and San Juan Rivers than if it is located upstream at Navajo Reservoir. This flexibility may make it easier for the Project to be operated in a manner that will satisfy the San Juan River Recovery Implementation Program's flow recommendations.

For the cost estimates presented in this technical memorandum, it has been assumed that the San Juan River Diversion Alternative would use the existing San Juan Generating Station Diversion Structure. This structure is located on the San Juan River at river mile 166, downstream of the La Plata River confluence and upstream from the Chaco Wash. However, other diversion points such as at the Hogback Diversion Structure and a Ranney infiltration gallery will also be considered.

8.1.1 Potential San Juan River Points of Diversion

During the 1980's and 1990's several points of diversion were evaluated including: (1) direct diversions out of the San Juan River, (2) collection of NIIP subsurface drainage return flows, (3) a direct pipeline from Navajo Reservoir, (4) developing groundwater and (5) routing water through the NIIP Main Canal to Moncisco Reservoir. Diverting water directly from the San Juan River is evaluated in this section.

Reclamation investigated two new sites for the diversion structure: (1) upstream from the Fruitland Diversion Structure, and (2) a Ranney infiltration gallery. The impacts of the new diversion on the endangered fish species may be minimized if the Project utilizes an existing diversion structure. Five sites at existing diversions were also evaluated: (1) the diversion for the Fruitland Irrigation Project, (2) the NTUA intake in Shiprock, (3) the BHP diversion to Morgan Lake which provides cooling water to the Four Corners Power Plant, (4) the APS diversion to the San Juan Generating Station, and (5) the diversion for the Hogback Irrigation Project. The potential points of diversion are described in the following sections.

The locations of these diversions are shown in Figure 8.3 and they are described in greater detail in the following section. Other small diversions used by the Lower Valley Water Users Association and the Lee Acres Hammond Irrigation Project diversion may also need to be evaluated. All of the proposed diversion sites could be connected to the existing and proposed Farmington to Shiprock pipelines.

- Potential Diversion Site #1: Upstream from the Fruitland Diversion Structure

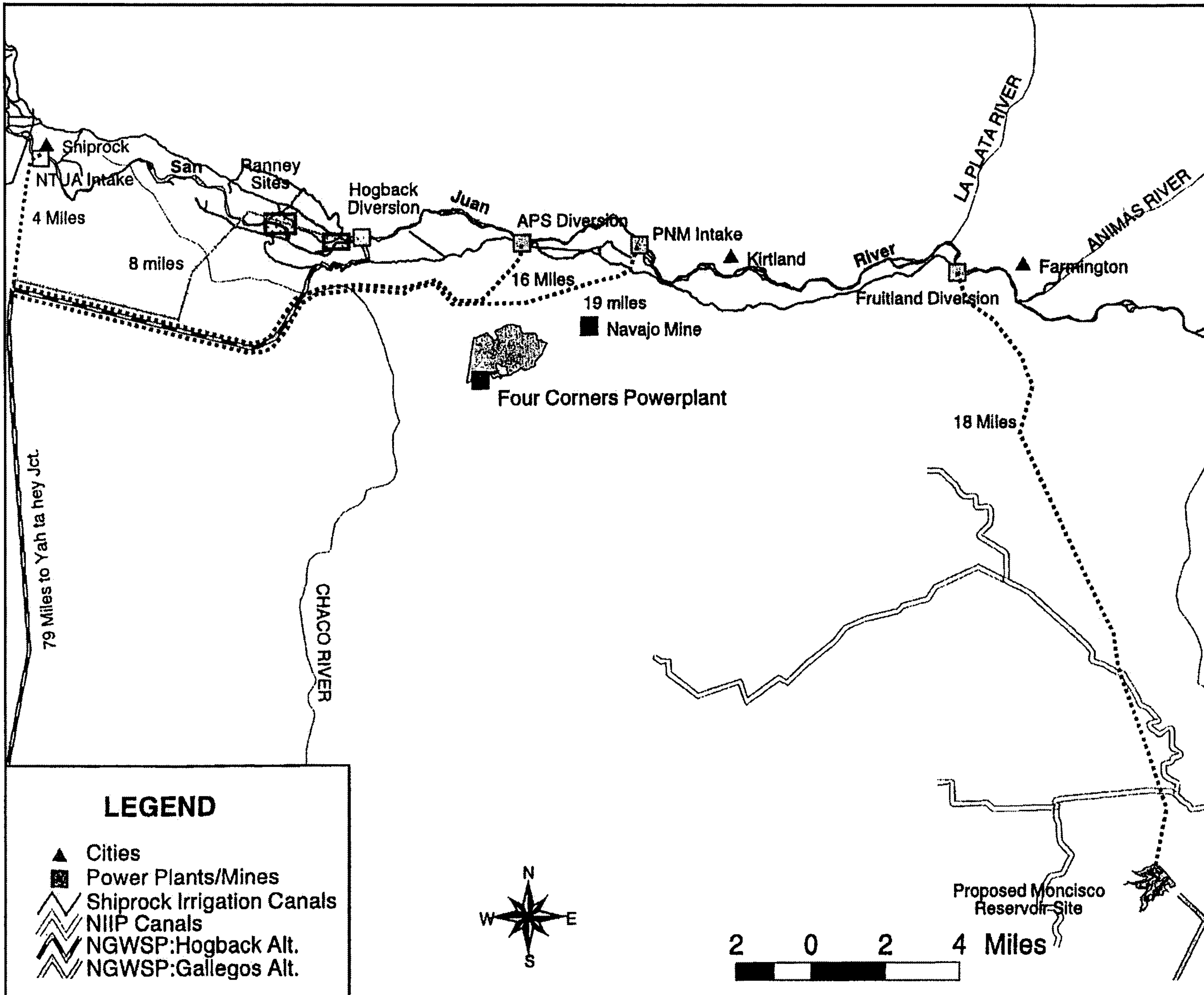
  Reclamation assessed direct diversions out of the San Juan River for the 1984 Environmental Statement, and again in 1996 (*Water Supply and Storage Options, Gallup Navajo Pipeline Project, Engineering and Cost Estimates, Appraisal Level Report*, 1996, Reclamation). Reclamation evaluated a pipeline, pumping plant, pipeline outlet structure, 1,800 acre-foot storage facility and appurtenant structures. The total estimated cost for construction including the pipeline and pumping plants, dam, power lines, and relocation of utilities and archeological mitigation is $58 million in 1996 dollars ($64 million in 2000 dollars). This estimate includes five percent for unlisted items and 20 percent for contingency. This configuration would require an 800-foot lift from the intake pipeline. With a power demand rate of $3.54/kw/month and an energy rate of $0.008 kWh, the annual power cost at full build out would be $414,000 or approximately $13.80 per acre-foot. The estimated field cost of the diversion structure is $2 million.

  In addition to the diversion facilities, a lined regulating pond with a capacity of approximately seven percent of the annual demand, or 1,500 acre-feet of the total annual diversion, may be required to provide water when the water quality of the river is low and the pumps must be shut down. This pond has an estimated field cost of $9.6 million.

  The point of diversion has critical hydrologic implications for the endangered species in the San Juan River. A diversion on the San Juan River upstream from the confluence of the La Plata and San Juan Rivers may be unable to accommodate with the current flow recommendations. For this reason, this site was not considered further.

Figure 8.3
Direct Diversions Options

nilpproj.apr
By: R.L. Kirk
March 15, 2001
Department of Water Resources



Navajo-Gallup Water Supply Project

- Potential Diversion Site #2: The Fruitland Diversion Structure

The Fruitland Irrigation Project includes approximately 350 farming plots totaling 3,830 assessed acres (*BIA 1993 Crop Utilization Survey*, BIA, 1993). The Fruitland Diversion Structure is located two miles west of Farmington, San Juan County, New Mexico, on the southern bank of the San Juan River at river mile 178.5 about 0.4 miles upstream from the confluence of the La Plata River. The diversion structure is located on land which was previously owned by the Navajo Mission and is now owned by the City of Farmington.

The Fruitland Diversion Structure is a quarry rock structure that is maintained on an as-needed basis. A sluiceway to the river adjacent to the canal can sluice up to 1,000 cfs back to the river through two 10 foot wide gates. During midsummer these gates are operated to allow a flow of 100 to 200 cfs through the sluiceway. The gates are opened wider during periods of higher flows and are left open during the winter. The capacity of the canal is approximately 165 cfs although 120 cfs is considered the likely maximum. This diversion does not operate during the winter months (BIO/WEST, 1996).

The Fruitland Diversion is very close to the upstream diversion site evaluated in the 1984 Environmental Statement, and it is very close to the site evaluated by Reclamation in 1996. Of the diversion sites considered, the Fruitland Diversion is the furthest upstream and it has the best water quality. Utilizing the existing Fruitland Diversion would require significant upgrades including fish screens and passages, better sediment control, and a more permanent weir. A nearby rock quarry has several excavated pits that have filled with water from the San Juan River. These ponds might provide regulating storage for the Project. However, they would need to be protected from potential flood damage during high flows.

The Fruitland Diversion is upstream from the confluence of the La Plata and San Juan Rivers. Consequently, its location does not have the hydrologic flexibility needed to accommodate the San Juan River Recovery Program Flow Recommendations. For this reason, it was not further evaluated.

- Potential Diversion Site #3: The Shiprock NTUA Diversion Structure

NTUA has an octagonal intake tower set in the river channel on the north side of the San Juan River near river mile 145. It is adjacent to the Highway 666 bridge. The NTUA facilities include a gravity line leading to a settling basin, pumps and a pipeline to the water treatment plant. The diversion diverts approximately 600 acre-feet per year. The original facilities have been modified twice to reduce the intake of river sand. These modifications include an infiltration gallery beneath the river bed and a venturi type sand separator. The sand separator is not able to extract sand fast enough which creates major problems. The operators have indicated that suspended solids originating largely from the Chaco Wash also create water treatment problems (Molzin-Corbin, 1993).

Reclamation ruled out a diversion structure for the Project at Shiprock because the extra 300 foot pumping lifts were excessive and the water quality was low. The Recovery Program reports that during 1999 turbidity of the San Juan River at Shiprock exceeded 4,000 NTU's for three six-day periods. Reclamation reports that the total dissolved solids (TDS) at Shiprock ranged from 149 mg/l to more than 2,000 mg/l during low flows. The median concentration was 488 mg/l which barely meets secondary safe drinking water standards. Projected flow reductions in the San Juan River by the year 2030 will cause those concentrations to increase. Reclamation recommended a more favorable site up stream closer to Farmington (Reclamation, 1984). The NTUA diversion is downstream from the Uranium Mine Tailing Reclamation Act site in Shiprock. A diversion downstream from this site may raise health and safety concerns in the future. For these reasons, this site was not further evaluated.

- Potential Diversion Site #4: The Four Corners Generation Station Diversion Structure

The Arizona Public Service Company (APS), which operates the Four Corners Power Plant, diverts water from the San Juan River near river mile 160. The intake structure is at the base of a cliff on the south side of the river. It was constructed during the late 1960's. Since then silt and landslides have shifted the river channel away from the intake making it more difficult to maintain an adequate water supply to the power plant. From the intake structure, two sets of two pumps convey 32,000 gpm approximately 2.5 miles from the river to Morgan Lake. Morgan Lake is used as a cooling pond for the power plant. Depending on the weather and power demands, during a typical year the pumps operate between 60 and 70 percent of the time.

Morgan Lake impounds 39,000 acre-feet. The water is used for condenser cooling, domestic use at the plant, boiler feed makeup, ash sluicing and scrubbers. Approximately 10,000 acre-feet of the Morgan Lake water returns to the San Juan River each year via the Chaco River.

One of the concerns with incorporating Morgan Lake into the Project is the poor quality of the water in the lake. The cooling process results in a build up of solids. While relatively low TDS water (415 ppm) is diverted from the river, the operation of the lake results in TDS concentrations between 900 and 1000 ppm. APS tries to keep the TDS between 700 and 800 ppm. The TDS of the water discharged to the Chaco Wash has been measured at 3,300 ppm. Data from 1975 indicate that the water in Morgan Lake is, on average, twice as hard as the water in the San Juan River near Shiprock (230 verses 452 ppm) and that it fails to meet a large number of secondary water treatment standards (*Four Corners Power Generating Plant and Coal Mine, Environmental Report*, March 1975, Westinghouse Environmental Systems Department).

Although these water quality issues are not necessarily fatal flaws, they would result in much more complex water treatment requirements. Theoretically, the Lake could be managed to maintain higher water quality. However, occasional contamination due to small amounts of turbine lubricating oil has occurred. The Lake Morgan water supply meets the water quality demands of the power plant. However, domestic systems have much more stringent water quality standards, including notification requirements if standards are violated. These safe drinking water standards make it much more difficult to use a cooling pond for a municipal domestic water supply. For these reasons, this site was not further evaluated.

- Potential Diversion Site #5: The Ranney Infiltration Gallery

The Ranney Method Western Cooperation (Ranney) conducted an initial assessment of the practicality of developing an infiltrated water supply using the San Juan River aquifer materials to pre-treat the supply. The Ranney staff conducted a site visit to the San Juan River. Theoretically, an infiltration gallery can be installed anywhere along the river. The San Juan River between Shiprock and Farmington was inspected to determine the most suitable sites. One criterion was to locate the infiltration galleries upstream from Uranium Mine Tailing Reclamation Act (UMTRA) site in Shiprock. Additional effort was made to identify sites that would minimize the potential environmental impacts. With these criteria three sites were field inspected.

Ranney reviewed information in their corporate files. Ranney installed a similar unit one mile west of Farmington, New Mexico for the Lower Valley Water Users Association (Brewer, 1977 and 1981). Reports indicate that the gallery yielded approximately 1.0 million gallons per day. But, the water from that gallery had a noticeable hydrogen sulfide odor and it was high in iron and manganese. That gallery has been abandoned. In 1973 Ranney investigated a site near the Hogback Diversion for the Fluer Corporation. For that investigation five test wells were installed. The Fluer investigation indicates that each gallery may yield 2.0 million gallons per day.

Ranney recommends 20 foot deep reinforced concrete caissons with inside diameters of nine feet and concrete top slabs. The caissons would be 500 feet apart. Each caisson would have three 500 foot long horizontal gallery lines installed beneath the streambed. Ranney estimates that individual units would yield approximately 1.5 million gallons per day and have an estimated cost between $900,000 and $1,100,000. This option would require approximately 22 caissons to meet the average annual demand of the Project at full build out and approximately 26 caissons to meet the 1.3 peaking requirement. The reconnaissance level cost for this diversion is $26 million. The cost for pumps, pump houses, access roads, and conveyance pipelines to the treatment facility would be additional.

This proposed configuration for three banks of caissons is down stream from the Hogback Diversion Structure. One bank of caissons would be located directly downstream from the Hogback Diversion Structure on the north side of the river between the river and the Hogback Canal. Another bank of caissons would be approximately two miles downstream from the Hogback Diversion Structure on the south side of the river. The third bank would be about four miles downstream from the Hogback Diversion Structure on the south side of the river. Compared to the San Juan Generating Station Diversion, this site eliminates approximately 36,000 feet, or seven miles, of 52 inch diameter pipe. It may also eliminate the need for a storage reservoir to supply water during times of high turbidity and it may result in lower water treatment costs. However, it will require a more extensive collection system. The banks of caissons could be phased as the Project demand increases over time. This option will be further investigated.

- Potential Diversion Site #6: The San Juan Generating Station Diversion Structure

The Public Service Company of New Mexico (PNM), which operates the San Juan Generating Station, diverts water from the San Juan River approximately 13 miles downstream from the City of Farmington near river mile 166. This diversion was constructed in 1972 and it diverts approximately 30 cubic feet per second or 24,000 acre-feet per year, of which 16,400 acre-feet is under a contract from the Secretary of the Interior. The San Juan Generating Station is a zero discharge facility. The PNM diversion is downstream from the La Plata River confluence and upstream from the Ojo Amarillo Wash confluence. This location may have slightly better water quality than the other downstream sites, but with respect to the endangered species, it has somewhat less hydrologic flexibility.

The water is diverted through a sluice way on the north side of the river to a pumping station. Three 800 horsepower pumps lift the water about 200 feet to a 2,700 acre-foot cooling and regulating pond about three miles away. When the river turbidity exceeds 5,000 NTU's the pumps are shut down and the plant draws on water stored in the pond. After 27 years of operation PNM has lost about 600 acre-feet, or 20 percent, of its capacity due to sediment and suspended solids. PNM and City of Farmington power facilities are located at the pump station. The weir is being modified with a manned fish bypass on the south side of the river to enable endangered species greater access to habitat upstream.

The PNM diversion could readily incorporate an additional sluiceway and pump station. For this Project the sedimentation sluiceway will need to be enlarged to maintain the appropriate velocities to ensure that the suspended solids in the water pumped by the PNM pumps does not increase. It may also be possible to utilize the existing PNM pond during times when the river water is turbid by releasing water down back down the existing pipeline. It also appears that the PNM site is large enough to accommodate the treatment facilities. The PNM Diversion has been used for the cost estimates presented in this technical memorandum. This site will be further evaluated.

- Potential Diversion Site #7: The Hogback Diversion Structure

The Hogback Irrigation Project includes 9,614 acres of irrigable land (BIA, 1962). The Hogback Diversion Structure is located at river mile 158.9 (BIO/WEST, 1996). It is downstream from the La Plata River and the Ojo Amarillo Wash confluences with the San Juan River, and upstream from the Chaco Wash confluence. It was constructed of alluvial fill materials pushed up from the river bed to form a berm across the channel and it is routinely damaged and reconstructed with major flow events. The size and configuration varied from year to year.

As a result of NIIP's Section 7 Consultation with the USFWS for NIIP, the BIA and Reclamation are rebuilding the diversion dam. The new sheet pile diversion will be completed in 2001, and the headworks will be completed in 2002. This upgrade will improve fish passage and improve the water control for the Shiprock irrigators. These upgrades will result in a much more sound structure that may be more suitable for a municipal project than the previous one.

The diversion structure forces water into a side channel where water either passes through radial gates into the canal or returns to the main river channel using a side channel sluiceway. The headgate is a remnant of an older quarry rock structure. Up to 1,700 cubic feet per second (cfs) of water can be diverted into the inlet bay where the majority of flow passes through a sluiceway back to the main channel. Radial gates in the control structure are used to regulate flow into the irrigation canal. Approximately 300 cfs of water typically passes into the irrigation canal. A second sluiceway, located approximately 1,500 feet farther down stream returns about 100 cfs back to the main river channel. Approximately 200 cfs continues down the canal for irrigation. NTUA has a 900 gallon per minute, or 2 cfs, gravity lateral which conveys water from the Hogback Canal to the NTUA Shiprock water treatment plant (Molzen-Corbin, 1993).

The Hogback Canal does not operate during the winter months, and it may have capacity constraints during the summer months. However, water is diverted through the headworks throughout the year. The canal headgates are on the north side of the San Juan River. Consequently, to reach the Project service area, either a new headgate would be needed on the south side, or the diverted water would need to be siphoned across the San Juan River. Compared to the San Juan Generating Station Diversion, this site eliminates approximately 36,000 feet, or seven miles, of 52 inch diameter pipe. Depending on the results of the analysis of the Ranney Infiltration Gallery and the PNM diversion, this site on may be further evaluated.

In conclusion, in 1996 Reclamation concluded that the capital cost of a direct diversion from the San Juan River may be more expensive than utilizing the NIIP facilities. However, that analysis did not include the full costs using the NIIP facilities. For this technical memorandum sites upstream from the La Plata River confluence were not further considered because their limited hydrologic flexibility will make it difficult to accommodate the flow recommendations. Sites downstream from the Chaco Wash and the Shiprock UMTRA site were eliminated due to water quality concerns. The Four Corners Diversion Site was eliminated due to hydraulic constraints and the incompatibility of combining a municipal water supply with the power plant's cooling pond water supply.

Three options may be further considered: (1) A Ranney infiltration gallery downstream from the Hogback Diversion, (2) PNM's San Juan Generating Station Diversion Structure and (3) possibly the Hogback Diversion Structure. For the cost estimates presented in this technical memorandum, the PNM San Juan Generating Station Diversion Structure is used. Reconnaissance evaluations indicate that the overall costs of any of these three options will be similar. More detailed analysis is required to determine a preferred alternative.

8.1.2 The Highway 666 Pipeline Corridor

During the 1980's and 1990's several possible main line alignments were evaluated. The alignment for the San Juan River Diversion Alternative generally follows the Highway 666 corridor and is similar to the "San Juan Alignment "described in the *1984 Environmental Statement and Planning Report*. This alignment was considered the preferred alternative in the 1984 report. Descriptions and cost estimates of the main pipeline and pumping stations from the Hogback Diversion Structure to Yah-ta-hey are presented in the following sections.

For the San Juan River Diversion Alternative, the main pipeline may originate near PNM's San Juan Generating Station Diversion Structure. This pipeline alignment proceeds west along Highway 36 to Highway 666 south of Shiprock. The pipeline route follows Highway 666 to Yah-ta-hey where it connects to laterals serving the Window Rock and Gallup areas. The use of the highway corridor will have to address the concerns of the State of New Mexico Highway Department. This route brings together transportation, power, and water corridors. With this alternative it may also be possible to take advantage of previous environmental compliance investigations conducted for the highway. This alignment is shown in Figures 2.1 and 8.1.

The main line has been sized to accommodate a seasonal peaking factor of 1.3. The diameter of the main line is estimated to be 52 inches at the first reach and it decreases incrementally to 34 inches near Yah-ta-hey. These diameter and lengths are shown in Table 8.1. The pipe material would likely be steel, polyvinyl chloride (PVC), or ductile iron. Steel has been used for this cost estimate. Appurtenant structures such as air valves, blowoffs, meter structures, and sectionalizing valves, will be specified during final design. The diameters, lengths and appraisal level field costs for the main line reaches are presented in Appendix D. The unit cost for the pipelines are based on cost estimates prepared by Reclamation for similar projects in northern Arizona (Reclamation, 2000).

Reclamation evaluated the geology on this pipeline corridor. Approximately 10.2 percent of the Highway 666 pipeline corridor is in possible bedrock. For the cost estimates presented in this technical memorandum, the pipeline corridor is based on 90 percent common excavation and 10 percent rock excavation.

At individual NTUA points of delivery, storage tanks of sufficient capacity are needed to supply water during peak use periods, during system repair, and for fire suppression. These tanks will either be located at high elevations or equipped with booster pumps to provide adequate system pressure. Regulating storage capacity has been included in the cost estimates. The IHS recommends approximately 2,000 gallons of system storage per household. Assuming 4.5 people per household, this standard is equivalent to a 4.4 day supply at 100 gallons per capita per day or a 2.7 day supply at 160 gallons per capita per day. Reclamation's Denver Technical Center recommends three days of storage capacity for a system with multiple water sources, and five days of supply for a system with a single source. These two criterion are very similar to the criterion recommend by Bosserman (et al). The NDWR recommends a local Project storage capacity adequate for five days of average demand.

The cost estimates for the storage tanks are based on Mean's Handbook for ground level tanks. At some sites, more expensive elevated tanks may be required, but that option was not considered in the cost estimate. With this criterion the Project main line will need 33 million gallons of storage at a cost of $8.7 million (or $13.6 million including indirect costs).

8.1.3 San Juan Alternative Pumping Requirements

Approximately 14 pumping plants are needed to lift the water to higher elevations and to supply energy to overcome friction resistance of water moving through the pipeline. The initial pumping plant would be located at the diversion structure on the San Juan River with booster pumping plants located on the main line and on the laterals. Each pumping plant would have multiple pumps with electric motors located indoors. Each pump would have an arrangement of valves and valve operators for startup control and isolation from the pipeline. The pumping plants would have flow meters for measurement of water distribution. The field cost of the pumping plants assumes 70 percent efficiency. Exact locations, sizes, and power requirements will be determined in the final design process. The main line will require a total horsepower of 17,000 and will cost of $10.5 million (or $16.4 million with indirect costs).

Table 8.1
The San Juan River Alternative Main Line Reach Diameters and Lengths

Reach	Length (Feet)	Diameter (Inch)
PNM Diversion to NAPI Junction	8,388	52
NAPI Junction to Highway 666 near Shiprock	91,042	52
Shiprock Junction to Sanostee	94,323	50
Sanostee to Burnham Junction	51,075	48
Burnham Junction to Newcomb Junction	19,088	48
Newcomb Junction to Sheep Springs	51,174	48
Sheep Springs to Naschitti	29,635	46
Naschitti to Tohatchi	90,183	46
Tohatchi to Coyote Canyon Junction	34,954	46
Coyote Canyon Junction to the Twin Lakes Junction	15,594	42
Twin Lakes Junction to the Ya-ta-hey Junction	31,161	42
Total	516,617	

8.2 The NIIP Alternative

Several NIIP points of diversion were evaluated including: (1) collection of NIIP subsurface drainage return flows, (2) a direct pipeline from Navajo Reservoir, and (3) conveying water through the NIIP Main Canal to Moncisco Reservoir. Due to the relatively small volume of NIIP return flows, the high cost of the collection system, concerns regarding the expense of water treatment, and the minimal environmental benefits, the sub-surface option was not further considered. Due to the high cost, a direct pipeline from Navajo Reservoir was not further considered. Conveying water through the NIIP facilities is evaluated in this section.

With the NIIP Alternative the Project would convey 36,700 acre-feet per year through the NIIP facilities. The average diversion is 50 cubic feet per second and the peak diversion is 65 cubic feet per second. Water from the Navajo Reservoir would be conveyed through the NIIP Main and Burnham Lateral Canals to the proposed Moncisco Reservoir. Winter operation of the NIIP canals may reduce the size of the required storage. A treatment plant and pumping station would be constructed near Moncisco Reservoir. The pipeline alignment proceeds south from the treatment plant to an existing natural gas line corridor used by the El Paso San Juan Triangle Mainline and by the Transwestern San Juan Lateral System. The main pipeline route follows the gas line corridor to Twin Lakes where it follows Highway 666 south to Yah-ta-hey. At Yah-ta-hey one lateral follows Highway 64 east to Window Rock and another lateral goes south along Highway 666 to the City of Gallup and surrounding areas. From the main line three laterals include: (1) a pipeline from Naschitti north along Highway 666 to Sanostee, (2) a pipeline from Twin Lakes east along Indian Route 9 to Dalton Pass, and (3) a pipeline from the treatment plant near Moncisco Reservoir along Highway 44 to Nageezi then south to Torreon. Storage tanks and re-chlorination facilities are included in the Project. This alternative is shown in Figures 2.2 and 8.2.

8.2.1 Conveying water through the NIIP Facilities

Conveying water through the NIIP facilities is evaluated in this section. With the NIIP Alternative, the water would be diverted from Navajo Reservoir through the NIIP Main Canal, the water would be lifted approximately 300 feet at Gallegos Pumping Plant into the Burnham Lateral Canal. A pipeline and a stabilized channel would deliver the water from the Burnham Lateral Canal to the proposed Moncisco Reservoir. (The 1996 *Water Supply and Storage Alternatives Gallup Navajo Pipeline Project* report by Reclamation refers to the proposed reservoir as Moncisco Reservoir.) The proposed Moncisco Reservoir would only inundate the Moncisco Wash arm of the facility proposed in the *1984 Plan Formulation and Environmental Study.*

Conveyance losses through the NIIP canal system will need to be addressed. Diversion and metered agricultural deliveries data over the period 1989 to 1993 indicate that the mean conveyance efficiency of the NIIP canal system is 90 percent. The worst case conveyance efficiency is approximately 87 percent. This efficiency will improve if NIIP is not required to deliver selenium dilution water. For this technical memorandum NIIP conveyance losses are assumed to be 10 percent.

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Shiprock Junction to Sanostee	94,323	50
Sanostee to Burnham Junction	51,075	48
Burnham Junction to Newcomb Junction	19,088	48
Newcomb Junction to Sheep Springs	51,174	48
Sheep Springs to Naschitti	29,635	46
Naschitti to Tohatchi	90,183	46
Tohatchi to Coyote Canyon Junction	34,954	46
Coyote Canyon Junction to the Twin Lakes Junction	15,594	42
Twin Lakes Junction to the Ya-ta-hey Junction	31,161	42
Total	516,617	

8.2 The NIIP Alternative

Several NIIP points of diversion were evaluated including:(1) collection of NIIP subsurface drainage return flows, (2) a direct pipeline from Navajo Reservoir, and (3) conveying water through the NIIP Main Canal to Moncisco Reservoir. Due to the relatively small volume of NIIP return flows, the high cost of the collection system, concerns regarding the expense of water treatment, and the minimal environmental benefits, the sub-surface option was not further considered. Due to the high cost, a direct pipeline from Navajo Reservoir was not further considered. Conveying water through the NIIP facilities is evaluated in this section.

With the NIIP Alternative the Project would convey 36,700 acre-feet per year through the NIIP facilities. The average diversion is 50 cubic feet per second and the peak diversion is 65 cubic feet per second. Water from the Navajo Reservoir would be conveyed through the NIIP Main and Burnham Lateral Canals to the proposed Moncisco Reservoir. Winter operation of the NIIP canals may reduce the size of the required storage. A treatment plant and pumping station would be constructed near Moncisco Reservoir. The pipeline alignment proceeds south from the treatment plant to an existing natural gas line corridor used by the El Paso San Juan Triangle Mainline and by the Transwestern San Juan Lateral System. The main pipeline route follows the gas line corridor to Twin Lakes where it follows Highway 666 south to Yah-ta-hey. At Yah-ta-hey one lateral follows Highway 64 east to Window Rock and another lateral goes south along Highway 666 to the City of Gallup and surrounding areas. From the main line three laterals include: (1) a pipeline from Naschitti north along Highway 666 to Sanostee, (2) a pipeline from Twin Lakes east along Indian Route 9 to Dalton Pass, and (3) a pipeline from the treatment plant near Moncisco Reservoir along Highway 44 to Nageezi then south to Torreon. Storage tanks and re-chlorination facilities are included in the Project. This alternative is shown in Figures 2.2 and 8.2.

8.2.1 Conveying water through the NIIP Facilities

Conveying water through the NIIP facilities is evaluated in this section. With the NIIP Alternative, the water would be diverted from Navajo Reservoir through the NIIP Main Canal, the water would be lifted approximately 300 feet at Gallegos Pumping Plant into the Burnham Lateral Canal. A pipeline and a stabilized channel would deliver the water from the Burnham Lateral Canal to the proposed Moncisco Reservoir. (The 1996 *Water Supply and Storage Alternatives Gallup Navajo Pipeline Project* report by Reclamation refers to the proposed reservoir as Moncisco Reservoir.) The proposed Moncisco Reservoir would only inundate the Moncisco Wash arm of the facility proposed in the *1984 Plan Formulation and Environmental Study*.

Conveyance losses through the NIIP canal system will need to be addressed. Diversion and metered agricultural deliveries data over the period 1989 to 1993 indicate that the mean conveyance efficiency of the NIIP canal system is 90 percent. The worst case conveyance efficiency is approximately 87 percent. This efficiency will improve if NIIP is not required to deliver selenium dilution water. For this technical memorandum NIIP conveyance losses are assumed to be 10 percent.

Navajo-Gallup Water Supply Project

The ability to convey Project water through the NIIP canals depends on three constraints: (1) the available canal capacity during July, (2) the length of the canal operating seasons, and (3) the storage capacity of the proposed Moncisco Reservoir. Because each of these constraints affects the project configuration differently, each one is described in the following sections. A map of the NIIP canals and the related facilities is shown in Figure 8.4.

- Constraint #1: NIIP canal capacity available during July

  The capacity of the NIIP Gravity Main Canal is 1,285 cfs and the capacity of the Burnham Lateral is 880 cfs. The average municipal demand is approximately 50 cubic feet per second. The peak demand is 65 cubic feet per second. During most, but not all, of the year these facilities have more than adequate capacity to meet the demands of both NAPI's irrigated land and the Project's municipal requirements.

  One of the operating constraints for the Project may be the canal capacity required during the peak NAPI's irrigation demand in July. The irrigation demands for NAPI during a typical year for the Gravity Main Canal, the Burnham Lateral, and the Burnham Lateral West are shown in Table 8.2 (Reclamation, 1996). With an overall irrigation efficiency of 55 percent, NAPI's irrigation demand limits the canal capacity available for the Project during July. The municipal demand, however continues throughout the year. Insufficient midsummer capacity could be addressed if NAPI maintains higher irrigation efficiencies, stresses its irrigated crops or irrigates fewer acres. For instance, with an overall efficiency of 65 percent this limit is almost eliminated. These options may reduce NAPI's operational flexibility and increase NAPI's risks during unexpected weather events or canal breakdowns. Based on Reclamation's operation analysis, approximately 2,000 acre-feet of reservoir capacity is required to supply the municipal demand during July.

Figure 8.4 : Map of NIIP Facilities

Schematic of the NIIP Canals
and proposed NGWSP Facilities

niipproj.apr
By: R.L. Kirk
March 15, 2001
Department of Water Resources

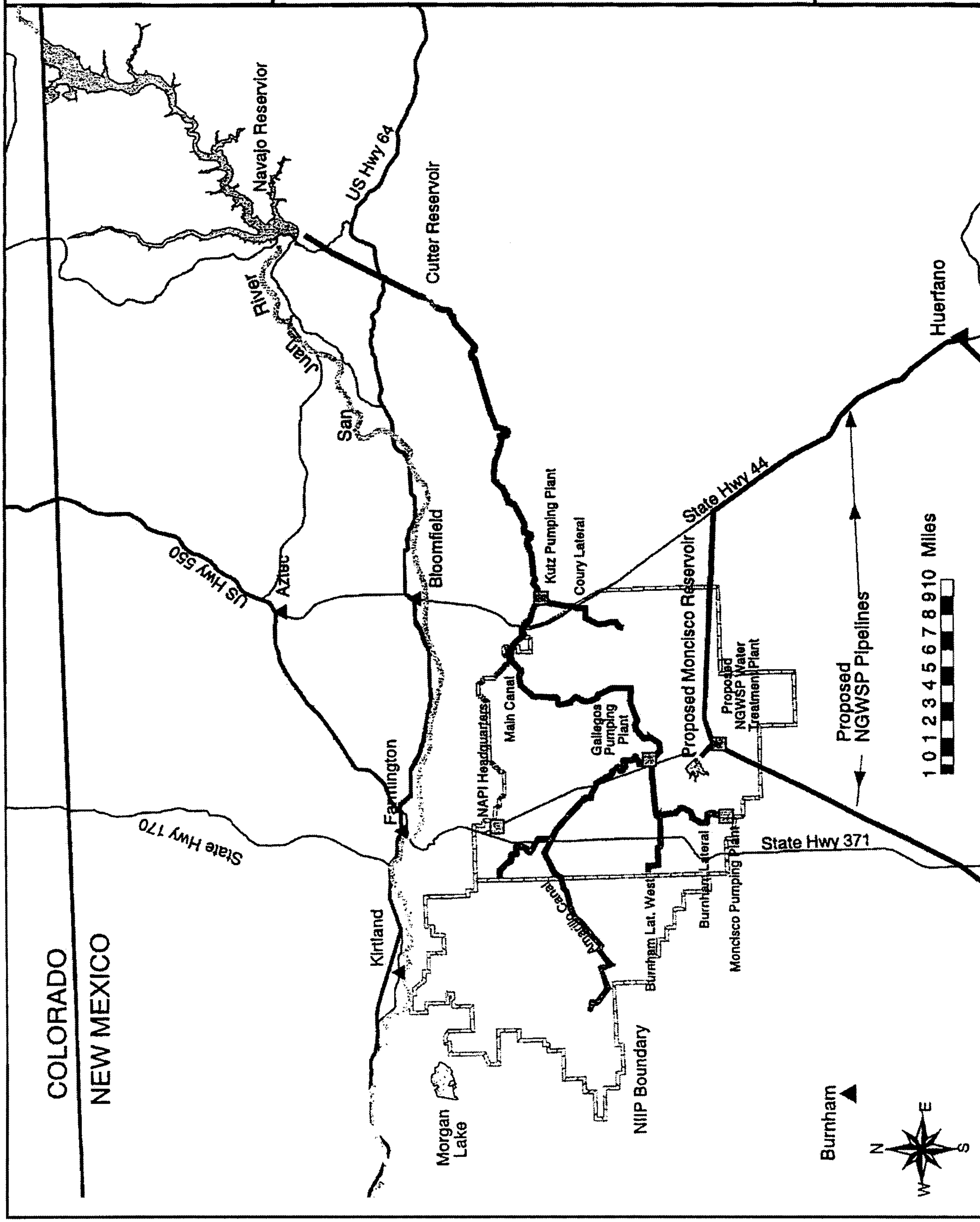


Table 8.2
NIIP Monthly Canal Capacities Available for the Navajo-Gallup Water Supply Project

Month	NAPI Demand as a Percent of the Peak Capacity[1] (Percent)	Gravity Main Canal Capacity Available for NGWSP[2] (cfs)	Burnham Lateral Capacity Available for NGWSP (cfs)	Burnham Lateral West Capacity Available for NGWSP (cfs)	Amarillo Canal Capacity Available for NGWSP (cfs)
January	0	1,285	880	320	190
February	0	1,285	880	320	190
March	0	1,285	880	320	190
April	25	964	660	240	143
May	55	578	396	144	86
June	75	321	220	80	48
July	100	0	0	0	0
August	82	231	158	58	34
September	50	643	440	160	95
October	17	1,067	730	266	158
November	0	1,285	880	320	190
December	0	1,285	880	320	190

[1] These percentages are the ratio of NAPI's peak monthly demand and that months average demand.

[2] Available canal capacities are the design capacity minus the NAPI irrigation demand. Canals are assumed to be operating at full capacity during the peak month to maintain NAPI's operational flexibility.

- Constraint #2: The length of the NIIP canal operating season

Municipal water supply projects require water throughout the year. In contrast, irrigation projects typically only operate during the irrigation season. The shorter the irrigation season lasts, the more storage will be required for the municipal project. The length of the canal operating season is the most critical constraint for determining the municipal storage requirement.

At NIIP the current irrigation season normally extends from April 1 to October 31. During the months that no irrigation occurs, November through March, NAPI conducts maintenance on the NIIP facilities. In addition to the storage required to provide water during the peak summer irrigation season, the Project requires storage while the canals are not in operation. Reclamation analyzed the Project's storage requirement based on three theoretical NIIP canal operating seasons: (1) the current canal operating season from April 1 to October 31, (2) an extended canal operating season from March 1 to October 31, and (3) all year operation of the canal system.

The Current Canal Operating Season. The current canal operating season begins in April and ends in October. This season provides NAPI with five full months during which the canals are not operated and annual maintenance can be conducted. With no water delivery during these winter months, Moncisco Reservoir needs approximately 11,000 acre-feet of active storage to supply the Navajo-Gallup Project.

An Extended Canal Operating Season. The current canal operating season could be extended by beginning water deliveries approximately one month earlier. The extended season would begin March 1 and end October 31. This season would provide NAPI with four months to conduct the annual maintenance. This extended canal operating season would avoid the likelihood of hard winter freezes which may severely damage the canal facilities. The earlier season reduces the required storage capacity at Moncisco Reservoir to approximately 8,800 acre-feet of active storage. The extended season might also provide NAPI with an opportunity to pre-irrigate some of its fields. Pre-irrigation stores water in the soil column reducing the peak irrigation diversion requirements and helps to circumvent canal capacity constraints during the summer months. Pre-irrigation may reduce pumping costs by taking advantage of off-season energy rates. Other local irrigation companies including the Farmers Mutual Ditch Company near Kirtland have extended delivery seasons to encourage pre-irrigation.

All Year Canal Operation. All year operation of NIIP canals and structures will impact NAPI's ability to conduct annual operation and maintenance. Specialized winter operation and preparation may increase NIIP's operation and maintenance expense, but it decreases the storage required to meet the municipal demands. Winter maintenance such as canal lining replacement, drain installation, crack sealing, and silt removal cannot be performed with water in the canal. Maintenance at canal check structures and turnout structures is more difficult if they are under water. All year operation will also require that positive seals be installed at turnouts to pumping plants to keep water out of the pump sumps. The siphon blowoffs also need to be protected from freezing. In addition, winter operation affects the operation of the canal drains. Water under the canal lining combined with the freezing action of the soil can damage the canal linings. Currently the canal drains are open during the winter and closed during summer. This operation drains water under the lining during the winter and conserves water during the summer. There is also the potential for canal lining and other structures to be damaged due to ice dams.

For food processing NAPI may need to operate a portion of the Main Canal and the Gravity Main Canal downstream from Cutter Reservoir during most of the year. NAPI has proposed a factory that would produce frozen french fry potatoes. This factory would have an annual diversion requirement of approximately 3,000 acre-feet and deplete approximately 400 acre-feet. Cutter Reservoir has an active storage of 808 acre-feet and an inactive storage of 942 acre-feet. This reservoir has adequate capacity to meet the factory's water demand for several weeks. This storage will enable NAPI to shut down portions of the Main Canal for brief periods of time for annual maintenance. All year operation reduces, but does not eliminate the need for additional municipal storage.

- Constraint #3: Regulating storage at the proposed Moncisco Reservoir

Gallegos Reservoir was a feature of the original project specifications for the Navajo Indian Irrigation Project and was originally designed to provide 45,000 acre-feet of storage for surface irrigation. In 1973, NIIP was redesigned as an all-sprinkler system operation and Reclamation maintained that the sprinkler modifications eliminated the need for Gallegos Reservoir. Consequently, the 1976 Environmental Impact Statement (EIS) for NIIP is based on all-sprinkler operation that does not include Gallegos Reservoir. After a four-year consumptive use study was completed by Reclamation in 1983, Reclamation and the BIA determined that the storage capacity in Gallegos Reservoir was required, and it was added as a project feature of NIIP. Since Gallegos Reservoir was not included in the 1976 EIS, a supplemental EIS is required before it, or an alternative reservoir, can be constructed.

The proposed Moncisco Reservoir is smaller than the proposed Gallegos Reservoir. It will be located on the Moncisco Wash. It will supply water during periods when the NIIP facilities are not operating. If the NIIP canals do not operate during the five winter months, the Project will need 11,000 acre-feet of active storage capacity to deliver 34,000 acre-feet per year. If the canals do not operate for four months, the Project will only need 8,800 acre-feet of active storage capacity. Even if the NIIP canals operate all year, the Project will need at least 1,850 acre-feet of active storage capacity. The Project cost estimate for the NIIP Alternative presented in this Technical Memorandum is based on 8,800 acre-feet of storage.

Navajo-Gallup Water Supply Project

Two possible sites near NIIP have been identified for the proposed Moncisco Reservoir: the Cottonwood site located in Section 25, R15W, T27N, and the Moncisco site located in Section 18, R12W, T26N. The Moncisco site is within the boundary of the originally proposed Gallegos Reservoir. At either location the proposed dam would be a zoned earth core dam with a concrete spillway and outlet works consisting of an intake structure, outlet pipe with valves, and outlet structure. At either location, a dam approximately 80 to 100 feet high with a 350-surface acre reservoir is expected. Detailed geologic field investigations are still required. Both sites were visited during March of 1998 by Reclamation biologists. Based on those field trips, the proposed reservoir sites are extremely arid and support mixed desert plant communities with small, sparse willows in the bottom of the washes. Neither site has habitat suitable for the Southwestern willow flycatcher, an endangered species. Appraisal level studies identify the Moncisco site as the preferred site. The cost estimates of various capacities are shown in Table 8.3 and a schematic of the Moncisco site is shown in Figure 8.5. The cost estimates presented in this technical memorandum are based on Reclamation's high range cost estimate for 8,800 acre-foot capacity.

The construction of any reservoir will require withdrawing land. Reclamation staff have indicated that there may be some local opposition to withdrawing land for either the Moncisco or Cottonwood sites.

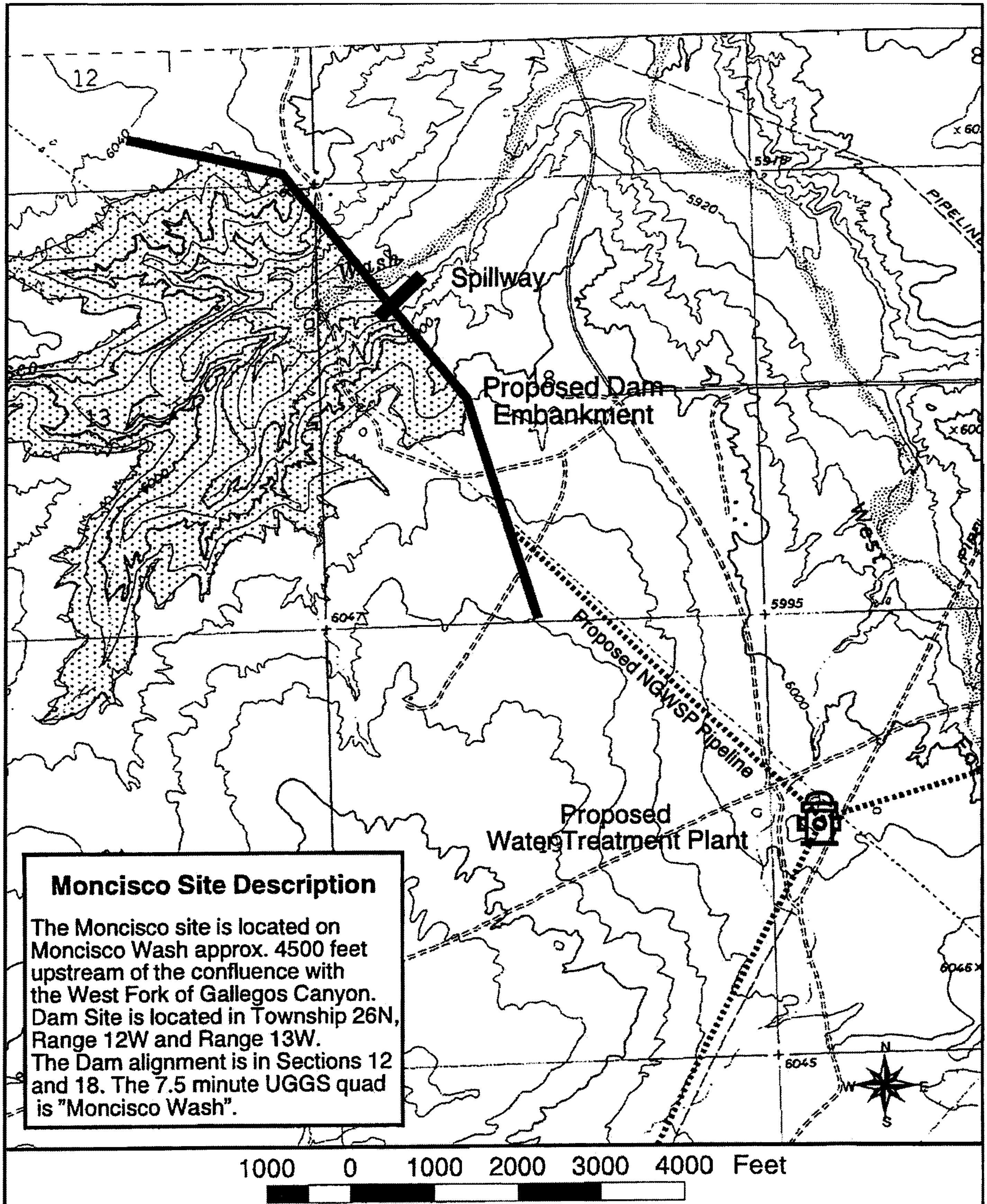
Table 8.3
Range of Estimated Cost for Project Storage Facilities at NIIP
(FY 2000 Dollars)

Capacity (Acre-feet)	Low Range (Million Dollars)	High Range (Million Dollars)
11,000	$38.6	$40.0
8,800	$33.0	$36.1
4,380	$22.5	$27.8

Navajo-Gallup Water Supply Project

To better characterize the three water delivery constraints at NIIP, the NDWR analyzed the operation of the NIIP facilities. The results of a representative scenario are shown in Figure 8.6. For this scenario, the NIIP canals begin operating in early March. During March, April and May the canals have adequate capacity to meet the irrigation and the municipal demand. Late in May and early June the diversions into Moncisco Reservoir are increased. The reservoir is partially filled as late as possible to minimize the duration that it is full and when evaporation and seepage losses are the greatest. Late in June and most of July the irrigation demand requires essentially all of the canal capacity. During this period the municipal demand is met by releases from the reservoir. Depending on the weather, a portion of the irrigation demand may also be met with reservoir releases. By late July the irrigation demand deceases and the canal capacity is again adequate. To keep evaporation and seepage losses to a minimum, the reservoir is filled as late as possible in the fall. The reservoir should be filled some time in early October to supply the municipal water demand during the winter months when the canals are shut down. From October to March the municipal demand is met by releases from the reservoir.

The evaporation and seepage losses from Moncisco Reservoir are impacted by the overall efficiency at NIIP. For this technical memorandum it is assumed that the evaporation loss is a depletion and that the seepage loss returns to the San Juan River. If NIIP's efficiency is 55 percent, there is a canal capacity constraint during July. Consequently, Moncisco Reservoir needs to be partly filled in June. The evaporation loss is approximately 540 acre-feet per year and the seepage loss is approximately 323 acre-feet per year. If NIIP's efficiency is 65 percent, there are no canal capacity constraints during July. Consequently Moncisco Reservoir only needs to be filled in September to provide water during the winter months. The evaporation loss is approximately 210 acre-feet per year and the seepage loss is approximately 130 acre-feet per year. NIIP's 1999 Biological Assessment indicates that NIIP's overall efficiency in the future will be close to 65 percent (Keller Bliesner, 1999). For the depletion estimates in this technical memorandum NIIP's overall irrigation efficiency is assumed to be 65 percent.



LEGEND

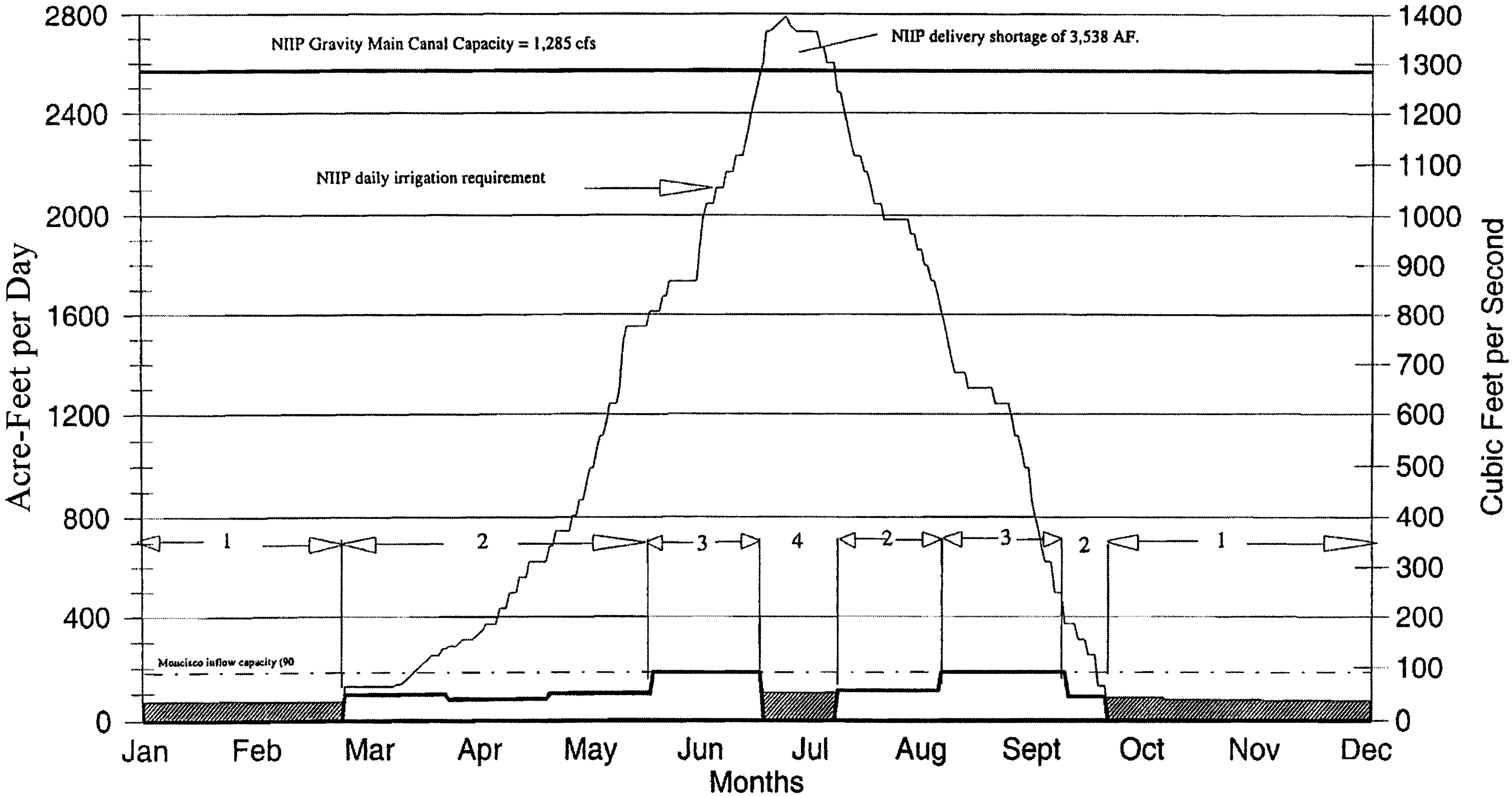
Moncisco Dam Site
Gallegos Water indentations
Navajo-Gallup Pipeline

Figure 8.5
Navajo-Gallup Water Supply Project

Proposed Moncisco Dam Site

Ngwspwork.apr, By: R. Kirk
March 15, 2001

Figure 8.6: Navajo Indian Irrigation Project vs. Navajo-Gallup Water Supply Project Demand



1. NIIP canals closed for winter. NGWSP water delivery from Moncisco Reservoir.

2. Diversions from NIIP canals through Moncisco Reservoir to NGWSP Pipeline.

3. Moncisco Reservoir is filled. Late season fill minimizes reservoir losses. Reservoir only supplys water during summer and winter shortages.

4. Inadequate capacity for NGWSP and NIIP industrial water delivery. Diversions from Moncisco Reservoir are required during summer shortages.

Note:
* NIIP Irrigation delivery requirement is based on the 1994/95 operating season.
* Moncisco Reservoir has a 8,800 AF capacity.
* NIIP overall Efficiency is 55%

8.2.2 The Transwestern Pipeline Corridor

During the 1980's and 1990's several possible alignments for the main line were evaluated. The pipeline alignment for the NIIP Alternative generally follows the Transwestern Pipeline Corridor and is similar to "Alternative C" described in the *San Juan River Gallup/Navajo Water Supply Project Engineering and Cost Estimates Technical Appraisal Report*, November 1993. Of all the alignments between NIIP and Yah-ta-hey considered, this alignment is the shortest and requires the least amount of lift and fewest pumping stations to serve the Project area. The description and cost estimate of the main line from Moncisco Reservoir to Yah-ta-hey are presented in the following section.

For the NIIP Alternative, the main line originates near the pumping plant below the proposed Moncisco Reservoir. This pipeline alignment proceeds south to an existing natural gas line corridor used by the El Paso San Juan Triangle Mainline and by the Transwestern San Juan Lateral System. The pipeline route follows the gas line corridor to Twin Lakes where it turns south to Yah-ta-hey where it connects to water lines for the Window Rock and Gallup areas. Use of the gas line corridor will have to be negotiated with the respective pipeline representatives. However, a memorandum of understanding between the Navajo Nation and the companies regarding the pipeline right-of-ways should facilitate these discussions. This alignment is shown in Figures 2.2 and 8.2.

The main line has been sized to accommodate a peaking factor of 1.3. The diameter of the main line is estimated to be 52 inches at the beginning and 42 inches near Yah-ta-hey. The pipe material would likely be steel, polyvinyl chloride (PVC), or ductile iron. Appurtenant structures such as air valves, blowoffs, meter structures, and sectionalizing valves, will be specified during final design. The diameters, lengths and appraisal level field costs for the main line reaches are presented in Table 8.4. At individual points of delivery, storage tanks with a total capacity of 33 million gallons and a cost of $8.7 million (or $13.7 million including indirect costs) are included in the cost estimate.

Reclamation evaluated the geology on this pipeline corridor. Approximately 7.7 percent of the Highway 666 pipeline corridor is in possible bedrock. For the cost estimates presented in this technical memorandum, the pipeline corridor is based on 90 percent common excavation and 10 percent rock excavation.

8.2.3 Pumping Requirements

Approximately 14 pumping plants are needed to lift the water and to supply the energy to overcome the frictional resistance of water moving through the pipeline. The initial pumping plant would be located below the forebay of Moncisco Reservoir with booster pumping plants located on the main line and on the lateral pipelines. Six pumping plants are needed. The main line will require 10,000 horsepower at a cost of $6.1 million (or $9.7 million including indirect costs). The exact locations, sizes, and power requirements will be determined in the final design process (Reclamation 1993).

Table 8.4
The NIIP Alternative Main Line Reach Diameters and Lengths

Reach	Length (Feet)	Diameter (Inch)
Moncisco Water Treatment Plant to the Main Line (Huerfano Junction)	4,478	52
Main Line (Huerfano Junction) to the Burnham Junction	55,732	50
Burnham Junction to the Lake Valley Junction	72,046	50
Lake Valley Junction to the Naschitti Junction	76,272	48
Naschitti Junction to the Tohatchi Junction	82,686	46
Tohatchi Junction to the Coyote Canyon Junction	34,954	44
Coyote Canyon Junction to the Twin Lakes Junction	15,594	42
Twin Lakes Junction to the Ya-ta-hey Junction	31,161	42
Total	372,923	

8.3 Service to the Municipal Subareas

The objective of this section is to describe the alternatives for conveying water from the main line to each of the communities. One critical goal is to develop a Project that can be readily operated. NTUA raised several operational concerns. First, if a significant portion of the water in a proposed lateral or water tank is not used, the water stagnates. Under these circumstances it is difficult to maintain chlorine residuals and it can result in bacteria problems. Second, the pipelines and other facilities will be subjected to wear and tear as soon as they are installed. Even with a long life expectancy, the water purveyor needs to address maintenance as soon as a facility is built, whether or not the facility is used. Third, additional miles of long laterals which serve relatively small demands create a disproportionate operation and maintenance burden for the water purveyor and the water users. And, fourth, the water users must be able to afford the water. The proposed alternatives combine Project and programmatic components to balance the short-term and long-term demands of the service area in a cost-effective manner.

The laterals are designed with a peaking factor of 1.3 and a per capita water use of 160 gallons per person per day. The pipe diameters of the laterals range from 34 to 6 inches and the pipes would likely be steel, polyvinyl chloride (PVC), or ductile iron. Pipe diameters and lengths for the San Juan River and the NIIP Alternatives shown in Figures 8.1 and 8.2 and Tables 8.5, 8.6, 8.7 and 8.8. Depending on the Project alternative, the total estimated cost for the laterals is between $117 (for the San Juan Alternative) and $123 million (for the NIIP Alternative).

An additional objective of this section is to present surface and groundwater supply options for each municipal subarea. The Project, as proposed, will require additional conjunctive groundwater development. Groundwater development in this region is very difficult and costly. Further study will be required to determine if the conceptual groundwater components described in this memorandum are viable. As shown in Tables 8.7 and 8.8 the cost of the proposed groundwater component is approximately $73 million.

If the entire municipal demand in the service area could be met with groundwater, the capital cost of developing wells to meet those demands would exceed $500 million. For the reasons presented in Chapter 5, groundwater development does not provide a viable option at any cost because groundwater supplies are inadequate to provide a reliable, long-term water supply. However, for comparatives purposes, 100 percent groundwater scenarios are presented for every subarea along with the recommended conjunctive groundwater option. Regulating storage tanks have been included with the surface water components. Presumably the groundwater component and the regulating storage tanks can be phased over the next forty years.

To better characterize the water supply and demand of the region and the Project's service area, the communities have been grouped into twelve municipal subareas. The subareas include: (1) The City of Gallup, (2) Central Project, (3) Crownpoint, (4) Huerfano, (5) NAPI, (6) Navajo Land adjacent to the City of Gallup and the City of Gallup, (7) Rock Springs, (8) Route 666, (9) the San Juan River, (10) Thoreau-Smith Lake (which is within the planning region, but it is not within the Project's proposed service area), (11) Torreon, and (12) Window Rock. The service options for the subareas within the service area are described in the following section.

Table 8.5
The San Juan River Alternative Project Laterals - Lengths, Diameters and Cost including pumps, storage tanks and indirect costs

Lateral	Length (Feet)	Diameter (Inch)	Cost (Million Dollars)
Window Rock Lateral			$25.55
Yah-ta-hey to Rock Springs	29,439	26	
Rock Springs to St. Michaels	58,871	24	
Crownpoint Lateral			$18.94
Coyote Canyon Jct to Coyote Canyon	35,938	16	
Coyote Canyon to Standing Rock	81,321	14	
Standing Rock to Dalton Pass	37,998	14	
Cutter Reservoir - Torreon Lateral			$50.33
Cutter Reservoir to Huerfano	136,961	18	
Huerfano to Nageezi	61,308	18	
Nageezi to Counselor	105,773	16	
Counselor to Torreon	85,396	10	
Gallup Area Lateral			$22.62
Yah-ta-hey to Gamerco Hill	20,482	32	
Gamerco Hill to Gallup Junction	15,072	32	
Gallup Junction to Churchrock	46,041	14	
Gallup Junction to Red Rock	26,320	14	
Gallup Junction to Manuelito	47,050	14	
Total	787,970		$117.44

Table 8.6
The NIIP Alternative Project Laterals - Lengths, Diameters and Costs including pumps, storage tanks and indirect costs

Lateral	Length (Feet)	Diameter (Inch)	Cost (Million Dollars)
Window Rock Lateral		0	$25.55
Yah-ta-hey to Rock Springs	29,439	28	
Rock Springs to St. Michaels	58,871	24	
Crownpoint Lateral			$16.46
Coyote Canyon Jct - Coyote Cyn	35,938	14	
Coyote Canyon - Standing Rock	81,321	12	
Standing Rock to Dalton Pass	37,998	12	
Moncisco - Torreon Lateral			$37.91
Huerfano Junction to Huerfano	98,788	18	
Huerfano to Nageezi	61,308	16	
Nageezi to Counselor	105,773	16	
Counselor to Torreon	85,396	10	
Gallup Area Lateral			$22.62
Yah-tah-hey to Gamerco Hill	20,482	32	
Gamerco Hill to Gallup Junction	15,072	32	
Gallup Junction to Churchrock	46,041	14	
Gallup Junction to Red Rock	26,320	14	
Gallup Junction to Manuelito	47,050	14	
Sanostee Lateral			$20.06
Naschitti Jct to Naschitti	51,354	16	
Naschitti to Sheep Springs	29,459	14	
Sheep Springs to Newcomb	51,058	14	
Newcomb to Sanostee	51,019	10	
Shiprock Lateral			$19.59
Moncisco to Hogback	139,824	18	
Hogback to Shirpock	55,532	18	
Total	1,128,043		$122.60

TABLE 8.7
Recommended Municipal Conjunctive Groundwater Development

MUNICIPAL SUBAREA	1998 G.W. PRODUCTION (Acre-feet)	2040 DEMAND (Acre-feet)	PROPOSED 2040 G.W. PRODUCTION (Acre-feet)	PROPOSED CONJUNCTIVE GROUNDWATER COMPONENT
1. Central	27	911	77	Burnham: 1 well at 4,000 feet in the Gallup, Dakota or Morrison at 120 gpm ($4,000,000) Lake Valley: 2 wells at 100 feet the Chaco River Alluvium at 20 gpm ($200,000) White Rock: 1 well at 4,000 feet in the Morrison at 100 gpm ($4,000,000) Whitehorse Lake: 2 wells at 500 feet in the Menefee Formation at 20 gpm ($1,000,000)
2. Crownpoint	330	3,226	752	Coyote Canyon: 2 wells at 1,500 feet in the Dalton Sandstone at 60 gpm ($3,000,000) Crownpoint: 3 wells at 2,000 feet in the Westwater Sandstone at 100 gpm ($6,000,000) Dalton Pass: 2 wells at 2,000 feet in Gallup Sandstone at 20 gpm ($4,000,000) Standing Rock: 2 wells at 2,500 feet in the Westwater at 80 gpm ($5,000,000)
3. Huerfano	90	910	46	2 wells at 1,000 feet in the Ojo Alamo Sandstone at 60 gpm ($2,000,000)
4. Gallup Area	328	4,823	502	Breadsprings: 2 well at 2,000 feet in the Gallup Sandstone at 50 gpm ($4,000,000) Church Rock: 2 well at 2,000 feet in the Chinlee at 30 gpm ($4,000,000) Iyanbito: 2 well at 2,000 feet in the Glorietta at 125 gpm ($4,000,000) Red Rock: 2 well at 2,000 feet in the Gallup Sandstone at 50 gpm ($4,000,000)
5. Rock Springs	58	2,287	169	3 wells at 1,700 feet in the Gallup Sandstone at 40 gpm ($5,100,000)
6. Route 666	551	6,161	795	Naschitti: 2 wells at 1,500 feet in the Point Lookout Sandstone at 80 gpm ($3,000,000) Tohatchi: 3 wells at 1,500 feet in the Point Lookout Sandstone at 150 gpm ($4,500,000)
7. Torreon	113	2,316	77	6 wells at 1,500 feet in the Menefee/Point Lookout Sandstone at 20 gpm ($9,000,000)
9. Window Rock	1,043	7,179	767	6 wells at 750 feet in the Gallup/Dakota/Morrison at 60 gpm ($4,500,000) 6 wells at 300 feet in the C-Aquifer at 50 gpm and conveyance system ($1,800,000)
NAVAJO TOTAL	2,540	27,813	3,185	
GALLUP TOTAL	4,335	8,900	1,400	See City of Gallup's Well Production Planning Report and DePauli Report

Table 8.8
Groundwater Supply Options for the Project Service Area (excluding distribution systems)

Municipal Subarea	2040 Municipal Demand	100 Percent Groundwater Scenario	Recommended Conjunctive Groundwater Scenario
	(Acre-feet)	(Million Dollars)	(Million Dollars)
1. City of Gallup	8,459	n/a	n/a
1. Central	911	$16.5	$9.2
2. Crownpoint	3,225	$67.5	$18.0
3. Huerfano	910	$20.0	$2.0
4. Gallup (Navajo land adjacent to the City)	4,822	$107.0	$16.0
5. Rock Springs	2,287	$95.0	$5.0
6. Route 666	6,161	$52.0	$7.5
7. San Juan River	n/a	n/a	n/a
8. Torreon	2,316	$117.0	$9.0
9. NAPI	n/a	n/a	n/a
10. Window Rock	7,179	$59.0	$6.3
Navajo Nation Total	27,811	$534.0	$73.0

8.3.1 City of Gallup

In 1997 the City assessed its groundwater development options. That year the City produced 4,335 acre-feet of water. By the year 2040, the City's water demand will increase to approximately 8,500 acre-feet. According to the City's *Well Production Planning Report* (Sterling & Mataya, and John W. Shomaker and Associates, Inc, 1998) without a new water source the City anticipates a one million gallon per day shortage during peak periods as early as 2010. This section describes water services options with and without the Project.

- The No-Action Alternative with 100 percent groundwater

  According to the City's reports, the static water level of the Santa Fe Well Field has decline more than 340 feet since the 1960's and the Yah-ta-hey Well Field has declined more than 700 feet since the 1970's. The City's forty-year master plan identified two short-term alternatives including the expansion of the Yah-ta-hey Well Field to the north and developing water in the Ciniza area to the east. The City is also considering developing groundwater near Mount Taylor. None of these options will result in a sustainable, long-term water supply. None of these options meet the Project's purpose and need.

- The NIIP or San Juan River Project Alternative with the preferred conjunctive groundwater development

  With either Project alternative, the City of Gallup's groundwater withdrawals will be dramatically reduced. During the first few years, groundwater withdrawals can be completely eliminated, and the aquifer recharge can be maximized. By the year 2040 the City will again use groundwater during the summer. With the Project, the City estimates that by 2040 it will use approximately 1,440 acre-feet of groundwater per year. One result of the Project is that the City will not need new groundwater development. And, the associated groundwater operation and maintenance expenses will be greatly reduced.

  Depauli Engineering and Surveying Company presented a preliminary design and cost estimate for distributing the Project water from the Yah-ta-hey Junction through the City of Gallup to the NTUA systems in Churchrock on the east, Manuelito and Spencer Valley on the west, and Redrock on the south. The total estimated cost for construction, engineering and contingencies for the regional project is $23.5 million (excluding costs associated with addressing NEPA, cultural resources and rights-of-way).

8.3.2 Central Project Subarea

The Central Project Subarea includes the Chapters of Burnham, Lake Valley, White Rock, and Whitehorse Lake. The projected municipal demand for this area in the year 2040 is 911 acre-feet, of which 77 acre-feet will be met with groundwater. Two options have been considered for serving this subarea, with either alternative a lateral from the main line and conjunctive groundwater development.

- The San Juan River Alternative with a lateral from the main line

  To ensure that the long-term needs of this subarea are not ignored, capacity for these chapters has been included in the main line under the NIIP and San Juan River alternatives. With the San Juan River Alternative a 65,000 foot long programmatic lateral could be constructed from the Highway 666 corridor to Burnham. This lateral would cost $4.0 million. Lake Valley and White Horse Lake would be served from the Crownpoint Lateral. This 165,000 foot long programmatic lateral would cost $9.3 million.

- The NIIP Alternative with a lateral from main line

  With the NIIP Alternative a 82,500 foot long programmatic lateral from the Transwestern Pipeline corridor could be constructed to Burnham and a 83,000 foot long programmatic lateral could be constructed to Whiterock and Lake Valley. These laterals would cost $10.3 million. Depending on the alternative, Whitehorse Lake would be served from either from Crownpoint or Cutter Reservoir. These programmatic options are shown in Figures 8.1 and 8.2.

- Groundwater development

  A possible groundwater option for Burnham is to drill additional wells in the Pictured Cliffs Sandstone Aquifer. Assuming an average of 10 gpm could be attained, 12 wells at depths of about 700 feet would be required. Given the low yields, this alternative is not considered viable. Another alternative would be development of the Gallup, Dakota or Morrison aquifers. Assuming that a well in any of these aquifers could attain 120 gpm, at least one well would be required. This well would need to be between 3,500 and 5,000 feet deep at a cost of $3.5 to $5 million. This option may be viable, but the water quality is poor (specific conductance 2,000 to 5,000 microseimens per centimeter).

  An alternative for Lake Valley is to drill additional wells in the Chaco River alluvial aquifer. Assuming 20 gpm could be attained, two wells with depths of less than 100 feet would be required at a cost of about $200,000. Water quality in the alluvium is generally good (specific conductance about 1,000 microseimens per centimeter). Another alternative would be to complete wells in the Morrison aquifer at depths of more than 4,000 feet. Water quality would be marginal too poor.

An alternative for White Rock is to complete an additional 100 gpm well in the Morrison aquifer at a depth of more than 4,000 feet and a cost of $4 million. Water quality in the Morrison would be marginal too poor (specific conductance 2,000 to 5,000 microseimens).

An alternative for Whitehorse Lake is to complete two wells with a 20 gpm yield in the Menefee formation at a depth of more than 500 feet and a cost of $1 million. Water quality in the Menefee would be marginal too poor (specific conductance 2,000 to 5,000 microseimens). Meeting the total conjunctive groundwater demand will cost $9.2 million.

If the entire demand is to be met with groundwater, the cost of well development would be $16.5 million. These groundwater alternatives will need further study to determine if groundwater is viable. For instance, IHS recently spent one million dollars drilling a well in the Ojo Alamo formation near Whitehorse Lake that was unusable due to benzene. Groundwater can only be incorporated into a preferred alternative if the water supply can be sustained. However, it is unlikely that this groundwater could supply more than 10 percent of the total demand. These costs are shown in Table 8.8.

8.3.3 Crownpoint Subarea

The Crownpoint Subarea includes the chapters of Becenti, Coyote Canyon, Crownpoint, Dalton Pass, Little Water and Standing Rock. The projected municipal demand for the Crownpoint Subarea in the year 2040 is 3,225 acre-feet, of which 752 acre-feet will be met with groundwater. With either alternative two options have been considered for serving this subarea: a lateral from the main line and conjunctive groundwater development.

- The NIIP or San Juan River Project Alternative with a lateral from the main line and the preferred conjunctive groundwater development

  Both the San Juan River and the NIIP Project alternatives include capacity in the main line and a 118,000 foot long lateral from the main line near Coyote Canyon to the NTUA regional system near Dalton Pass. The estimated cost of this lateral is $17 million. The NTUA system will require additional programmatic upgrades costing an additional $17 million to convey this water. The Project lateral costs for both alternatives are shown in Tables 8.5 and 8.6.

- Groundwater development

  The 752 acre-foot conjunctive groundwater demand for Crownpoint, Becenti and Dalton Pass could be met by increasing groundwater withdrawals from the Westwater Canyon Sandstone Aquifer near Crownpoint and constructing a regional distribution system. The regional distribution system will distribute a combination of San Juan River water and groundwater. Further study is required to ensure that these groundwater withdrawals are sustainable. It is possible that the Westwater Canyon Aquifer is tributary to the San Juan River, and increased groundwater withdrawals may eventually result in depletion to the river.

For Coyote Canyon, additional wells could be drilled in the Menefee Formation or the Dalton Sandstone. This alternative could extend the regional system to meet the combined conjunctive demands of Tohatchi, Mexican Springs, Coyote Canyon, and Twin Lakes. Assuming an average of 60 gpm could be attained, 2 wells at depths of about 1,500 feet and a cost of $3 million are required.

A groundwater option for Crownpoint is to drill additional wells in the Westwater Canyon aquifer. Assuming an average of 100 gpm could be attained, 3 wells at depths of about 2,000 feet at a cost of $6 million is required.

A groundwater option for Dalton Pass is to drill additional wells in the Gallup Sandstone. Assuming an average of 20 gpm could be attained, 2 wells at depths of about 2,000 feet at a cost of $4 million is required.

A groundwater option for Standing Rock is to drill additional wells in the Westwater Canyon aquifer. Assuming an average of 80 gpm could be attained, 2 wells at depths of about 2,500 feet at a cost of $5 million is required. Meeting the total conjunctive groundwater demand will cost $18 million.

Consideration was given to meeting the entire subarea demand with groundwater. The cost of well development to meet the entire demand would be $67.5 million, However, it is unlikely that this groundwater could supply more than 25 percent of the total demand. These costs are shown in Table 8.8.

8.3.4 Gallup Area (Navajo Land Adjacent to the City of Gallup)

The Gallup Subarea includes the chapters of Breadsprings, Chichilta, Church Rock, Iyanbito, Mariano Lake, Pinedale, and Red Rock. In addition to 7,500 acre-feet for the City, the projected municipal demand in the year 2040 is 4,823 acre-feet, of which 721 acre-feet will be met with groundwater. Two options have been considered for serving this subarea: a regional City of Gallup distribution system from the main line at Yah-ta-hey and groundwater development.

Previous investigations of this Project resulted in appraisal level designs and cost estimates for the conveyance system as far south as Yah-ta-hey. However, considerable attention needs to be given to the infrastructure south of Yah-ta-hey. The Gallup Subarea distribution system has been explicitly included in this plan formulation.

Navajo-Gallup Water Supply Project

Due to water supply shortages, the City of Gallup has a city ordinance that prevents the deliver of municipal water to the surrounding Navajo trust land. In a letter date March 16, 1998, the Public Works Director for the City of Gallup indicated that the municipal code could be changed once the Project's water becomes available. The City of Gallup, the Indian Health Service and the NDWR are working to remove the administrative and technical obstacles. The trust land raises two delivery opportunities. The first opportunity is delivery to individual Navajo home sites close to the City's current distribution system. If additional water becomes available, these individuals will be able to connect with the City's system in a revenue-neutral manner. This additional system flexibility will provide benefits to the individuals served and for the City's water planning. The second opportunity is to convey water through the City's municipal system to the NTUA public water systems in Bread Springs, Chichiltah, Church Rock, Iyanbito, Pinedale, and Red Rock.

- Regional Gallup Distribution System from Gamerco Hill

  Both Project alternatives include capacity in the main line for the City of Gallup's demands and for the demands for the trust land adjacent to the City. A lateral from the main line near Gamerco Hill would connect to a Regional City distribution system. A 22-cfs pipeline with an initial diameter of 32 inches will convey 12,300 acre-feet of treated water from Yah-ta-hey south toward the City. From the pumping station local laterals will convey water south toward Red Rock, east toward Church Rock, and west toward Manuelito. The NDWR estimated cost of this lateral is $23 million.

  Depauli Engineering followed up the NDWR cost estimate with a more refined estimate for this regional system. The Depauli estimated cost of this regional City distribution system is $23.5 million (excluding costs associated with addressing NEPA, cultural resources and rights-of-way). The Depauli estimate included additional storage tanks and other specific appurtenants. A schematic of this system is presented in Figures 2.1, 2.2, 8.1 and 8.2.

- Groundwater development

  Even with the Project's surface water supply, approximately 721 acre-feet of demand will be met with conjunctive groundwater use by Bread Springs, Chichiltah, Church Rock, Iyanbito, Pinedale, and Red Rock. The NDWR considers this rate of groundwater withdrawal sustainable. This conjunctive component can be met by increasing groundwater withdrawals from the Gallup sandstone, the Glorietta and the Chinle formations. The short-term needs of Church Rock and Iyanbito may be met with groundwater conveyed from the east. However, the Manuelito, Red Rock and Bread Springs Chapters have very limited groundwater development opportunities.

A groundwater option for Breadsprings is to drill additional wells in the Gallup Sandstone. Assuming an average of 50 gpm could be attained, 2 wells at depths of about 2,000 feet at a cost of $4 million is required.

A groundwater option for Church Rock is to drill additional wells in the Chinle Aquifer. Assuming an average of 30 gpm could be attained, 2 wells at depths of about 2,000 feet at a cost of $4 million is required.

A groundwater option for Iyanbito is to drill additional wells in the Glorietta Sandstone. Assuming an average of 125 gpm could be attained, 2 wells at depths of about 2,000 feet at a cost of $4 million is required.

A groundwater option for Red Rock is to drill additional wells in the Chinlee aquifer. Assuming an average of 50 gpm could be attained, 2 wells at depths of about 2,000 feet at a cost of $4 million is required. Meeting the total conjunctive groundwater demand will cost $16 million.

Consideration was given to meeting the entire subarea demand with groundwater. The cost of well development to meet the entire demand would be $107 million. However, it is unlikely that this groundwater could supply more than 15 percent of the total demand. These costs are shown in Table 8.8.

8.3.5 Huerfano Subarea

The Huerfano Subarea includes the chapters of Huerfano and Nageezi. The projected municipal demand for the Huerfano Subarea in the year 2040 is 910 acre-feet. Conjunctive groundwater development could supply 92 acre-feet of this demand. Under the NIIP Alternative the remaining 828 acre-feet of demand can be served by a lateral from Moncisco Reservoir. Under the San Juan River Alternative it can be served with a lateral from Cutter Reservoir.

- The San Juan River Alternative with a lateral from Cutter Reservoir

  Under the San Juan River Alternative a lateral from Cutter Reservoir to the NTUA systems at Huerfano, Nageezi and Torreon would be constructed. The estimated cost of this lateral is $50.3 million. This lateral can be readily extended to the TeePee Junction in order to serve the Jicarilla Apache Nation.

  A variation of this alternative is to convey the water for this subarea through the NIIP main canal to the Kutz pumping plant and then on through the Coury Lateral. This variation may enable the delivery of water to this subarea with a minimum of new construction. However, this option may compromise the ability to provide water to some of NIIP's fields.

- The NIIP Alternative with a lateral from Moncisco Dam

  Under the NIIP Alternative a lateral from Moncisco Reservoir to the NTUA systems at Huerfano, Nageezi and Torreon would be constructed. The estimated cost of this lateral is $37.9 million. A schematic of this lateral is shown at Figure 8.2 on page 62.

- Groundwater development

  The 92 acre-foot conjunctive groundwater demand for Huerfano and Nageezi could be met by increasing groundwater withdrawals from the Ojo Alamo Sandstone and connecting the wells to a regional distribution system. Assuming an average of 60 gpm could be attained, 2 wells at depths of about 1,000 feet at a cost of $2 million is required.

  Consideration was given to meeting the entire subarea demand with groundwater. The cost of well development to meet the entire demand would be $20 million; however, it is unlikely that this groundwater could supply more than 20 percent of the total demand. It is also likely that the Ojo Alamo aquifer is tributary to the San Juan River. Therefore, increased groundwater withdrawals may eventually result in depletions to the river. These costs are shown in Table 8.8.

8.3.6 Rock Springs Subarea

The Rock Springs Subarea includes the chapters of Manuelito, Rock Springs and Tsayatoh. The projected municipal demand for the Rock Springs Subarea in the year 2040 is 2,287 acre-feet, of which 123 acre-feet would be met with conjunctive groundwater. Two options have been considered for serving these demands: with either alternative a lateral can be constructed from the main line and developing additional groundwater.

- The NIIP or San Juan River Project Alternative with a lateral from the main line and the preferred conjunctive groundwater development

  Both Project alternatives include capacity in the main line and the Window Rock Lateral for this subarea. This lateral will connect with the NTUA systems at Rock Springs and Tsayatoh. Manuelito would be served from the Gallup regional system.

- Groundwater development

Navajo-Gallup Water Supply Project

One possible alternative for Rock Springs would be to drill additional wells in the Gallup Sandstone aquifer. Assuming 40 gpm could be attained for each well, three such wells at depths of more than 1,700 feet would be required at a cost of $5.1 million. A regional system could distribute this water to the other chapters.

Consideration was given to meeting the entire subarea demand with groundwater. Meeting the entire demand will require 32 wells in the Gallup Sandstone aquifer at 40 gpm each, or 16 wells in the Morrison aquifer at 80 gpm each, at a cost of $95 million. However, it is unlikely that this groundwater could supply more than 18 percent of the total demand. These costs are shown in Table 8.8.

8.3.7 Route 666 Subarea

The Route 666 Subarea includes the chapters of Mexican Springs, Naschitti, Newcomb, Sanostee, Sheep Springs, Tohatchi, Twin Lakes and Two Grey Hills. These chapters are located along Highway 666. Under either alignment alternative, the public water systems in these communities are well situated to take advantage of the Project water as soon as it is available. The projected municipal demand for the Route 666 Subarea in the year 2040 is 6,161 acre-feet, of which 882 acre-feet could come from groundwater. Two options have been considered for serving these chapters: with either alternative, the subarea can be served from the main line and developing additional groundwater.

- The NIIP or San Juan River Project Alternative with a lateral from the main line and the preferred conjunctive groundwater development

  Both Project alternatives include capacity in the main line for these chapters. These chapters are well positioned to take advantage of the main line without any additional Project laterals. The NTUA systems in the area will need to be upgraded.

- Groundwater development

  An extended regional system could be developed to meet the combined demands of Tohatchi, Mexican Springs, Coyote Canyon, and Twin Lakes. To meet the conjunctive groundwater of the regional system, this extended regional system would require three wells with depths of 1,500 feet in the Point Lookout Sandstone aquifer, or 1,500 to 2,000 feet deep in the Morrison aquifer, at 150 gpm each. Water quality in both the Point Lookout and the Morrison would be good (specific conductance less than 1,000 microseimens per centimeter (Stone and others, 1983)). These wells would cost $4.5 million.

  An alternative for Naschitti would be to drill additional wells in the Point Lookout Sandstone aquifer. Assuming an average of 80 gpm could be attained, two wells at depths of more than 1,500 feet would be required. These wells would cost $3.0 million. Meeting the total conjunctive groundwater demand will cost $7.5 million.

Consideration was given to meeting the entire subarea demand with groundwater. Meeting the entire demand will cost of $52 million. However, it is unlikely that this groundwater could supply more than 15 percent of the total demand. These costs are shown in Table 8.8.

8.3.8 San Juan River Subarea

The projected municipal water demand in the San Juan River Subarea by the year 2040 is 8,421 acre-feet per year. The Animas-La Plata Project Supplemental EIS describes three alternatives for delivering approximately 4,680 acre-feet of diversion, or 2,340 acre-feet of depletion, to the Shiprock Area. These alternatives are also described in the NDWR technical memorandum *An Appraisal Level Study of the Proposed Farmington to Shiprock Municipal Pipeline.* The Animas-La Plata Project water supply is only adequate for 55 percent of the Shiprock Subarea's 2040 water demand. This Project includes an additional 3,740 acre-feet of diversion, or 1,870 acre-feet of depletion, to meet the balance of the subarea's municipal demand. Delivery options were considered for both the NIIP Alternative and the San Juan River Alternative. Groundwater is not available in this subarea.

- Serving the San Juan River Subarea with the San Juan River Alternative

  One option is to convey the Project's 3,740 acre-feet of water diversion for this subarea through an enhanced Animas-La Plata Navajo Municipal Pipeline. However, the City of Farmington will have water treatment and conveyance constraints. If Farmington is constrained, this option could include a separate diversion structure which would join the Animas-La Plata Navajo midway between Farmington and Shiprock. The NDWR has estimated that adding this capacity to the Animas-La Plata Navajo pipeline will cost approximately $10 million.

  With the San Juan River Alternative a blind tap can be installed at the Junction of Highway 666 and Highway 34. The NDWR has estimated that adding this capacity to the San Juan River Alternative main line from the from the PNM Diversion to the highway junction will add approximately $ 8.7 million to the Project. For the San Juan River Alternative, this option is the most cost effective and it has been used for the cost estimates in this technical memorandum.

- Serving the San Juan River Subarea with the NIIP Alternative

  It is possible to convey the Project's 3,740 acre-feet of water diversion through an enhanced Animas-La Plata Navajo Municipal Pipeline. The NDWR has estimated that adding this capacity to the Animas-La Plata Navajo pipeline will cost approximately $10 million. For the NIIP Alternative, this option is the most cost effective.

With either alternative it is possible to convey the Project water through a separate stand-alone pipeline. The NDWR estimated that the cost of a stand-alone pipeline from the PNM Diversion to Shiprock would be $20 million.

It is also possible to convey the treated Project water from the proposed Moncisco Reservoir to the Shiprock Junction at Highway 666. The advantage to this option is that is may be able to take advantage of the proposed treatment plant at NAPI. The NDWR estimated that the cost of this option would add $19.6 million. This option has been used for the cost estimates in this technical memorandum.

It is also possible to convey the treated Project water from the proposed Moncisco Reservoir through the main conveyance line to Sanostee. From Sanostee a lateral would convey the water to Shiprock. The NDWR estimated that the cost of this option would be $27.6 million.

8.3.9 Torreon Subarea

The Torreon Subarea includes the chapters of Counselor, Ojo Encino, Torreon and Pueblo Pintado. The projected municipal demand for the Torreon Subarea in the year 2040 is 2,317 acre-feet. Conjunctive groundwater development could supply 177 acre-feet of this demand. The remaining demand can be served by a lateral from the NIIP Main Line or the San Juan River Cutter Lateral.

- The San Juan River Alternative with a lateral from the Cutter Lateral

  Along with serving the Huerfano subarea, with the San Juan River Alternative the Cutter Lateral will also serve the Torreon Subarea. The estimated cost of this lateral is $50.3 million.

- The NIIP Alternative with a lateral from Huerfano

  Under the NIIP Alternative, this subarea will be served from the Huerfano-Torreon Lateral. The estimated cost of this lateral is $37.9 million.

- Conjunctive groundwater development

Navajo-Gallup Water Supply Project

An extended regional system could be developed to meet the combined demands of Counselor, Ojo Encino, Pueblo Pintado, and Torreon. To meet the conjunctive groundwater of the regional system, this extended regional system would require six wells with depths of 1,500 feet in the Menefee or Point Lookout Sandstone aquifer and a yield of 20 gpm. Water quality in both the Point Lookout and the Morrison would be good (specific conductance less than 1,000 µS/cm; Stone and others, 1983). Meeting the conjunctive groundwater demand will cost $9.0 million.

Consideration was given to meeting the entire subarea demand with groundwater. Meeting the entire demand will cost of $117 million. However, it is unlikely that this groundwater could supply more than 10 percent of the total demand. These costs are shown in Table 8.8.

8.3.10 NAPI Subarea

NAPI has plans to develop agricultural processing projects with a total treated water demand of 7,274 acre-feet. The BIA has recently consulted with the USFWS on a french fry processing venture that will require NAPI to deplete 400 acre-feet per year. NAPI is developing a two million gallon per day water treatment plant to provide potable water for the potato processing venture. Both Project alternatives include 300 acre-feet of depletion, in addition to the 400 acre-feet, for food processing opportunities such as vegetable canning. With the NIIP Alternative NAPI will be served from the water treatment plant at the proposed Moncisco Reservoir. With the San Juan River Alternative NAPI will be served from a tap at the junction of the pipeline with Highway 64. No groundwater component is proposed. With either alternative, the cost of water treatment capacity has been included in the cost estimates.

8.3.11 Window Rock Subarea

The Widow Rock Subarea includes the chapters of Fort Defiance and Saint Michaels. The projected municipal demand for this Subarea in the year 2040 is 7,179 acre-feet, of which 767 acre-feet will be groundwater. Two options have been considered for serving these demands including: with either alternative, a lateral from the main line, and groundwater development.

- The NIIP or San Juan River Project Alternative with a lateral from the main line and the preferred conjunctive groundwater development

  With either the NIIP or the San Juan River Alternatives, a lateral from the main line near Yah-ta-hey connects to the existing NTUA system serving the Window Rock Subarea. The estimated cost of this lateral is $25.6 million. The NTUA system will require additional programmatic upgrades to convey this water. This later will also have capacity to serve the Rock Springs Subarea. A schematic of this lateral is shown at Figures 8.1 and 8.2.

- Groundwater development near Ganado

  The Navajo Nation has considered developing a well field in the Coconino Aquifer near Ganado 30 miles away to augment the Window Rock water supplies. However, the static water level is approximately 200 feet below the surface. From Ganado the water would have to be lifted another 1,400 feet to cross the 7,800 foot pass between Ganado and Window Rock. Based on reconnaissance level estimates, the 26-mile Ganado-Window Rock pipeline would cost approximately $50 million. Importing this water from the Ganado Area to the Window Rock area would strain the limited water supply for the NTUA regional system in Ganado which is Projected to exceed its sustainable supply over the next 40-year planning horizon. The Ganado-Window Rock Project does not meet the purpose and need of the Navajo-Gallup Water Supply Project.

- Groundwater development in the Window Rock Area

  An extended regional system could be developed to meet the combined conjunctive groundwater demands of Fort Defiance and St. Michaels. To meet the conjunctive groundwater of the regional system would require six wells with depths of 750 feet in the Gallup, Dakota or Morrison formations with a yield of 60 gpm and a cost of $4.5 million, and six wells with depths of 750 feet in the C-aquifer with a yield of 50 gpm and a cost of $1.8 million. Water quality in both would be good (specific conductance less than 1,000 µS/cm; Stone and others, 1983). Meeting the conjunctive groundwater demand will cost $6.3 million.

  Consideration was given to meeting the entire subarea demand with groundwater. Meeting the entire demand will cost of $59 million. However, it is unlikely that this groundwater could supply more than 10 percent of the total demand. These costs are shown in Table 8.8.

8.3.12 Thoreau-Smith Lake Subarea

The Thoreau-Smith Lake Subarea includes the chapters of Baca/Haystack, Casamera Lake, Smith Lake and Thoreau. This subarea is in the planning region, but it is not within the proposed Project service area. The projected municipal demand for the Thoreau Subarea by the year 2040 is 2,196 acre-feet. These chapters are primarily located in the Rio San Jose watershed which is tributary to the Rio Grande. Presently, a significant portion of the water withdrawn by NTUA in this area is conveyed to the Navajo Chapters of Pinedale, Iyanbito, and Church Rock. With the Project, the Thoreau Subarea will benefit because these exports will be greatly reduced. This subarea is also well positioned to take advantage of groundwater in the Mount Taylor Area. The preferred alternative for this subarea is additional groundwater development.

8.4 Power transmission lines, SCADA systems, and cathodic protection

Power lines must be built to furnish the electric power to run the motors and controls of the pumping plants. Electrical connections at existing facilities of the NTUA, Continental Divide Electric Cooperative (CDEC) and Jemez Mountain Electric Cooperative (JMEC) would be required. Power lines of the Navajo Indian Irrigation Project and the City of Farmington may also be an option to provide power. The power lines would be constructed on wood pole structures with overhead conductors. The closest existing 115, 69, or 34.5 kV power line in the vicinity of each pumping plant would be tapped to provide the power to the large horsepower motors. The small horsepower motor of the Huerfano/Nageezi lift pumping plant could be served from a 13.8 Kv power line. Connecting to the larger Kv power lines will require more expensive transformers. The locations and voltages of the transmission lines will be determined after final pumping plant locations are determined. Reclamation's Farmington Construction Office estimated that the power transmission system will cost $3,000,000. This cost could be incorporated into the annual power costs.

A project with over 200 miles of pipelines and tying into over 30 public water systems will need a Supervisory Control and Data Acquisition (SCADA) system to control and monitor the pumping stations, storage and regulating tanks, and the distribution points. The Master control station will cost $318,000, 10 remote stations will cost $232,000 and the installed cable will cost $1.79 per foot (Reclamation, 2000). The total estimated cost for the SCADA system is $1.2 million. Cathodic protection based on stations 1,000 feet apart will cost $0.58 per foot (Reclamation, 2000). The estimated cost of the cathodic protection system is $900,000.

8.5 Water treatment

Reclamation evaluated water treatment options for this Project. Surface water for public drinking systems requires compliance with the Environmental Protection Agency's Surface Water Treatment Rule (SWTR). This rule is part of the National Primary Drinking Water Regulations for public water systems using surface water sources or groundwater under the direct influence of surface water. Each Project alternative was evaluated separately.

NIIP water is characterized by low sulfate concentrations, low total dissolved solids (TDS) concentrations and turbidities less than 100 NTU. Table 8.9 lists potential treatment systems and estimated construction cost for treating NIIP water. Figures 8.7, 8.8 and 8.9 provide preliminary site layouts for a 30 million gallon per day treatment system.

Table 8.9
Treatment Alternatives for the Navajo Indian Irrigation Project Water

Alternative	Generated Waste Streams	Estimated Construction Cost per MGD Capacity
Microfiltration (CMF-S)	Backwash water conveyed to evaporation ponds.	$1,030,000 to $1,240,000
Conventional	Chemical sludge, dried and transported to landfill. Filter backwash water conveyed to evaporation ponds	$900,000 to $1,000,000
Diatomaceous Earth	Spent DE material to Landfill	$770,000 to $973,000

Note: Construction cost is only for treatment system and building. The estimate does not include intake structure, lined evaporation ponds or treated water conveyance system.

Table 8.10 lists treatment alternatives and estimated construction costs for treating water from the San Juan River. To meet the SWTR requirements using these systems, the diversion of water should occur upstream from the Hogback Diversion. Due to high turbidities in the San Juan River during the spring runoff and summer rain storms, a settling pond will be required to decrease the turbidity of the San Juan River water to 500 NTU. Water in the San Juan River upstream from the Hogback Diversion is characterized by sulfate concentrations of less than 200 mg/L and TDS concentrations less than 300 mg/L. To assist in the removal of turbidity in the settling pond, a polymer injection system is required at the pumping plant intake. Figures 8.9 and 8.10 provide preliminary site layouts for a 30 MGD treatment system for each alternative.

Table 8.10
Treatment alternatives and costs for treatment of San Juan River Water at or upstream of the Hogback Diversion

Alternative	Generated Waste Streams	Estimated Construction Cost per MGD Capacity
Pre-settling followed by Microfiltration (CMF-S)	Backwash water routed back to settling pond.	$1,030,000 to $1,240,000
Pre-settling followed by Conventional Treatment	Chemical sludge dried and transported to landfill. Filter backwash water routed back to settling pond.	$900,000 to $1,000,000

Note: Construction cost for treatment system and building only. Estimates do not include river intake, sediment channel, settling pond or treated water conveyance system.

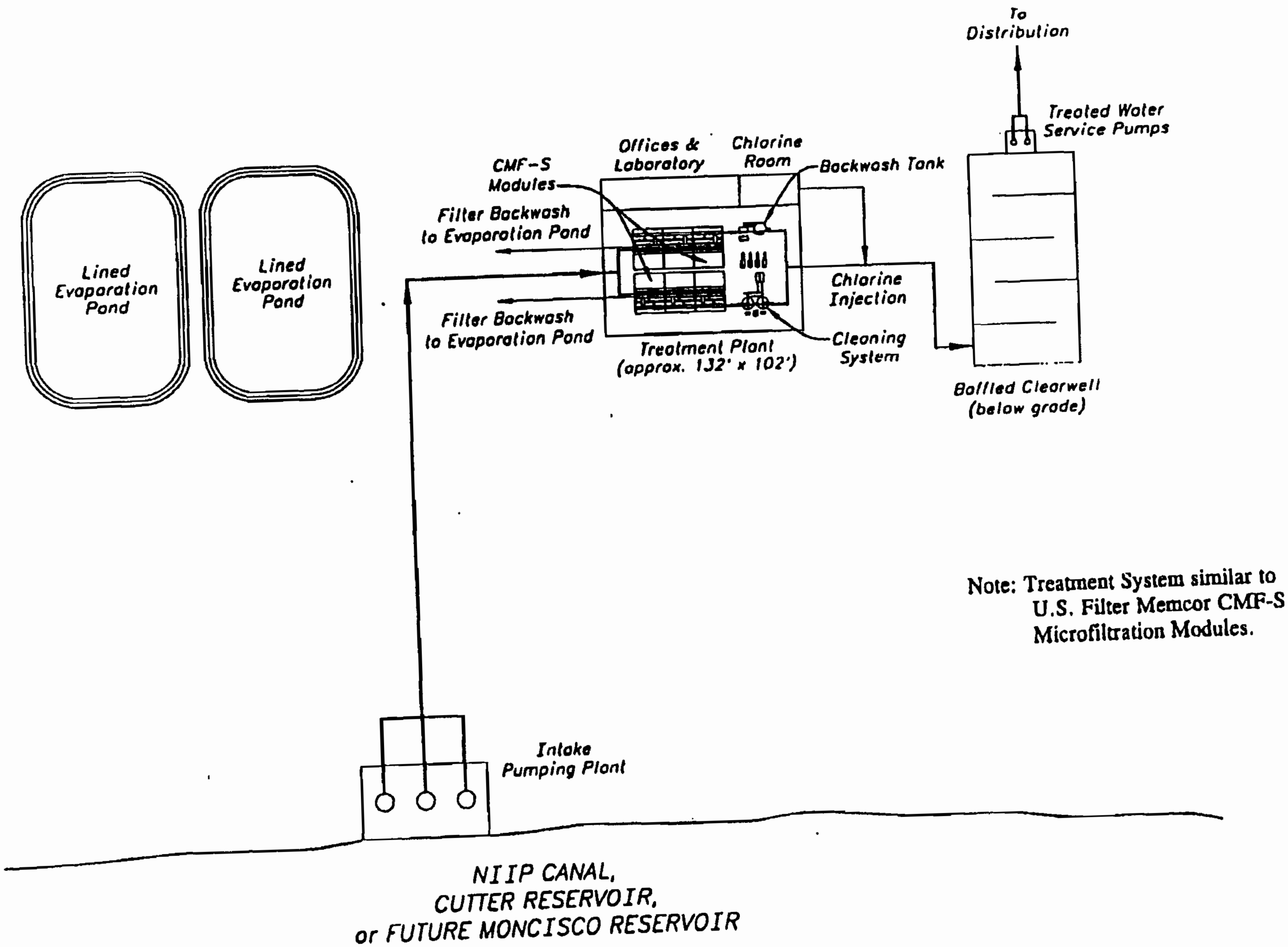
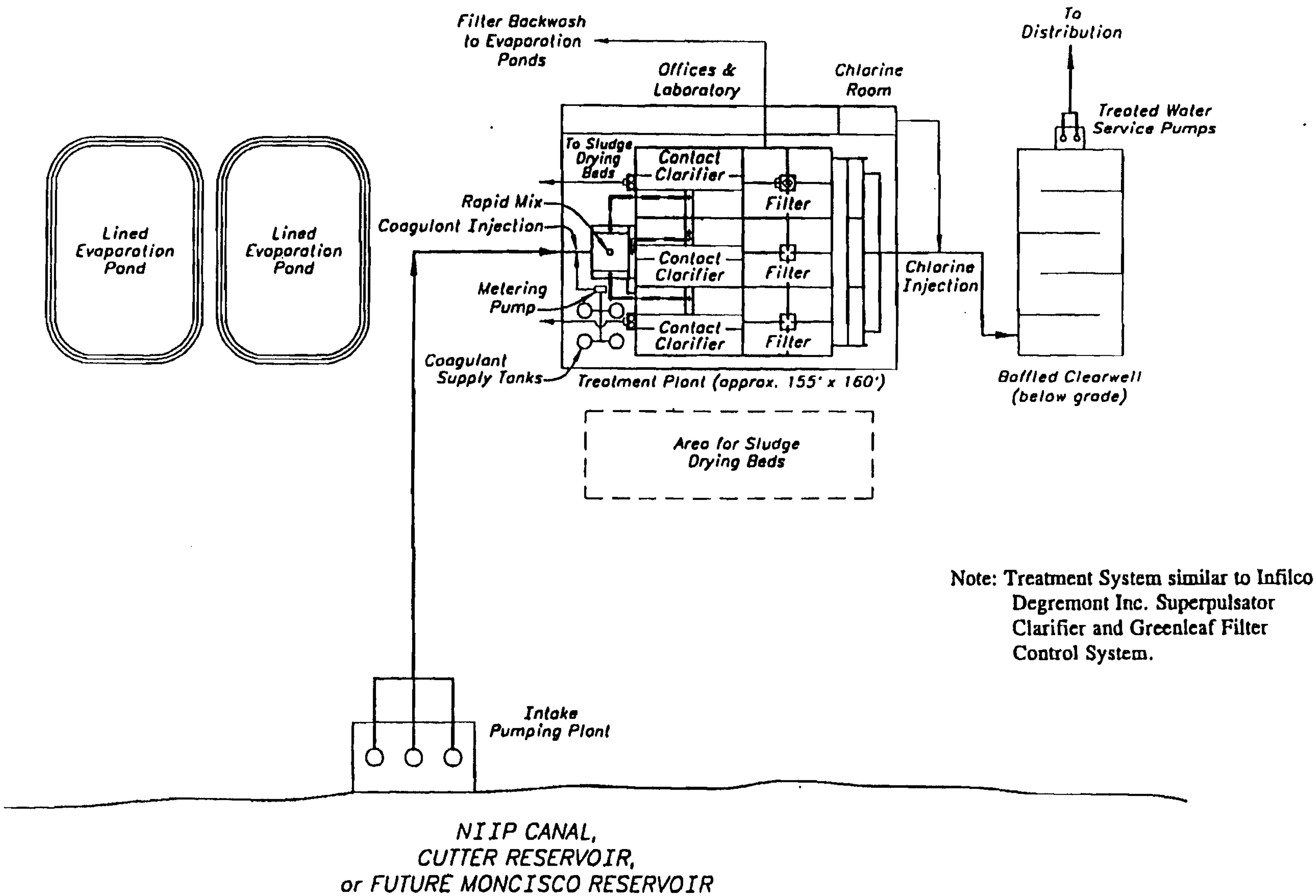
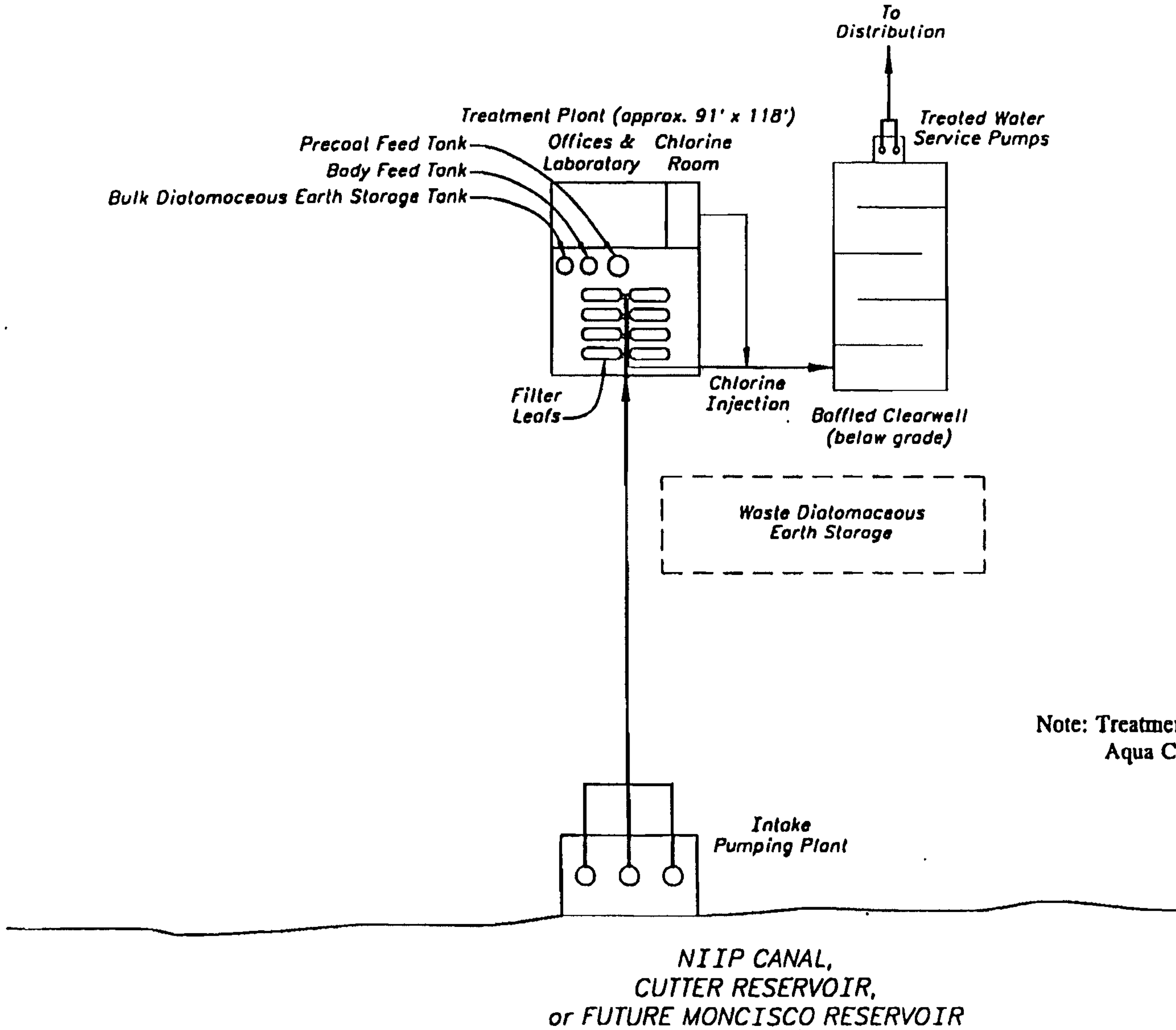


Figure 1 - 30 MGD Microfiltration Treatment System, Treating Navajo Indian Irrigation Project (NIIP) Water



Note: Treatment System similar to Infilco Degremont Inc. Superpulsator Clarifier and Greenleaf Filter Control System.

Figure 2 - 30 MGD Conventional Treatment Plant, Treating Navajo Indian Irrigation Project (NIIP) Water

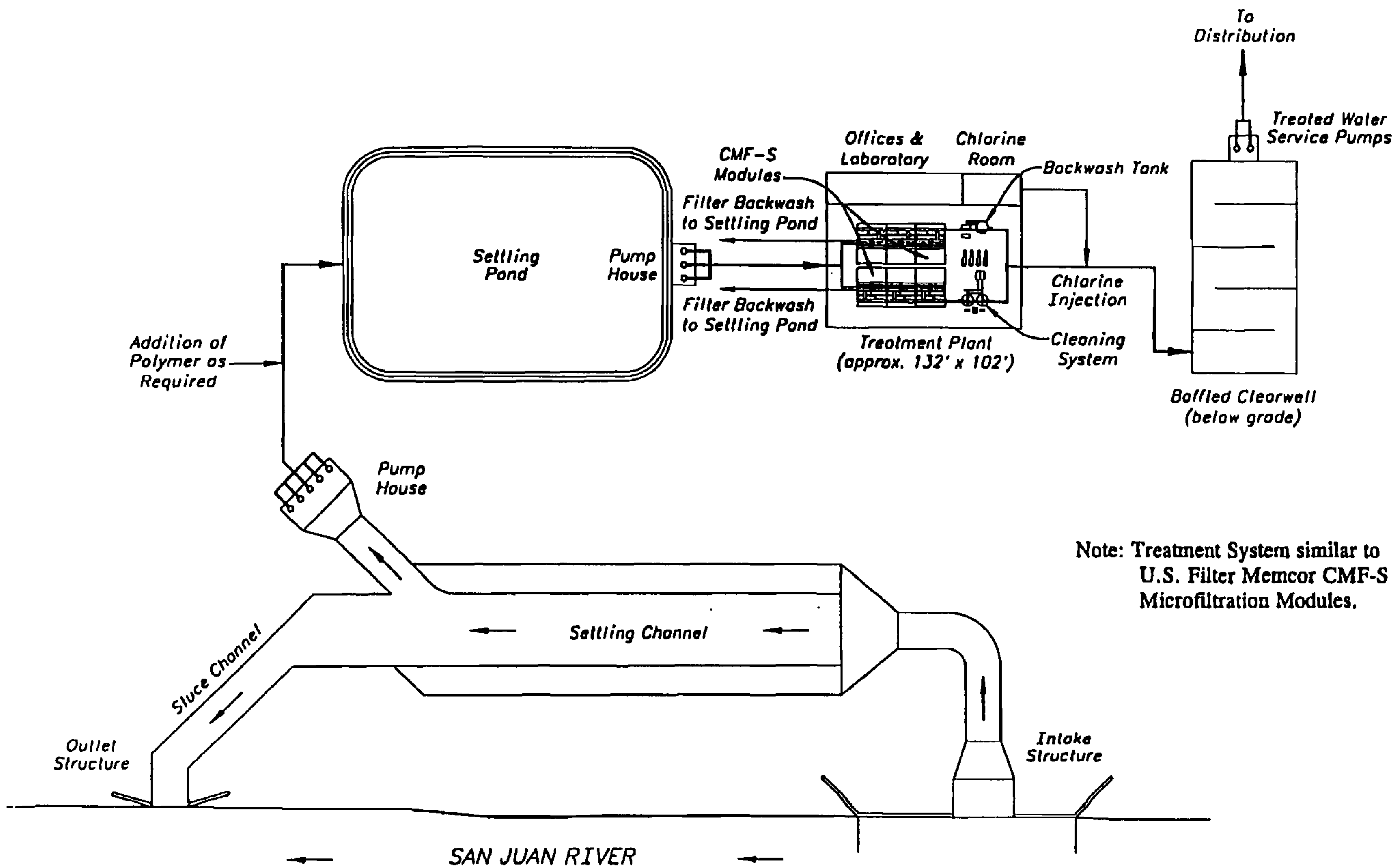


Note: Treatment System similar to Aqua Care Inc. Leaf Filters.

Figure 3 - 30 MGD Diatomaceous Earth Water Treatment Plant for Navajo Indian Irrigation Project (NIIP) Water

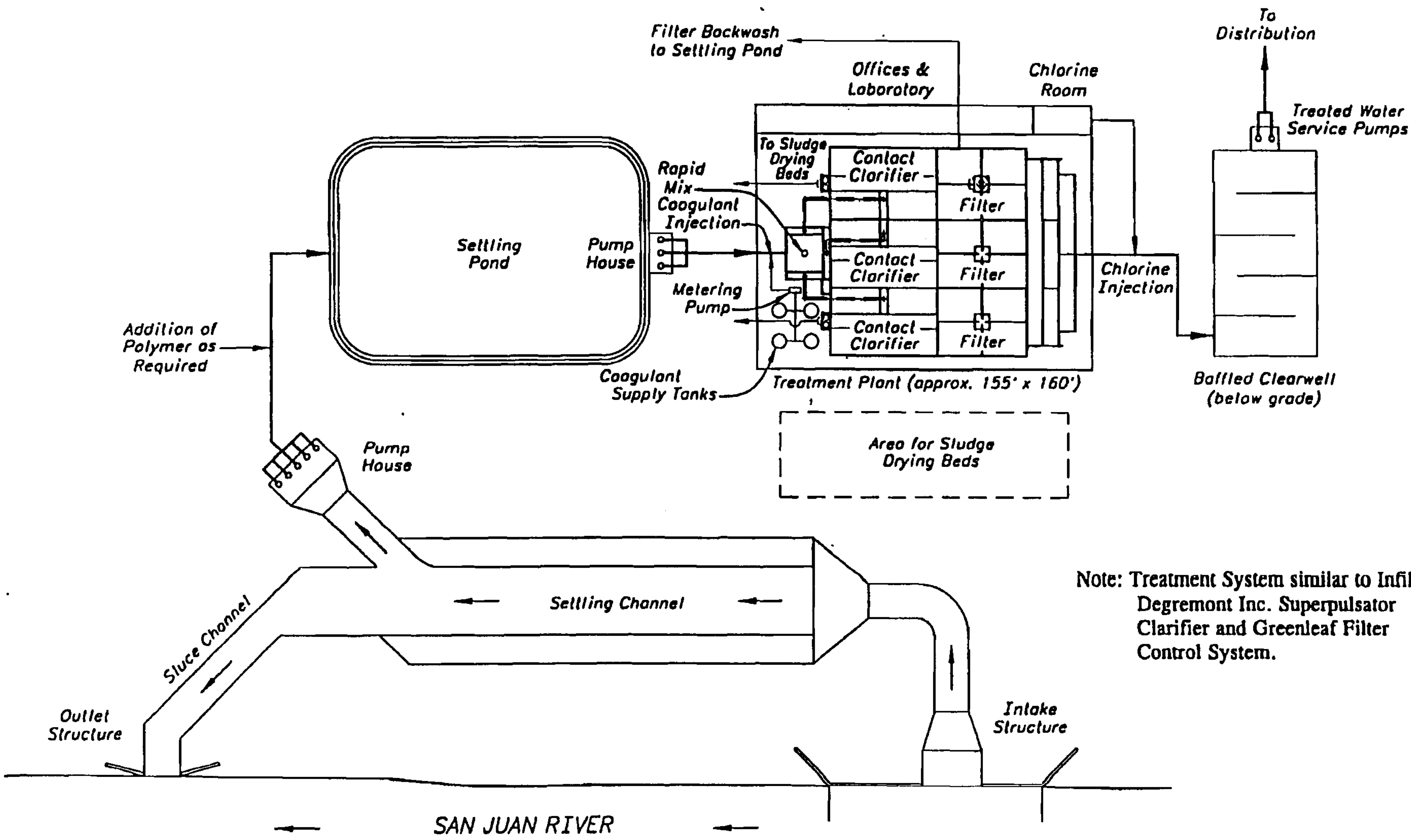
8.5.1 Conventional Water Treatment Systems

Most water treatment plants use conventional treatment systems. Conventional systems use aluminum sulfate (alum) or ferric chloride, and a polymer to coagulate and flocculate inorganics and organics. This process is followed by gravity settling and filtration. Conventional treatment systems generate large quantities of sludge that is typically dewatered in drying beds and disposed in domestic landfills. To reduce the footprint of the conventional treatment systems, solid contact clarifiers and filters are used. Figures 8.10 and 8.11 provide a site layouts of conventional treatment system for NIIP and San Juan River water. The treatment systems shown are similar to the 30 million gallon per day plant that is presently in operation in Green River Wyoming. Estimated costs in Table 8.11 are prorated from the Green River facility. Annual operation and maintenance costs are also provided in Table 8.11. Operation and maintenance costs include: (1) seven operators (four operators, two maintenance personnel and one supervisor) per day working seven days a week; (2) chlorine for disinfection; (3) alum for flocculation; and (4) the annualized cost for replacing the filter media every ten years and the pumps every five years. The annualized costs are based on a plant life of 50 years and an interest rate of eight percent. The estimated construction cost is between $34 and $38 million.



Note: Treatment System similar to U.S. Filter Memcor CMF-S Microfiltration Modules.

Figure 4 - 30 MGD Microfiltration Treatment System on San Juan River



Note: Treatment System similar to Infilco Degremont Inc. Superpulsator Clarifier and Greenleaf Filter Control System.

Figure 5 - 30 MGD Conventional Treatment Plant on San Juan River

8.5.2 Microfiltration Treatment Systems

Microfiltration treatment systems use a relative new technology that does not require chemicals to coagulate suspended solids to meet the drinking water requirements. This process physically separates the suspended particles larger than 0.2 microns from the water. These particles include *Giardia* which are 5 to 15 microns in size, *Cryptosporidium* which are 4 to 6 microns in size, and the majority of organic molecules. The continuous Microfiltration System (CMF-S) is a bundle membrane system which can filter water with high and variable turbidities by drawing untreated water through tubular hollow fiber membranes. Designed for large scale systems, the pre-engineered modules are submerged into open top concrete or steel tanks. The 30 million gallon per day, *US Filters CMF-S Memcor System*, as shown in figures 8.7 and 8.10, provides six Microfiltration cells located in steel tanks. Each cell has a five million gallon per day capacity and contains 576 membrane modules which are continually monitored for proper operation. Large scale CMF-S treatment systems have not been in operation as long as conventional systems. These systems have had great success in meeting the drinking water requirements. Construction cost data are from *US Filter* and are prorated for the proposed plants. The annual operation and maintenance estimates are provided in Table 8.11. The operations and maintenance costs include: (1) seven operators (four operators, two maintenance personnel and one supervisor) per day working seven days a week; (2) chlorine for disinfection; and (3) the annualize cost for the replacement of the microfiltration modules and pumps every five years. The annualized costs are based on a plant life of 50 years and an interest rate of eight percent. The annualized costs used for replacing the microfiltration modules use current costs. Future replacement costs are expected to go down as microfiltration becomes more widely used. This option has been recommended by Reclamation. The estimated construction cost is between $39 and $47 million.

8.5.3 Diatomaceous Earth Water Treatment Systems

Diatomaceous Earth Water Treatment Systems have a precoat filter using diatomaceous earth (DE). These systems require no coagulants and operate effectively in low turbidity water sources. DE is a soft powdery material resembling chalk that contains the remains of single cell algae called diatoms. The system constantly monitors the turbidity of the filtered water. If the turbidity is greater than the determined set point, the system recycles the water until enough DE is added to meet the set point requirements. The spent media cake is air dried before being disposed as a soil amendment or to a domestic landfill. Although different types of DE filters are available, Figure 8.9 is the site plan for a 30 million gallons per day DE system using large diameter leaf filters manufactured by *Aqua Care Systems*. These large leaf filters are typically used in the chemical, steel and mining industry. Construction cost estimates in Table 8.11 are prorated from information from the *Aqua Care Systems*. Annual operation and maintenance estimates are provided in Table 8.11. Estimated operations and maintenance costs include: (1) seven operators, (four operators, two maintenance personnel and one supervisor) per day working seven days a week; (2) chlorine for disinfection; (3) DE material and (4) the annualized cost for the replacement of pumps every five years. The estimated construction cost is between $32 and $40 million.

Table 8.11
Appraisal Level Costs for the Proposed Treatment Plants

Plant Type, Capacity and Location	Estimated Construction Cost	Estimated Annual Operation and Maintenance Cost
Conventional, 38 MGD, Moncisco Reservoir	$34,200,000 to $38,000,000	$1,777,000 to $1,955,000
Microfiltration,38 MGD Moncisco Reservoir	$39,140,000 to $47,120,000	$5,411,000 to $5,914,000
DE Filtration, 38 MGD, Moncisco Reservoir	$29,260,000 to $35,985,000	$1,263,000 to $1,389,000
Conventional, 34.8 MGD, San Juan River	$31,320,000 to $34,800,000	$1,702,000 to $1,872,000
Microfiltration, 34.8 MGD, San Juan River	$35,844,000 to $43,152,000	$5,030,000 to $5,498,000
Conventional, 28.3 MGD, San Juan River	$25,470,000 to $28,300,000	$1,551,000 to $1,706,000
Microfiltration, 28.3 MGD, San Juan River	$29,149,000 to $35,092,000	$4,258,000 to $4,655,000
Conventional, 3.2 MGD, Cutter Reservoir	$2,880,000 to $3,200,000	$969,000 to $1,065,000
Microfiltration, 3.2 MGD, Cutter Reservoir	$3,296,000 to $3,968,000	$1,275,000 to $1,399,000
DE Filtration, 3.2 MGD, Cutter Reservoir	$2,454,000 to $3,115,000	$925,000 to $1,017,000

8.6 Wastewater treatment

Increasing the domestic water supply will result in more wastewater. To protect human health and safety wastewater treatment must be developed in conjunction with the new water supply. Wastewater improvements are considered to be a programmatic cost, not a Project cost. On the Navajo Reservation wastewater treatment facilities are funded by the IHS. Several EPA and USDA programs also provide assistance in developing these facilities which can be phased in as the demands gradually increase.

Wastewater on the Navajo Reservation is typically processed by sewage lagoons or septic tanks. Based on projects in similar regions, Natural Resource Consulting Engineers estimated that the average cost of providing sewerage is $10,000 to $13,000 per household, excluding engineering and contingency costs. Assuming 4.5 people per household, approximately 25,000 new homes will be constructed over the next 40 years in the Project service area. Providing sewerage for those homes is approximately 250 million. However, these expenditures are non-Project costs, and should be considered to be part of the Navajo Nation's ongoing housing program.

In 1999 the City of Gallup produced approximately 3.0 million gallons of waste water pre day. This flow rate exceeded the plant capacity of 2.5 million gallons per day. In 1999 Sterling and Mataya prepared a plan for increasing the City's treatment capacity to 5.5 million gallons per day which will meet the City's needs through the year 2035. The four phase plan has an estimated cost of $24 million. The City has secured grants and loans of approximately $6 million to initiate the first phase of this plan. This phased plan will provide adequate waste treatment capacity for the Project's water supply. Assuming that the unit cost of water treatment for the City's demand is comparable to the unit costs of the on-reservation treatment requirement, the cost for regional waste treatment facilities for the Project service area will be $113 million.

8.7 Terminus storage

Terminus storage stores and facilitates the distribution of water so that instantaneous and daily demands for water can be met without interruptions. This storage may be considered "equalizing" storage because it provides equalizing flow to meet maximum and minimum daily requirements. Terminus storage provides:

- A ready and continuous supply of water during repairs
- Adequate reserve for normal and emergency use without interruptions in supply
- Constant pressure in the system
- Lower energy and pumping costs
- Potential reduction in the peak water treatment plant capacity
- Potential reduction in the maximum pipe sizes

The objective of terminus storage is to ensure that adequate water is available during peak demand and when the conveyance system is under repair. Terminus storage can also be used to reduce the velocity of the water in pipes during high demand periods. The lower velocities result in lower frictional losses and lower energy and maintenance requirements. If the terminus storage is able to manage the peak demands, then a smaller, less expensive conveyance system may be possible. These tradeoffs can only be determined after more extensive site investigations and system hydraulic modeling runs are completed. After careful review,

- The Chuska Dam Site

  Approximately 2,000 acre-feet of terminus storage was considered to increase operational efficiency of the water deliveries to Gallup and Window Rock. From an operational standpoint the best site for terminus storage is as close to the final distribution point as possible. The NDWR identified 17 potential terminus storage sites along the main line using criteria such as proximity to the proposed pipeline alignment, elevation, geology, land status, and capacity. Based on this preliminary investigation, Chuska Reservoir near Tohatchi was the highest ranking site. Chuska Reservoir is close to U.S. Highway 666 between Tohatchi and Gallup. Using this existing reservoir could result in lower construction costs, and it may raise fewer environmental and land status concerns. The existing Chuska Reservoir water supply may help to ensure that the lift pumps are submerged year round. Improvements to Chuska Reservoir to provide terminus storage will cost approximately $7 million. No geologic or environmental field investigations have been performed on any of the potential terminus storage sites. However, the geology of the area is relatively uniform and should not present significant problems. Additional treatment will be needed after the water leaves the reservoir.

The City of Gallup considered several terminus storage options: (1) the Cliff Dwellers site, (2) the Hogback Site, (3) the Mine Dump Site and (4) excavated storage, and (5) concrete covered tanks. These proposed sites may store either San Juan River water from the north or imported groundwater from the east. In August 1999, Reclamation conducted a reconnaissance geology report for the proposed terminus storage sites.

- The Cliff Dwellers Site

  The Cliff Dwellers Canyon Site is located approximately 6 miles northeast of Gallup and east of the Hogback (Section 29 and 30, T.16N, R. 17 W.). The Cliff Dwellers Canyon is a narrow vertical walled canyon which would minimize reservoir evaporation. The Cliff Dwellers Canyon site was not considered feasible by Reclamation because of anticipated high reservoir losses through the Dakota Sandstone.

- The Hogback Site

  The Hogback Site is located approximately 1.5 miles northeast of the Gallup along the topographic feature named "The Hogback"(Section 12, T.15 N., R. 18 W.). The Hogback Site has potential based on reservoir holding capacity, geology, and available construction materials. The Hogback site appears to be a feasible site for a zoned earth fill, but numerous petroleum pipelines cross through the dam axis and would make it an expensive site to use. This site location can take advantage of possible groundwater imported from wells near Mt. Taylor.

- The Mine Dump Site

The Mine Dump Site is located approximately 3 miles west of Highway 666 and north of Interstate 40 (Section 13 and 14, T.16N., R. 19 W.). The Mine Dump site has potential based on reservoir holding capacity, geology, and available construction materials. The Mine Dump Site appears to be feasible for a zoned earth fill dam. The Mine Dump Site location could receive effluent from the nearby sewage treatment plant. The effluent could be blended with Project water providing for significant water reuse opportunities.

- Excavated Storage

If the required capacity is relatively small, it may be possible to excavate a storage site. An excavated site can be located in the most convenient location and its lining reduces seepage. Sterling and Mataya estimated that a 1,500 acre-foot storage reservoir with a natural clay liner would cost $5.9 million and a reservoir with a synthetic liner would cost $9.6 million. These costs include engineering, construction and contingency.

- Water tanks

If the water is treated and the capacity is relatively small, it may be possible to utilize closed tanks to store water for peaking purposes. The current alternatives anticipate that the water will be treated near the San Juan River or at NIIP and that potable water will be conveyed through the water system. For this technical memorandum, steel tanks have been included in the cost estimate.

8.8 Project rights-of-way

According to the 1984 Environmental Statement, the proposed pipeline corridor needs a 66-foot wide permanent easement and a 100-foot temporary easement. The majority of land for the Project lies on the Navajo Nation. In the 1984 cost estimate the cost of a permanent right-of-way easement was included as part of the 15 percent contingency factor.

The Navajo Nation requires that an appraisal of the proposed right of way be conducted. This evaluation is based on the beneficial use of the land and the value of the product in the pipeline. For comparative purposes, a study of the fair market value of rights-of-way by Winius (1991) for the Transwestern pipeline expansion along the same corridor as the NIIP Alternative main line was reviewed. The study identified 25,318 rods of Navajo Tribal Land and 1,902 rods of Individual Allotment land along the corridor. One rod is equal to 16.5 feet. In 1999 the typical right-of-way consideration by the Navajo Nation was 300 to 500 dollars per rod for Tribal land and 25 to 50 dollars per rod for allotted land.

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The total length of the NIIP Alternative pipeline is approximately 240 miles. Of this corridor, 8,300 rods or 12.5 percent is allotted trust land and 47,000 rods, or 61.2 percent, is Tribal trust land. The remainder is split between a variety of state, federal and private ownership. The total length of the San Juan River Alternative pipeline is approximately 287 miles. Of this corridor, 8,300 rods or 10.1 percent is allotted trust land and 47,000 rods or 51 percent is Tribal trust land. The remainder is split between a variety of state, federal and private ownership. The distribution of the land status is shown in Table 8.12. Based on the Winius study the fair market value of the corridor through the allotted land is between $240,000 and $480,000 and the fair market value of the corridor with either alternative through Tribal Trust land is between $14.1 and $23.5 million.

Table 8.12
Land Status of the Navajo-Gallup Water Supply Pipeline

Land Status	NIIP Alternative (Miles)	San Juan River Alternative (Miles)
Main Navajo Reservation	97	117
BLM	11	25
Indian Allotment	29	29
Navajo Fee	21	17
Navajo Trust	50	30
PLO 2198	5	5
Private	17	32
State	8	15
Other		17
Total	240	287

As described in the Code of Federal Regulations 25 Part 169 - Rights-Of-Way Over Indian Lands the BIA has a multi-step process for establishing right-of-ways across trust land. Information on the specific procedures is available from the BIA. Depending on the number of Indian land allotments the Project corridor crosses, the rights-of-way procedures may be complicated. The land affected must be appraised, the individual allotment owners must be contacted and informed about the fair market value of the land, and consents for the Project must be obtained. This process may take up to 18 months to complete.

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The BIA estimates that rights-of-way clearance will require 2 ½ full-time staff plus support services and incidentals including: (1) a full time Real Estate Specialist to work on the process, (2) a half-time appraiser, and (3) other managers, accountants, clerical staff and legal services as needed. As part of these costs, travel, training, and per diem expenses are included. The cost estimate for the BIA to perform the Rights-Of-Way procedures are presented in Table 8.13.

Table 8.13
Estimated BIA Rights-Of-Way Clearance Costs

Personnel	Salary	Travel/Per diem	Training	Incidentals
1 GS-11 Real Estate Specialist – full time	$47, 412	$15,000	$2,000	GSA Vehicle Rental $6500
1 GS-9 Appraiser – half time	$39, 184	$15,000	$2,000	GSA Vehicle Rental $4500
Other personnel, equivalent to full time FTE, GS-11 (Rights Protection Section Chief, clerical staff, and accounting staff)	$47, 412	$5,000	$5,000	Legal Services $1,500.00
Total				**$190,508**

The general process for completing a right-of-way is described in the following section:

- General Approach for Permission to Survey

  The Branch of Real Estate Services, Navajo Region, counsels the applicant concerning right-of-way procedures and assists in determining the land status of the proposed application. The applicant uses Form 5-104B in obtaining the signed consent of the owners of each trust allotment crossed. Official ownership records of Indian allotted land in New Mexico are located at: 1) the Eastern Navajo Agency, Real Estate Services (P.O. Box 328, Crownpoint, New Mexico, 87313), 2) the Shiprock Agency, Real Estate Services (P.O. Box 3538, Shiprock, New Mexico, 87420), the Office of Special Trustee, Records and Litigation Support and 4) the BIA Office of Land, Titles and Records, Southwest Regional Office, P.O. (Box 26567, Albuquerque, NM 87125-6567).

- Action to be taken by the Applicant

  The Applicant will provide an application for the Permit to Survey to the Navajo Regional Office Director (25 CFR 169.4). The application cites the statute under which it is filed and it shows the width, length, area and land status for the entire corridor.

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- Action to be taken by Navajo Region Real Estate Services

  Prior to acceptance, the BIA Regional Office reviews the application for completeness. If the application is complete, the BIA processes the application according to BIA procedures. If there are no conflicts, the map is sent to the Realty Officer for acceptance. The Project sponsors are responsible for the archeological clearance and for complying with environmental laws. For the Project the Navajo Region Real Estate Services Office will coordinate with the Navajo Nation, Reclamation, state, county and local governments.

- Upon compliance with these requirements, Real Estate Services will prepare the Grant of Easement for Right-of-Way.

  After approval from the Navajo Nation for the corridor within tribal lands, the BIA Real Estate Services Office will distribute signed copies of the easement to: 1) the Applicant, 2) the Tribe (through the Project Review Office), and 3) the Title Plant (for recording). For allotted lands the Navajo Nation's approval is not required. However, the BIA anticipates distributing signed copies of the easements.

8.9 Other direct and indirect costs

Different entities have various methods to determine "other direct and indirect costs". Table 8.14 presents the results of methodologies for three Reclamation cost estimates, one prepared by Depauli Engineering, and one prepared by MSE-HKM. Some methods include 5 percent for mobilization, 30 percent for contingency and 25 percent for engineering (Reclamation September 2000). MSE-HKM reports that Reclamation often uses 7 percent for mobilization, 15 percent for preparation, and 25 percent for contingency. After peer review sessions with Reclamation on the Lake Powell Core Pipeline from Lake Powell to Black Mesa, MSE-HKM recommends 10 percent of the construction cost of major items for appurtenances. This total value results in the contract cost. The contingency is 20 percent of the contract cost. The contract costs plus the contingency is the field cost. And, 27 percent of the field cost is added for non-contract cost. The non-contract costs plus the contract costs result in the total cost.

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Table 8.14
Indirect Costs Incurred on Municipal Pipeline Projects

Activity	Reclamation NGWSP (1993)	Reclamation Mt Taylor (1999)	Reclamation West. Nav. (2000)	DePauli NGWSP (2000)	MSE-HKM Lake Powell (1997)
Mobilization	5%	5%	5%		
Appurtenants					10%
Unlisted Items	5%	5%			
Contingencies	25%	25%	30%	15%	20%
Engineering			25%	22%	
Indirect	19%	19%			27%
ROW	10%	10%			
Total Percent	64%	64%	60%	37.00%	57.00%

The non-contract costs include engineering design, construction inspection, contract administration, NEPA compliance, easements, geotechnical investigations, archaeological clearances, design survey, and other special investigations. These percentages which are shown in Table 8.15 reflect costs typically incurred on non-Indian projects (MSE-HKM, August 1996, Lake Powell Pipeline Cost Estimate).

Table 8.15
Indirect Costs Incurred on non-Indian Projects

Activity	Percent	Activity	Percent
Facilitation	1%	Archeological	1%
TERO Service	2%	Design survey	1%
Contract Administration	1%	Investigations	2%
Environmental	2%	Design	6%
Easements	1%	Construction Observation	10%
Geochemical	1%		

8.10 Summary of the capital costs

Cost summaries were prepared for the NIIP and the San Juan River Alternatives. As presented in this technical memorandum, both alternatives serve the same area. The total Project cost for the San Juan River Alternative is $368 million and the total Project cost for the NIIP Alternative is $390 million. These estimates include the Gallup Regional System and delivery to the Shiprock Subarea. The cost of power transmission lines is assumed to be incorporated in the unit price of the power. The separate allocated costs for the Navajo Nation and City of Gallup are based on each ones share of the annual capacity of each component or pipe segment. The total project and programmatic costs, and the allocated costs, are shown in Tables 8.16 and 8.17.

The NDWR investigated the mutual benefits due to the shared economy of scale of a joint Navajo /City of Gallup Project. The NDWR estimates that a stand-alone Gallup only system would cost approximately $107 million. A stand-alone Navajo project using the San Juan River Alternative would cost $324 million and a stand-alone NIIP Alternative would cost $354 million. By partnering with the Navajo Nation, the City's share of the resulting project is approximately $60 million. By partnering with the City, the Navajo Nation's share of the resulting project is $310 million for the San Juan Alternative and $326 for the NIIP Alternative. The operation and maintenance costs presented in Tables 8.16 and 8.17 show similar benefits with partnering.

The water delivery costs have been divided between programmatic and Project costs. A number of federal and state programs may be able to assist with water development in the region. For instance, the IHS has P.L. 86-121 authorization to construct domestic water systems on the Navajo Nation. The IHS annual budget is approximately $25 million per year. The EPA, USDA, HUD and other federal agencies also assist with water development. The Project will provide a core system around which programmatic funding can build on.

Table 8.16
Navajo-Gallup Water Supply Project Capital Costs
(Millions of Dollars)

Component	Project Cost	Programmatic Cost	Total Cost
1A. 36,700 af NIIP Alternative			
8,800 af Moncisco Reservoir	$59.72	$0.00	$59.72
65 CFS Treatment Plant	$78.21	$0.00	$78.21
Conveyance to Yah-ta-hey	$129.58	$0.00	$129.58
Project Laterals	$122.60	$27.30	$149.90
Power Lines, SCADA etc.	$5.10	$0.00	$5.10
1B. 36,700 af San Juan River Alternative			
Diversion Structure	$3.14	$0.00	$3.14
Water Treatment Plant	$70.81	$0.00	$70.81
Regulating Reservoir	$15.07	$0.00	$15.07
Conveyance to Yah-ta-hey	$161.47	$0.00	$161.47
Project Laterals	$117.44	$30.30	$147.74
Power lines, SCADA, etc.	$5.10	$0.00	$5.10
2. Groundwater Component	$0.00	$73.00	$73.00
3. Wastewater treatment	$0.00	$113.00	$113.00
4. Value of Water Rights	$0.00	$90.00	$90.00
5. Value of Rights-of-way	$0.00	$24.80	$24.80
Total NIIP Alternative	$395.21	$328.10	$723.31
Total SJR Alternative	$373.03	$331.10	$704.13

Table 8.17
Navajo-Gallup Water Supply Project Summary of Allocated Capital Costs

Scenario	Water Supply (Acre Feet)		Capital Cost (Millions of Dollars)		
	Navajo Nation	City of Gallup	Navajo Nation	City of Gallup	Total
SJR Alternative					
	29,067	0	$324	$0	$324
	29,067	7,500	$310	$58	$368
NIIP Alternative					
	29,067	0	$354	$0	$354
	29,067	7,500	$326	$64	$390

Note: Tabulated costs exclude transmission lines and groundwater components.

8.11 Summary of the Project's operation and maintenance

In the 1984 Planning Report and Draft Environmental Statement Reclamation assumed that NTUA would require seven management personnel at half time and 14 field positions at full-time to operate the Project. This staff would have an estimated annual cost of $400,000 (or $3.17 per acre-foot) in 1984 dollars. For this technical memorandum, the annual operation and maintenance expenses are based on the following fixed percentages of the capital investment. For the annual operating costs the following values were used:

- Intake - 6 percent
- Pumps - 4 percent
- Storage - 4 percent
- Conveyance pipes - 0.5 percent
- Wells - 4 percent
- Others - 4 percent

The cost of energy is based on 6.5 cents per kilowatt. If CRSP set aside power is available to NTUA at 3.5 cents per kilowatt, it may be possible to finance the power distribution infrastructure through the power fees.

Table 8.18
Navajo-Gallup Water Supply Project Summary of Allocated O&M Costs

Scenario	Water Supply (Acre Feet)		O&M Cost (Millions of Dollars)		
	Navajo Nation	City of Gallup	Navajo Nation	City of Gallup	Total
SJR Alternative	29,067	0	$8.58	$0.00	$8.58
	29,067	7,500	$7.99	$1.95	$9.95
NIIP Alternative	29,067	0	$6.16	$0.00	$6.16
	29,067	7,500	$5.33	$1.71	$7.04

Note: Tabulated costs exclude transmission lines, Shiprock conveyance, groundwater components, NIIP conveyance losses of 10%, and NIIP canal operation and maintenance.

Navajo-Gallup Water Supply Project

For Project authorization, a contracting entity must be identified for repayment obligations and for the operation and maintenance of the Project. Several other projects may provide constructive examples:

- Mni Wiconi - The Mni Wiconi Project is owned by the federal government and is operated by the Department of the Interior.

- NIIP - NIIP is owned by the federal government. It is authorized for construction by the BIA and Reclamation is providing technical assistance. NIIP facilities are operated under a PL. 638 Indian Self Determination Act contract by NAPI. Upon completion of NIIP, the NIIP facilities will eventually be transferred to the Navajo Nation. The scheduling and the conditions of that transfer are currently being formulated.

- Hammond Irrigation Project - The Hammond Irrigation Project was built by the federal government. A contracting entity, the Hammond Irrigation District, was established to contract with the United States for repayment of the reimbursable portion of the project costs and to operate the facilities.

The Project could be operated by NTUA under a contract to the Department of the Interior. Because this project has a significant non-Indian component, this contract would not necessarily be a P.L. 638 contract, but the same contractual relationship that the Department of the Interior has with other contracting entities.

The eventual ownership of the Project also needs to be evaluated. In other circumstances, after the repayment obligation has been met, federally constructed projects are candidates for transferring to the contracting entity. In some cases the contracting entities are eager to assume control of, and responsibility for, the water control facilities. In other cases the contracting entities have little interest in transferring facilities. Under different administrations the Department of the Interior has maintained different policies to address the transfer and ownership of water projects. This Project has the added complication that it combines Indian and non-Indian interests. Due to the Indian component, this Project will retain a significant residual trust responsibility. On the other hand, the City will only be able to invest in the Project if it has adequate guarantees that its investment will be protected. The eventual transfer to the Tribe or to a joint holding entity can only be considered if these issues are addressed.