A PRELIMINARY ECONOMIC FEASIBILITY STUDY FOR THE ESTABLISHMENT OF AN ENERGY-WATER COMPLEX IN THE TULAROSA BASIN -- AN EXECUTIVE SUMMARY

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For a detailed discussion of this study, see WRRI Report 068.

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Principal investigators include the following professionals with universities represented, area of expertise, and study area responsibility. This was an interdisciplinary team effort. The order of authors indicate study area responsibility in this report. Robert R. Lansford served as the coordinator for all phases of the project.

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Darrel Gertsch and William Gregory of the Los Alamos Scientific Laboratory acted in an advisory capacity in the research effort and made contributions both in advice to the study group and in data development. Although the research team is solely and totally responsible for statements and conclusions in this report, many people helped in the work.

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A PRELIMINARY ECONOMIC FEASIBILITY STUDY FOR THE ESTABLISHMENT OF AN ENERGY-WATER COMPLEX IN THE TULAROSA BASIN -- AN EXECUTIVE SUMMARY*

This study is a preliminary evaluation of the feasibility of the construction and operation of an industrial, agricultural, and recreational complex in the Tularosa basin. The proposed project involves desalting 500,000 acre-feet of saline groundwater, generating 2,000 megawatts of electricity, and recovering minerals from the reject brine.

Since the major components of the complex were assumed to be publicly financed, benefit-cost analysis was used to determine preliminary feasibility. Environmental risks associated with the energy-water project and social and political inputs were not evaluated. If portions of the complex were located on military lands in the Tularosa basin area, evaluation of the impact on the White Sands Missile Range, Holloman Air Force Base, and the McGregor Range of Fort Bliss would be needed.

The source of energy studied was nuclear power to generate steam for electricity production and desalting. Most of the electricity was to be exported outside the Tularosa basin. A small amount of the production would be required for the increased local demands created by the project.

The desalted water would be used chiefly by irrigated agriculture, with smaller amounts for municipal, industrial, and recreational needs. The water for irrigation would be blended with water from the well field to obtain water of 1,000 parts per million (ppm) dissolved solids, and then discharged to an impoundment reservoir for distribution to the irrigation system. The reservoir would also provide water-based recreation. The proposed location of the reservoir would allow gravity flow to the irrigation system, but the water would have to be pumped to the reservoir.

Minerals recovered from the desalting brine would provide additional benefits from the project. Magnesium, potash, barium, sodium chloride, and magnesium oxide were the primary minerals analyzed for recovery.

Since an energy-water complex of this size has not been built or even planned to use saline groundwater, the design and cost data for desalting sea water were used. These data, mostly from published sources, had to be scaled up or down taking into account the change in feed water (sea to groundwater supplies). Cost data were adjusted to the 1972-1974 period, and applicable technology bases were in the same time frame. The proposed complex was assumed to come on-line in the year 2000.

The study was limited by assumptions to the size of electrical generation capacity, source and type of nuclear facility, quantity of water to be desalted, and the technology of multistage flash evaporation. These assumed values may not be those best suited to a complex in the Tularosa basin. Further research is needed to evaluate this question.

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WATER RESOURCES

Holloman Air Force Base, White Sands Missile Range, and the City of Alamogordo, the major users of water in the Tularosa basin, are developing limited amounts of available fresh water. The proposed energy-water complex would extract 500,000 acre-feet of water per year containing less than 10 g/l of dissolved solids. Quantity and quality of water were the primary considerations in the selection of a well field. The most promising site is near the eastern side of the basin. Quality of water in this well field was determined from analysis of other wells in the area. The dissolved solids concentration of the water produced from the well field would be about 5,000 parts per million. The drawdown in the well field is estimated to be about 600 feet at 30 years, and the drawdown five miles outside the field is about 12 to 15 feet. Cost estimates to build and maintain a well field to provide 500,000 acre-feet of water per year for 30 years are $98 million for well construction and collection system, $15.6 million for equipment replacement, and $440,000 per year for maintenance.

LAND RESOURCES

An energy-water complex in the Tularosa basin would require land resources for irrigation, urban development, and recreational activities. At present, 88 percent of the land is in public domain and five percent is privately owned. The public land is controlled as follows: Military services, 54 percent; Bureau of Land Management, 16 percent; Forest Service, six percent; National Park Service, four percent; Mescalero Apache Indian Reservation, seven percent; and state of New Mexico, seven percent. Land suitable for the proposed agricultural-energy project would be available.

DESALINATION

An evaluation of current water-desalting technology suggests that a multistage flash desalting plant would best suit the design of the project. Estimated costs are $300 million for construction and capital outlay, and about $13.8 million per year for pretreatment, operation, and maintenance; including a mineral recovery process.

NUCLEAR ENERGY PLANT

Among the different types of nuclear reactors considered as an energy source to produce electricity and desalted water, a steam cycle, high temperature gas reactor was selected as the most suitable. Estimated costs for the construction of such a nuclear energy plant would be about $974 million and about $119 million per year for operation and maintenance.

The seismic risk of installing a nuclear plant in the Tularosa basin was considered minor, but for precaution, the site should be on bedrock. Isolated outcrops of Permian rocks are located about six miles southwest of Tularosa and about 12 miles southwest of Alamogordo.

WATER TRANSPORTATION, STORAGE, AND RECREATION

Since not all water is used as it is produced, the water from the desalination plant would be conveyed to a storage reservoir. The distance from plant to reservoir would be about 10 miles, with an increase in elevation of about 1,000 feet. The cost of a conveyance system is estimated at $50.6 million for construction, about $34.7 million for replacements, and about $506,000 per year for maintenance.

The storage reservoir would need to hold about 250,000 acre-feet of water. Rinconada Creek, northeast of Tularosa, was selected as a suitable site for the reservoir, which would have a range of water elevations from about 5,200 feet (minimum recreational pool) to about 5,500 feet (maximum pool size).

An earthen dam across the canyon would cost about $230.8 million to construct and about $231 thousand per year to operate and maintain. The recreational potential of the reservoir was estimated by using a theoretical demand model, which projected 1,873,152 annual visitors to the proposed lake.

WATER EXPORTATION

The water plan prepared by the State Engineer Office indicates that New Mexico may face extreme shortages of water by the year 2000. Therefore, exportation of the desalted water to the Rio Grande or Pecos River was analyzed. Of three alternatives considered, two for the Rio Grande and one for the Pecos, the Elephant Butte (Rio Grande) exportation plan was selected. Costs would be about $70 million for the conveyance system, $34.7 million for replacements, and about $700 thousand per year for maintenance and operation.

IRRIGATED AGRICULTURE

Costs and returns budgets for selected agricultural enterprises were used in a linear programming model with an objective function to maximize net return subject to water, land, and capital cost constraints. The purpose of this analysis was to determine the maximum amount farmers could pay for irrigation water. This point was determined when the aggregate net return was zero for irrigated agriculture. Increasing the interest rate from five to 10 percent does not drastically affect the cropping pattern or water use but decreases the amount that the agriculture sector can pay for irrigation water from between $55 and $56 per acre-foot to $45 to $46 per acre-foot. The distribution system would cost about $26 million for construction and $206,000 per year for operation and maintenance.

MARKET POTENTIAL FOR ELECTRICITY AND MINERAL BY-PRODUCTS

A demand analysis indicates that market potential may exist for the 2,000 MW of electricity produced by the proposed Tularosa project if the product is competitively priced.

There could be a market for the mineral products to be recovered from the reject brine. The minerals considered were magnesium metal, potash, barium, sodium chloride, magnesium oxide, sodium oxide, and sodium hydroxide. The primary products are expected to be magnesium metal and potash, for which the market potential was derived by a demand equation analysis. Market potential of the other minerals was estimated from an examination of the characteristics of each industry. Estimated costs for construction and capital outlay for mineral recovery facilities are $109 million. Operation and maintenace would run about $27.3 million per year.

PRELIMINARY ECONOMIC FEASIBILITY

Three Alternative project designs at four interest levels were evaluated by benefit-cost analysis.

The first Alternative was the project itself as originally designed for production of 500,000 acre-feet of water and 2,000 megawatts (MW) of electric power from a dual plant (nuclear and desalting) and recovery of certain minerals from the reject brine. All water is to be used within the Tularosa basin by a greatly-expanded agricultural sector and increased municipal and industrial development. Electricity production, after fulfilling project power requirements, will be exported to surrounding areas in the Southwest and only enough to satisfy local needs designated for in-basin use.

The second Alternative was the production of power only. Water production would be limited to an amount sufficient to satisfy cooling requirements. All power produced would be exported to surrounding regions in the Southwest.

The third Alternative comprised equivalent water production, power generation, and mineral recovery. But all water over and above Tularosa basin needs (those that would have occurred without the project) would be exported to the Rio Grande. Only enough water to supply a "without project" local economy would be retained within the basin and all excess from the 500,000 acre-foot production would be transferred. All net power produced (excluding internal requirements) would be exported to other regions in the Southwest.

Four interest or discount rates--five, six, eight, and 10 percent--were used to check the sensitivity of the results to changes in the discount rate. The two lower interest rates (five and six percent) represent rates commonly used for water project evaluations, and the two higher rates are representative of the lower range of publicly funded projects (municipal bonds).

The capital outlay and annual operating cost for each component in the three Alternatives are presented in Table 1. For Alternative 1 (nuclear reactor, desalting, and agriculture), the total capital outlay is $1,788.7 million and the total annual operating costs are $163.7 million. For Alternative 2 (nuclear reactor only), the total capital outlay is $1,037.1 million and total annual operating costs are $119.13 million. Costs of the nuclear plant in this Alternative are higher than in Alternative 1, because the number of turbines for generating was increased to take advantage of available steam. The total capital outlay for Alternative 3 (nuclear reactor, desalting, and water export) is $1,551.3 million and total annual operating costs are $161.34 million.

Sources of benefits for Alternative 1 would be sales of power (local and export), water for in-basin use, and minerals and recreation. Benefits in Alternative 2 would be from the sale of power only. Alternative 3 would derive benefits from sales of power (local and export), water (local and export to the Rio Grande), and minerals. Estimated benefits from mineral sales are $67.702 million and from recreation, $3.746 million. The value of water is estimated at $50 per acre-foot for local municipal and industrial uses, and $90 per acre-foot for export. Total benefits from water sales vary over the life of the project due to changes in amounts used by the different sectors.

The price of power was calculated on the basis of estimated cost of a coal-fired plant. For export, the price varies from $9.44 per MW at a discount rate of five percent to $10.06 at six percent, $11.38 at eight percent, and $12.79 at 10 percent. The price to local municipal and industrial users ranges from $10.38 per MW at five percent discount to $11.07 at six percent, $12.52 at eight percent, and $14.07 at 10 percent. Total benefits from the sale of electricity also vary over the life of the project according to the number of municipal and industrial users and the power requirements for pumping water.

Results of the analysis of the above costs and benefits are reported in Table 2. For the project to be feasible, the net benefits must be greater than or equal to zero and the benefit-cost ratio must be equal to one or more. The complete energy-water complex, Alternative 1, appears to be infeasible for two primary reasons:

Table 1. Capital outlays and annual operation costs for the cost components for the benefit-cost analysis for each alternative, Tularosa basin project, New Mexico

Cost Component	Total Capital Outlay Costs (million $)	Annual Operating Costs (million $)
Alternative 1--Nuclear Reactor, Desalting, Agriculture		
Nuclear plant	974.0	119.1
Desalting plant	300.0	13.8
Well field	98.0	0.4
Water delivery (plant to reservoir)	50.6	0.5
Agricultural distribution system	26.0	0.3
Reservoir	230.8	2.3
Mineral recovery	109.3	27.3
Total	1,788.7	163.7
Alternative 2--Nuclear Reactor Only		
Nuclear Plant	1,028.0	119.10
Well field	9.1	0.03
Total	1,037.1	119.13
Alternative 3--Nuclear Reactor, Desalting, Water Export		
Nuclear plant	974.0	119.10
Desalting plant	300.0	13.80
Well-field	98.0	0.44
Mineral recovery	109.3	27.30
Water export canal	70.0	0.70
Total	1,551.3	161.34

First, desalting technology at present is capital intensive and too costly in comparison to any reasonable projections of water values to allow feasibility even when waste heat from power production is available. Feasibility would require an increase in the value of water to $221 per acre-foot for agricultural, municipal, and industrial uses at a six percent discount rate.

Second, the capital costs and power drawdowns associated with storing water for agriculture are prohibitive in relation to the potential value. In Alternative 3, the value of water exported to the Rio Grande needs to be $187 per acre-foot to achieve feasibility. This value approaches minimum system cost of $149 per acre-foot for producing desalted water, excluding transportation costs.

Projected local uses of water cannot justify production of desalted water at this cost. Desalting, even with a dual nuclear plant and mineral recovery facility, is not economically feasible with current technology on the scale proposed for the Tularosa basin. The prospect of nuclear power production using brine water for cooling (Alternative 2) may prove feasible and the possible construction of a nuclear energy park in the Tularosa basin may merit further investigation. This decision would depend chiefly on environmental risks not evaluated in this preliminary study.

Table 2. Results of the benefit-cost analysis for Alternatives 1, 2, and 3, for the Tularosa basin project, New Mexico

Discount Rate	Net Benefits	Benefit-cost Ratio
	- - - - -(millions of dollars)- - - - - -	
Alternative 1--Nuclear reactor, Desalting, Agriculture		
5	-986.570	0.508
6	-1,012.340	0.505
8	-1,076.415	0.494
10	-1,137.528	0.486
Alternative 2--Nuclear reactor only		
5	57.723	1.050
6	84.421	1.072
8	110.042	1.090
10	132.817	1.105
Alternative 3--Nuclear reactor, Desalting, Water export		
5	-382.527	0.779
6	-424.824	0.758
8	-509.777	0.719
10	-578.612	0.693

Net contributions of the individual components to the overall project were also analyzed and tabulated. To facilitate analysis, the price of water was allowed to vary to the point where the project would just break-even--all costs covered. The basic configuration only considers costs associated with the nuclear plant, well field, and desalting plant (Table 3). Water would have to be priced to all users as indicated in the table at the various interest rates to just break-even.

When a mineral recovery process is added to the basic configuration, costs and benefits increase. Benefits from mineral sales lower prices of water substantially (at six percent, for example, $149 per acre-foot as opposed to $191 per acre-foot). The price of water to all users would change as delineated in Table 3 and all costs would be just recovered.

The third configuration combines the three components (nuclear plant, well field, and desalting plant) of the basic configuration with the storage reservoir and the plant-to-reservoir conveyance system. All costs and the benefits from recreational use of the reservoir are included. The price of water would have to be as shown in Table 3 for the project to break-even. If mineral recovery is added to this water configuration, total costs and benefits increase, therefore the break-even price of water would be somewhat lower ($205-$159 at the five percent interest rate).

When the exportation of water to the Rio Grande is included in the basic three-component configuration, the capital, operating, and maintenance costs are increased somewhat. The break-even prices of water without mineral recovery and with mineral recovery added are presented in Table 3. Since the price with mineral recovery is lower in all configurations, the net contribution of this component is important.

Table 3. Break-even water prices at selected interest rates for basic and enlarged project configurations

Interest Rate	Basic Configuration	Enlarged Configurations-Basic Plus				
		Mineral	Water	Mineral-Water	Export Water	Mineral-Export
(percent)	-(dollars per acre-foot)-					
5	183	138	205	159	217	173
6	191	149	215	173	228	187
8	212	177	240	204	254	223
10	238	212	269	247	281	256

SUMMARY OF RESULTS AND CONCLUSIONS

There is little chance under current Nuclear Regulatory Commission procedures that a nuclear plant would be licensed in the Tularosa basin because it would not be compatible with the White Sands Missile Range. The economic analysis did not consider the loss in value of canceling or modifying WSMR activities as an opportunity cost of constructing an energy-water complex.

The major findings and recommendations of this study are summarized below.

Summary Results

- DESALTING WATER IN THE TULAROSA BASIN ON THE PROPOSED SCALE OF 500,000 ACRE-FEET PER YEAR IS NOT ECONOMICALLY FEASIBLE.
- PRODUCTION OF NUCLEAR POWER WITH BRACKISH WATER FOR COOLING APPEARS MARGINALLY FEASIBLE IF CUMULATIVE ENVIRONMENTAL COSTS ARE NOT TOO SEVERE.
- LAND FOR DEVELOPMENT OF AGRICULTURE, INDUSTRY, AND MUNICIPAL NEEDS IS NOT A LIMITATION, BUT ACQUISITION OF THE MORE SUITABLE LAND IN MILITARY USE WOULD PRESENT PROBLEMS.
- ANALYSIS OF THE MARKET POTENTIAL FOR ELECTRICITY PRODUCED IN THE TULAROSA BASIN INDICATES THAT 47,000 MW(E) WILL BE NEEDED FOR THE SOUTHWEST BY 1990, BUT IF THE PRICE INCREASES BY 3.5 PERCENT PER YEAR, ADDITIONAL REQUIREMENTS WOULD BE LIMITED TO REPLACEMENT CAPACITY.
- THE FEASIBILITY OF MINERAL BY-PRODUCT SALES DEPENDS ON TRANSPORTATION COSTS TO MARKET AND POTENTIAL RECOVERY OF CERTAIN MINERALS, BUT EVEN SUBSTANTIAL SALES WOULD ONLY PARTIALLY OFFSET THE HIGH COST OF DESALTED WATER.
- THE ANALYSIS OF THE PROPOSED WELL FIELD WAS BASED ON AN OPTIMISTIC EVALUATION OF EXISTING VERY LIMITED HYDROLOGIC DATA: ACTUAL COST COULD BE SUBSTANTIALLY HIGHER AND OTHER SITES MAY PROVE TO BE MORE FAVORABLE.
- DATA ON THE GEOTHERMAL POTENTIAL OF THE TULAROSA BASIN ARE INSUFFICIENT TO EVALUATE THIS POTENTIAL SOURCE OF ENERGY FOR DESALTING WATER.

- Exportation of desalted water from the Tularosa basin is economically infeasible until the price of water increases, but appears to be a more likely alternative than local use for agriculture because of higher-valued uses in the Rio Grande or Pecos River basins.

Summary Recommendations

- An extensive program of hydrologic data collection, analysis, and modeling will be required for detailed evaluation and design of the proposed well field.
- A similar program of data collection and analysis should be considered to assess the geothermal potential of the Tularosa basin.
- The comparability of the proposed nuclear desalination complex or of an energy park with current military activities in the project area should be evaluated.
- Potential legal barriers to land acquisition should be investigated.
- Alternative desalination technologies and a nuclear energy center including dual-purpose facilities should be evaluated. High-value uses for variable quantities of desalted water may justify some dual-purpose capability.
- Alternative technologies, including solar and geothermal energy for the potential use of the saline water resources of the Tularosa basin should be explored.