Supporting Information For
SITE - SPECIFIC ANALYSIS OF
HYBRID GEOTHERMAL / FOSSIL POWER PLANTS
VOLUME ONE : ROOSEVELT HOT SPRINGS KGRA

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Sites of Known Geothermal Resource Areas (KGRAs)

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The study is based on theory developed at Brown University by Professors Ronald DiPippo, Joseph Kestin, and H. Ezzat Khalifa. This theory provided a clear and organized method of analysis of the hybrid geothermal/fossil fuel power plant.

The cost calculations are based upon a modification of the computer simulation "A Thermodynamic Process Program for Geothermal Power Plant Cycles" developed by M. A. Green and H. S. Pines of the Lawrence Berkeley Laboratory. This simulation provided the basis for the cost optimization process used for the geothermal portion of the study.

The analysis required an optimally sited coal-fired power plant of the latest state-of-the-art design as a reference in order to provide realistic design and cost considerations for the hybrid plant analysis. The Intermountain Power Project (Joseph C. Fackrell, President) power plant was selected as the reference because of its siting, size, design, and schedule for first operation in mid-1980s. The use of this ideally sited, cost efficient, reference plant greatly enhanced the realism of the analysis.

INTRODUCTION

As has been noted in the main report, Site-Specific Analysis of Hybrid Geothermal/Fossil Power Plants, the economics of a particular hybrid plant must be evaluated with respect to a specific site. The supporting volumes to this report consider four KGRA's of varying resource characteristics, climate, seismology, geography, and other environmental factors. (See Figure I-1):

- Roosevelt Hot Springs, Beaver County, Utah
- Coso Hot Springs, Inyo County, California
- East Mesa, Imperial County, California
- Long Valley, Mono County, California

This volume focuses on the Roosevelt Hot Springs KGRA.

Figure I-2 presents the major plant siting factors. Initially, of course, there must be an adequate geothermal resource capable of sustained production to justify a hybrid plant. Although data on lifetime resource capacity are not available at this time, the temperature, pressure, and flow rate data given in Section 1 of this volume and of the main report suggests that the four sites deserve serious consideration as sites for a hybrid plant. However, key siting considerations must be addressed before an economic judgment can be attempted:

- The availability, quality, and cost of coal
- The availability of water
- The availability of transmission.

If any of these factors present a major restraint, the hybrid plant, in all probability, could not be economically viable.

Figure I-1. - Location of the four KGRA's considered in this study

Figure I-2. - Major plant siting factors

The environment of each of the chosen KGRA's impacts the hybrid plant, and the plant, in turn, impacts the environment. Separate sections are devoted to seismological and climatic factors. While environmental and socioeconomic concerns are recognized to be of crucial importance, they were not addressed in this study. Rather, attention is focused upon sites which could economically support a hybrid plant. Except for seismicity and climate, all sites were considered environmentally equivalent. Environmental costs were based on the IPP costs and integrated with other costs. It is interesting to note (Table I-1) that all of the sites except Long Valley are at least 64.4 km (40 miles) away from national parks or monuments. (Long Valley lies 32.2 km (20 miles) east-southeast of Yosemite National Park.)

An environmental assessment is, of course, the first step that must be taken once a promising hybrid site is identified and selected. At that point the full EIAR/EIR process should be employed.

TABLE I-1. - LOCATION OF NATIONAL PARKS AND/OR MONUMENTS RELATIVE TO THE FOUR SITES

Site	Federal Lands	Distance from Site
Roosevelt Hot Springs	Cedar Breaks	57 miles directly south
	Bryce Canyon	62 miles southeast
	Capitol Reef	88 miles west
	Zion	80 miles south-southwest
Coso Hot Springs	Death Valley	40 miles east
	Sequoia	40 miles northwest
East Mesa	Joshua Tree	64 miles north-northwest
Long Valley	Yosemite	20 miles west-northwest

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SECTION 1.0

THE GEOTHERMAL RESOURCE

Roosevelt (McKeans) Hot Springs is in Beaver County, about 12 miles northeast of Milford and about 20 miles northwest of Beaver, Utah (Figure 1-1). Roosevelt Hot Springs is one of two KGRA's in Utah that were originally defined on geologic evidence by the U. S. Geological Survey.

This group of springs formerly issued from metamorphic rocks and alluvium on the western flank of the Mineral Range. Published reports, however, do not record the number of springs in the group. Lee (1908) states that one spring flowed at a rate of 10 gallons per minute, and that the temperature was at least 190°F. Mundorff (1970) indicates that the main spring was dry in 1966 and that it did not appear to have discharged for several years.

The springs of the Roosevelt Hot Springs area ceased flowing about 1963. Either the channels through which the water reached the surface were gradually sealed by deposition of dissolved solids, especially silica, or a general lowering of the water table in Escalante Valley caused a change in the ground-water flow regime, and the effect was to dry up the Springs (Petersen, 1975). This latter explanation assumes that Roosevelt Hot Springs was in close hydraulic connection with the shall ground-water system.

1.1 Geology

Bedrock of the eastern part of the Roosevelt Hot Springs area is comprised of metamorphic biotite gneiss, schist, and phyllite of Precambrian(?) age; intrusive granite, and aplitic and lamprophyric dikes of late Tertiary age; and two extrusive glassy silicic flows of late Pliocene or early Pleistocene age (Figure 1-2). Bedrock is not exposed in the central and

Figure 1-1: ROOSEVELT HOT SPRINGS KGRA

Scale 1:500000
1" = 8 miles (approx.)

Figure 1-2: GEOLOGIC MAP OF THE ROOSEVELT HOT SPRINGS AREA,
BEAVER COUNTY, UTAH

J. A. Whelan & C. A. Petersen

December 1974

Scale

1: 31680

2" = 1 mile (aprox.)

Correlation of Map Units

Alluvial Deposits

Qal

Hot Spring Deposits

Qhs

Unit C

Order
does not
reflect age

Bedrock

Unit B

Unit A

Tva

Tvg

Tg

Pcm

Holocene
Quaternary
Pleistocene
Tertiary
Precambrian

Description of Map Units

- Qal Quaternary alluvium.-- Gravel, pebbles, and cobbles derived from granite and silicic volcanic rocks. Unconsolidated. Most of the unit is Holocene or Pleistocene in age, but some parts may be Pliocene in age.
- Qhs Quaternary hot-spring deposits.-- Tan to white siliceous sinter; and layers of white, red, and brown opal.
- Unit C Unit C.-- Fragments of granite in siliceous matrix. Stratified or unstratified. White or tan but orange or purple streaks of hematite staining are common.
- Unit B Unit B.-- Fragments of granite in glassy matrix. Pale or green or white.
- Unit A Unit A.-- Fragments of granite in glassy matrix. Tan or medium brown.
- Tva Tertiary volcanic ash.-- Stratified white ash. Possibly water-laid.
- Tvg Tertiary glassy volcanics.-- Silicic flow rocks. Tan to gray glassy rock, or obsidian.

Symbols

--- ?...?...

Doubtful or probable
fault (dotted where
concealed).

Contact

La

Ap

Tg

Lamprophyric dikes

Aplitic dike

Granite dikes in
metamorphic rock

Figure 1-2

western parts of the area. Unconsolidated deposits, principally alluvium of Tertiary and Quaternary age, cover most of the Roosevelt area west of the Mineral Range. In addition, there are exposures of opalized and siliceous sinter which were deposited by hot springs, and silica-cemented alluvium which consist of three distinct mappable units (Petersen, 1975).

The oldest rocks of the Roosevelt Hot Springs area are the metamorphics. The deposition of the original sedimentary terrain and subsequent metamorphism took place during the Precambrian era.

Pre-Tertiary sedimentary rocks do not crop out within the Roosevelt area, although lower Paleozoic sedimentary rocks are exposed on the north end of the Mineral Range and middle Paleozoic through Mesozoic sedimentary rocks occur on the southern end of the range (Petersen, 1975). The central part of the Mineral Range is composed of plutonic rocks, and it has undoubtedly experienced the greatest amount of uplift. The pre-Tertiary sedimentary rocks that probably were present presumably have been removed by erosion.

This granitic pluton was emplaced during late Miocene or very early Pliocene time and has since been uplifted and eroded. The inferred east-west trending faults and the north-south trending faults within the Mineral Range may be related to the uplift. (See geologic map).

Young rhyolite domes, with associated flows, pierce the granitic complex a few miles east and south of the producing wells.

Alluvial deposits of the Roosevelt area accumulated during late Tertiary and Quaternary time. During the Pleistocene, hot springs were active and caused the formation of Units A, B, and C (Figure 1-3) and also the hot-spring deposits, which were offset by renewed movement along the Dome fault.

Other small siliceous deposits near the north end of the Dome fault were produced by hot springs that flowed during historic times.

Figure 1-4 is an E-W cross-section drawn from the Mineral Range to

Figure 1-3: Cross Section through the Mineral Range-Escalante Valley

- R 9 W
	Quaternary Alluvium
	Quaternary Hot Springs Lacustrine
	Tertiary volcanics
	Tertiary Granite
	Precambrian Metamorphic Rocks

ROOSEVELT KGRA UNIT AREA

	Wells drilled
	Wells planned
	Natomas well
	Phillips drilling well

Escalante Valley through Phillips Petroleum Company wells and diagrammatically shows the general relationship of the above geologic units.

1.2 Hot Spring Deposits

The largest hot spring deposits of Pleistocene age in the Roosevelt area are those at the south end of the Dome fault. Smaller, relatively recent, siliceous deposits also are present at the boundary of Sections 3 and 4 and at Roosevelt Hot Springs Resort. Three Pleistocene(?) units consisting of silica-cemented alluvium also occur in the Roosevelt area. In several places, the alluvium has been stained red, and the stained patches are interpreted to have once been hot springs or seeps. Although no water is presently being discharged to the surface at any of these places, hot ground in the bottom of exploratory trenches and borings shows that some hot water still occurs in the subsurface.

Several holes were drilled in the hot spring deposits in section 16 in 1968, and one is reported to have discharged steam. This hole reached a depth of 275 feet where steam blew the "tools" out of the hole. Uncontrolled discharge continued for about six weeks until the hole was plugged. Steam temperature was measured at 270^oF and increased slightly as discharge continued.

1.3 Structure

The Mineral Range is an isolated mountain range, typical of the Basin and Range province. It is flanked on the east by Beaver Valley and on the west by Escalante Valley (Milford Valley). According to Cook and Mudgett (1966), the eastern side of the Milford Valley graben near the Mineral Range contains about 5,500 feet of valley fill.

The Dome fault, the most conspicuous of several in the Roosevelt area, extended in a north-northeasterly direction (Figure 1-3). It is so named because its maximum offset is in gently domed siliceous hot spring deposits in section 16. Here, the vertical displacement is at least twenty feet, with the west block up relative to the east block.

Vertical displacement at the north end of the fault is probably about fifteen feet but may be less along the central portion of the fault. Roosevelt Hot Springs are located between the trace of this fault and the Mineral Mountains.

Small-scale north trending faults occur within the alluviated Escalante Valley. Movement on these faults has formed a series of low grabens and horsts which are transitory features being reduced, in part, by erosion.

Other north trending faults are in the foothills of the Mineral Range. East-west trending faults shown on Figure 1-3 may continue under the alluvium and strike into or abut the Dome fault. The intersections of these faults may act as conduits for the rise of the geothermal fluid.

1.4 Field Development

During 1973 and 1974, temperature-gradient wells were drilled in the Roosevelt area by Phillips Petroleum Company, Thermal Power Company of Utah, Incorporated, and unknown entities. Available temperature gradients indicate a range from 2.5 to 26.8[°]F per 100 feet.

On July 30, 1974, Phillips Petroleum Company was the successful bidder on most of the tracts offered by the U. S. Bureau of Land Management in the Roosevelt Hot Springs KGRA. Since that time, Phillips Petroleum has been engaged in exploring its leasehold. According to the U. S. Geological Survey, one of the Phillips Petroleum exploration wells (54-3) was drilled to 2,728 feet and had initial flows of steam of 250,000 pounds per hour, 750,000 pounds per hour of water, a temperature of about 467[°]F. Reservoir pressure was reported to be 500 psi.

Other wells have been drilled by Phillips Petroleum Company and Natomas (Figure 1-4). However, data from these wells are proprietary and information presented herein were obtained from the State of Utah, Water Right Division, and the University of Utah. According to these sources, temperature of over 260[°]C (505[°]F) and well pressure of 2,250 psi have been measured for one of the Phillips Petroleum Company wells. Further, well 12-54 has produced over

1,200,000 pounds per hour fluids and well 13-10 has produced over 1,500,000 pounds per hour fluids (6.5 sec. ft.) The reservoir is confined to fractures within the granitic and metamorphic rocks.

Well production is anticipated operating at 75-125 psi, with 8 percent fluids flashing in the casing and 12 percent in the separator. It is also anticipated that each 55 MWe plant to be constructed will have 5 to 7 wells with fluid use as shown in Figure 1-5.

Cost per production well, average depth of 5,000 feet, is estimated at \$600,000 to \$800,000.

1.5 Cost

At Roosevelt Hot Springs, costs borne by Phillips Petroleum Company for drilling of eight wells is \$3,440,000. An additional \$285,000 was expended for testing of these wells. Production costs are expected to be between \$600,000 to \$800,000 per well, average depth, 5,000 feet.

Although wellhead heat and collection pipe work costs for the above are currently unknown, an estimate for such work was made by the Bechtel Company (1975) for the Geysers KGRA at \$299,000 per well. It can be assumed that similar costs will be experienced at the Roosevelt Hot Springs KGRA.

1.6 Water Chemistry

Two types of geothermometers, one for silica and the other for sodium-potassium-calcium have been utilized to predict subsurface temperatures when only the water chemistry was known. Data for the latter type for hot springs in Utah are shown in Figure 1-6. The Na-K-Ca temperature for Roosevelt Hot Springs compares favorably with the measured temperature noted above.

Analyses of waters from Roosevelt Hot Springs and from the geothermal fluid produced from Phillips Petroleum Company wells are shown on Table 1-1.

WATER BALANCE FOR A 55 MW GEOTHERMAL POWER PLANT AT MILFORD, UTAH

RETURN TO RESERVOIR =
84% of produced fluids
~ 18.69 second - ft.

source: Phillips Petroleum Corp.

Figure 1-5

Na-Ca-K TEMPERATURES

Figure 1-6 Na-K-Ca temperatures (Fournier and Truesdell, 1973) of Utah warm springs from analyses of Mundorff (1970).

source: Parry, W.T., et al , 1976

TABLE 1-1. - SELECTED WATER ANALYSES OF ROOSEVELT K.G.R.A.

	Roosevelt ¹ Hot Springs	Roosevelt ¹ Hot Springs	Roosevelt Seep	Roosevelt Seep	54-3	3-1
Date	11-4-50	9-11-57	5-9-73	8-15-75	8-26-75	5-25-75
Temperature (°C)	85	55	17	28	> 260	> 205
Silica (ppm)	405	313	76	107	560 +	560 ?
Calcium (ppm)	19	22	113	107	10.1	8.0
Magnesium (ppm)	3.3	0	17	23.6	0.24	0.01
Sodium (ppm)	2080	2500	2400	1800	2000	2437
Potassium (ppm)	472	488	378	280	410	448
Bicarbonate (ppm)	158	158	536	300	200	180
Sulfate (ppm)	65	73	142	70	54	59
Chloride (ppm)	3810	4240	3800	3200	3400	4090
Fluoride (ppm)	7.1	7.5	5.2	3.3	5.0	5.0
Nitrate (ppm)	1.9	11	TR	TR	TR	0.1
Boron (ppm)	—	38	37	29	29	25
Lithium (ppm)	—	0.27	—	17	19.0	20.0
TDS (ppm)	7040	7800	7506	5948	6442	7067
pH	—	7.9	8.2	6.43	6.5	6.3
² . Na-K-Ca GEOTHERMOMETER (°C)	295	285	247	239	294	273
Na-K GEOTHERMOMETER (°C)	307	282	250	248	290	294
1. Mundorff (1970) 2. $\beta = 1/3$						

1.7 Discussion

According to available information, geothermal production has not been successful, to data, west of the Dome fault. Wells drilled in this area encounter high temperatures (however, less than the producing wells) and little or no fluid.

Apparently, successful wells drilled east of the Dome fault are controlled, in part, by east-west trending faults or fracture zones that strike into the Dome fault. This appears to be the case as indicated by several wells drilled by Phillips Petroleum Company which are sporadic in their production rates. However, it should be noted that because the reservoir rock is fractured, poorer wells may have encountered less permeable zones.

No quantitative data are available as to the non-condensibles in the steam fraction. Suffice to say that CO_2 is present.

Undoubtedly, the production field will probably develop in clusters in a north-south direction each of the Dome fault and controlled, in part, by the cross faults or fracture zones noted above.

Production rates exhibited to data, if sustained, should lead to electrical production of some consequence.

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Data presented in the foregoing sections have been freely excerpted from the following publications:

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SECTION 2.0

COAL

2.1 California Coal

Although there are small but measurable coal resources in California, this study will disregard California coal for the following reasons:

- Studies indicate that California coal is high in sulfur content - two to three percent - and hence probably unsuited for power plant use because of air pollution constraints. Costs of installation for sulfur removal equipment are prohibitively high on a per kilowatt basis.
- There is presently no coal production in California from which to gain operating experience.
- California coal occurs in small deposits in hilly country near highly desirably or densely populated land, making environmental considerations complex and unpredictable. Costs of establishing a mine or local regulations may prohibit production.

2.2 Arizona Coal

The Arizona Black Mesa coal deposit occurs within the Navajo reservation, and has been developed in cooperation with the Navajo Tribe specifically for the Navajo Power Plant at Page, Arizona. New transportation facilities for any further development of these mines would be required as this coal generally is not being marketed elsewhere. Environmental concerns for both mining and transportation development in this area are severe. It is unlikely that coal would be available from this source at a lower cost than coal expected to be available from the Wasatch-Emery or Kaiparowits areas, in view of the greater distance coupled with lack of transportation facilities.

2.3 Wyoming Coal

Wyoming deposits are extensive and coal is presently being mined and shipped to eastern electric utility markets, as is Utah coal. There is the possibility that additional strip mining may make large quantities of low cost coal available. However, because of existing transportation arrangements and competition from Utah mines, it appears that this coal would be shipped east rather than west. Other strip mines could be developed on the Great Plains but existing coal rail lines go east. Coal transportation westward from Wyoming would pass through the Utah coal areas and rail usage would be in competition with Utah coal.

2.4 Utah Coal

Possible sources of coal available for the four KGRA sites with distances to the sites in airline miles, are shown in Table 2-1.

Utah coal, either from the Wasatch-Emery area or the Kaiparowits areas, appears to be a relatively convenient source for all the sites, especially for Roosevelt Hot Springs. (See Figure 2-1). Further, it can be assumed that coal for a future plant may come from mines as yet not constructed, or from portions of coal fields not presently mined. Utah coal from the Wasatch-Emery and Kaiparowits areas has been extensively analyzed as part of the preparatory studies for the Kaiparowits Power Plant and the IPP. Hence, coal data are readily available. Also, these coal areas have been developed, in part, for planned power plants, existing local plants and other markets. Therefore, the relatively small amounts of coal required for the hybrid plant undoubtedly will be available at low cost.

2.5 Selection of Wasatch-Emery Coal

This study utilizes coal specifications derived for IPP from reports on the Wasatch-Emery coal fields. Data on the Kaiparowits coal fields are essentially identical. The Wasatch-Emery coals are preferred to that of Kaiparowits because:

TABLE 2-1. - AVAILABILITY OF COAL TO FOUR KGRA SITES

KGRA Site	Nearest Possible Coal Source	Second Nearest Possible Source	Third Nearest Possible Source
Roosevelt Hot Springs	Utah, Wasatch-Emery, 100 miles	Utah, Kaiparowits, 150 miles	Wyoming, 250 miles Arizona, Black Mesa, 250 miles
Coso Hot Springs	Utah, Kaiparowits, 300 miles	Utah, Wasatch-Emery, 500 miles Arizona, Black Mesa, 500 miles	Wyoming and New Mexico 600 miles
East Mesa	Utah, Kaiparowits, 400 miles Arizona, Black Mesa, 400 miles	Utah, Wasatch-Emery, 600 miles	Wyoming 700 miles
Long Valley	Utah, Kaiparowits, 300 miles	Utah, Wasatch-Emery, 500 miles Wyoming, 500 miles	Arizona, Black Mesa, 600 miles

Figure 2- 1 - Principal coal deposits in Utah

- Wasatch-Emery coal is more readily available. At present, the northerly portion of this field is being mined extensively and the amount of coal deposits is comparable to, perhaps larger, than Kaiparowits.
- There are existing rail lines that serve the Wasatch-Emery field. No rail lines, as yet, serve the Kaiparowits area
- Anticipated environmental constraints at Kaiparowits may not allow development of this field
- Kaiparowits coal is generally of lower quality than that of Wasatch-Emery coal before washing. Washing to bring Kaiparowits coal up to the quality of Wasatch-Emery coal will increase relative costs.

Average coal quality values from existing Wasatch-Emery mines have been used in all the design calculations. Composite Wasatch-Emery coal values for IPP are:

Heating Value	Sulfur Content	Ash Content
26 860 kJ/kg (11 560 Btu/lb)	0.56%	8.10%

The current base cost for coal is \$16.50 per tonne (\$15 per ton) loaded on trucks at the mine mouth. Transfer to rail cars, rail shipment, truck shipment, and unloading at the site are additional costs. An analysis of these costs for each site is presented below.

2.6 Delivered Coal Cost for Roosevelt Hot Springs

Because of the proximity of Roosevelt Hot Springs to the Wasatch-Emery area (see Table 2-1), coal could be most advantageously shipped by truck. The nearest probable coal delivery is Salina, Utah, approximately 160 kilometers (100 miles) by highway. The probable maximum distance by truck would be 320 kilometers (200 miles), which would place the delivery point in the center of Utah mining community at Carbonville. (See Figure 2-2.) Because of recent highway construction, truck shipment rates of 1.0 million tonnes (1.1 million tons) per year are presently contemplated. Based on average distance, the shipping cost is \$6.00 per tonne (\$5.50 per ton). With coal at \$16.50 per tonne (\$15.00 per ton), coal costs at Roosevelt are \$22.50 per tonne (\$20.50 per ton) for small plant sizes, 50 to 100 MW, or for startup or

Figure 2-2. - Coal Shipment Routes

test purposes.

Future shipments by rail of larger coal quantities may lower the relative cost, even though the existing rail route is much longer. For extremely large coal shipments, a study would be required to determine if a specially constructed dedicated coal railroad would further reduce relative costs, especially if future oil price increases make cost of electric rail transit more attractive than that of diesel truck. For quantities of coal for a 750 MW plant the cost of shipping could range from \$1.70 to \$3.50 per tonne (\$1.54 to \$3.18 per ton), depending upon the actual distance within the 160-to-320 kilometer (100-to-200-mile) range. Cost of delivered coal would then be between \$18.20 and \$20.00 per tonne (\$16.50 to \$18.00 per ton). Figure 2-3 compares the price of delivered coal at Roosevelt Hot Springs versus the other three sites examined in this study.

Based on the coal cost information presented, Table 2-2 gives the coal cost per joule (Btu) and the mills per kWh coal for hybrid plants of differing size. Table 2-2 also shows the required amount of coal for Roosevelt Hot Springs, given the plant size, assumed heat rate, and an assumed plant factor of 85 percent. Those figures applying to the 250, 500, and 750 MW hybrid plants are of special interest.

Figure 2-3. - Cost of coal versus rate of coal consumption

TABLE 2-2. - FUEL COST ESTIMATE DETAIL BREAKDOWN AND COMPARISON

Plant size, MW*	Assumed heat rate, 10^6 Joules/kWh (10^3 Btu/kWh)	10^{15} Joules/year (10^{12} Btu/year) from coal	Coal*** 10^3 tonnes/year (10^3 tons/year)	Coal cost *** 10^{-10} \$/J (10^{-7} \$/Btu) Mills/kWh fuel ** Roosevelt
50	10.6 (10.0)	3.36 (3.17)	125 (138)	8.0 7.0 (8.4)
100	10.5 (9.9)	6.65 (6.27)	248 (273)	7.7 6.9 (8.1)
250	10.5 (9.9)	16.63 (15.67)	619 (682)	7.5 6.6 (7.9)
500	10.5 (9.9)	33.25 (31.37)	1238 (1364)	7.4 6.6 (7.8)
750	10.5 (9.9)	49.88 (47.02)	1857 (2047)	7.4 6.6 (7.8)
1000	10.5 (9.9)	66.5 (62.7)	2475 (2729)	7.4 6.6 (7.8)
750 100% Coal at IPP site	10.5 (9.9)	58.7 (55.3)	2184 (2408)	7.4 7.8 (7.8)

*Total plant output including geothermal contribution; coal figures based on 85% coal contribution.

**based on net MWH, including "free" geothermal contribution

***based on 0.85 plant factor derived from postulated loading of 100% for 85% of the year and 0% for 15% of the year.

SECTION 3.0

WATER

3.1 Water Requirements

The consumption of water by an all coal-fired power plant is controlled by the makeup water required for the turbine exhaust condensing system. This system requires the disposal of nearly 2.30×10^6 J/kg (1000 Btu/lb) of steam exhausted by the turbine. A typical steam plant rejects most of this waste heat to the atmosphere usually by means of a wet cooling tower. Other workable methods of waste heat rejection consist of the wet/dry cooling tower, the dry cooling tower, the spray pond, the non-spray lagoon, and various combinations employing local bodies of water or rivers.

Among these methods, all consume water except the dry cooling tower which depends on large and costly water-to-air indirect heat exchangers in which the water does not contact the air. The other methods use direct contact with the atmosphere to exchange the waste heat. The direct contact aspect is the root cause of water consumption inasmuch as a large fraction of the heat is exchanged by the evaporation of the warm water. In a wet cooling tower, up to about 85 percent of the heat is rejected by evaporation with the remainder of the heat rejection dependent on conductive heat exchange and drift losses.

The turbine exhaust cooling water consumption is further dependent on the isentropic expansion efficiency of the turbine and the isentropic change in enthalpy for each pound of turbine steam flow. For a high temperature, high pressure turbine of the type proposed in the IPP study, an isentropic efficiency of 75 to 90 percent and an isentropic enthalpy change of 1.51×10^6 J/kg (650 Btu/lb) of turbine steam flow are assumed. Thus, the cooling water makeup requirement, W_m , in lb/hr may be calculated from ;

$$W_m = 3.413 \frac{E_f P}{\eta \Delta h}, \text{ where } E_f = \text{evaporation fraction} \quad (1)$$

P = output power, watts

Δh = isentropic enthalpy change, Btu/lb steam

η = isentropic efficiency

It is estimated that the IPP Plant, at an 85% plant capacity factor, would require 41.2×10^6 cubic meters (33 400 acre feet) of cooling makeup water per year which corresponds to an evaporation fraction of 0.70, an isentropic efficiency of .90, and an isentropic enthalpy change of 1.5×10^6 J/kg (650 Btu/lb) of steam. This amounts to 13.73×10^3 cubic meters (11.13 acre feet) per year per net MW.

Other water requirements are estimated to be:

	<u>Acre-feet</u> MW Year	<u>Cubic meters</u> MW Year
Plant O and M community	.37	456
Scrubber evaporation	1.35	1665
Ash and sludge disposal	.19	234
Waste water and miscellaneous losses	.40	393
Reserve	<u>1.83</u>	<u>2257</u>
	4.14	5005

If a plant cycle is used in which the geothermal fluid is flashed to produce steam, there may be a net production of water over than consumed in the cooling tower. The amount of this excess will vary with the resource temperature. For example, water at 177°C (350°F) could yield about 18.50×10^6 cubic meters (15 acre feet) per year per net megawatt from this source. The amount of fluid which can thus be permanently removed from the reservoir must consider that which is required for subsidence control.

3.2 Possible Sources of Water

Water for cooling towers and makeup for the hybrid plant can be obtained from several possible sources depending on the particular location of each

KGRA: ground water, the Los Angeles Aqueduct, or agricultural return water. Of course, spent geothermal water or steam would be available to all four geothermal sites.

If geothermal fluid is flashed to yield steam, which is then either condensed to produce water or is expanded through a turbine or other engine to yield work, a useful amount of relatively high quality water can result. If the fluid is flashed at atmospheric pressure, from about 10 to 25 percent of the hot water will appear as steam (depending on the initial water source temperature) which can be condensed to water. If the geothermal fluid is flashed at temperatures close to those proposed for the steam turbine exhaust condensing temperature then about twice as much water will be produced. If the flashed fluids product steam is used to drive an auxilliary turbine or engine the amount of produced water would be less than either of the above cases. However, because of the energy extracted by the turbine, there would be less heat to be rejected from the condensate and there could well be more pure water available to the system.

3.3 Water Availability at Roosevelt Hot Springs

Water rights in Utah are based on appropriation. The first Party using the water has the first right to the water, no matter for what purpose the water is used. As of December 1, 1976, the Roosevelt Hot Springs area has been closed to appropriation. However, water for cooling towers might be available in one or more of the following ways:

- Purchase an existing water right and petition the State Engineer for change of use
- Import water from outside the Milford Valley watershed
- Discover a new source of ground water and petition the State Engineer to appropriate additional waters in the area.

Water quality of ground water in the Milford area varies with depth and location, with the better quality water occurring in the southern part of the area at depths below 76 meters (250 feet). (See Table 3-1) Because the general

TABLE 3-1.- SUMMARY OF CHEMICAL-QUALITY DATA OF WATER FROM SELECTED WELLS
AND SPRINGS IN MILFORD VALLEY

	Number of Samples	Milligrams per Liter Range	Median
Wells 1970 - 72 Data			
Specific conductance (micromhos/cm at 25°C)	40	310-7 190	939
Total dissolved solids	35	224-4 600	569
Sulfate	40	25-1 500	140
Chloride	40	19-1 700	115
Hardness as CaCO ₃	40	23-2 000	385
Nitrate	34	0.0-14	1.3
Boron	33	0.0-2.2	.09
Springs			
Specific conductance (Micromhos/cm at 25°C)	24	100-2 760	795
Total dissolved solids	21	114-2 240	530
Sulfate	24	7.6-1 200	50
Chloride	24	5.0-290	76
Hardness as CaCO ₃	21	19-1 600	250
Nitrate	24	0.1-3.8	1.2
Boron	22	0.03-0.6	0.2

Source: Technical Publication No. 43, State of Utah, Department of Natural
Resources, 1974

ground water flow is to the north, the waters at the northern end of the valley contain a higher concentration of dissolved solids due to residual salts, a result of irrigation processes, evaporation, and transpiration.

3.4 Water Disposal

Ideally, the fluid disposal system should return the spent liquid to its original source in a quality that would not degrade the source, either for its initial use or for reasonable subsequent use.

Low quality waste water from certain plant processes and from the plant community would be treated in a conventional sewage disposal facility with secondary effluent being placed in a holding pond for observation and further treatment, if necessary, and then returned to the aquifer or receiving stream. Any dissolved solids recovered in the treatment plant would be combined with the spent geothermal fluids for injection. The waste and wash water from the demineralizer regeneration cycle would be segregated and added to the holding pond of pH adjustment prior to injection.

Sewage sludge along with the SO_2 scrubber sludge would be disposed in the sludge pit.

The final method of fluid and sludge disposal will depend on the compatibility of the receiving streams and aquifers to the materials to be disposed.

SECTION 4.0

TRANSMISSION

New transmission paths will be required to bring the bulk of plant output to the Los Angeles area. The new plant is conceived as a base load plant, and firm transmission must be available to allow for such operation. Existing transmission facilities in all transmission corridors are heavily loaded or committed. However, in some cases, firm wheeling arrangements can be made to transmit from 50 to 300 MW to the Los Angeles area over existing facilities with minor low cost modifications. In other cases, new transmission lines contemplated in connection with other large power generation projects can be increased in capacity to transmit large amounts of power at moderate cost. For large plants in the general case, the full construction costs of new transmission lines must be borne. Existing transmission lines may offer non-firm, off peak, or emergency backup transmission capacity which can reduce the redundancy normally required in new lines for reliable operation.

4.1 Basic Assumptions

Delivery to Victorville Substation. The bulk transmission lines will be built directly to the Victorville Substation of the Los Angeles Department of Water and Power which is used as a defined regional delivery point for this study. Victorville lies on a reasonable, direct, low cost transmission route, with minimum potential environmental complications, from all proposed sites.

- Los Angeles has studied actively all reasonable routes from Victorville into the San Fernando Valley, particularly to Station E, at which point Los Angeles and Burbank are already intertied. Los Angeles is already planning to enlarge the Victorville Substation and increase transmission capacity from Victorville to Station E. An agreement with Los Angeles to develop jointly capacity in addition to that already planned would result in minimum uncertainty, minimum environmental impact, and probably minimum cost to the City of Burbank, compared to the cost of

attempting to discover and develop an entirely separate transmission corridor through highly populated areas directly into Burbank. Los Angeles has been willing in the past to work with Burbank and other cities in similar projects, and Burbank's operating experience working in cooperation with Los Angeles has been excellent.

- Existing Los Angeles lines from Victorville to Station E could provide backup capacity for Burbank's firm capacity and would increase system reliability and lower cost substantially compared to one or even two all-Burbank lines from the desert area into town.

Double circuit line. The bulk transmission system will be double circuit line, for 605 MW plant size and larger, with each line alone capable of carrying the full load output of the plant briefly although normal full load operation will be with both lines in service. This design gives optimum continuity of service and reliability consistent with the concept of a base load plant. The two lines will be separated by as great a distance as economically and environmentally feasible to maximize the advantage. For plants smaller than 605 MW, in certain cases, over part of the route, intertie and wheeling arrangements with existing utilities may replace one of the two lines as an emergency backup transmission path, resulting in new construction of only one line, even though two paths will be provided.

Transmission voltage. Transmission voltage will be chosen so as to facilitate interconnection with existing transmission grids of other utilities at the site and along the route as much as possible, so as to increase reliability, operating flexibility and diversity of supply path.

AC Transmission. The transmission system between the plant and the first interconnection to existing switchyards or other transmission facilities is contemplated to be AC rather than DC for all plant sizes and locations studies. Present state of the art for converter facilities is such that DC transmission costs would probably be greater than AC costs for the plant sizes studied. Also, most of the approaches to solving transmission problems in this study involve interconnections with other transmission lines, which is impractical for a DC system. An exception is in the case where we propose use of the DC Intermountain Power Project transmission system as one concept based on joint-use of facilities.

However, with development work in process towards small converter facilities, it

is probable that a DC transmission system should receive serious consideration in any feasibility study of a specific project.

Two Transmission Concepts Considered. For purposes of cost comparisons, two transmission concepts were considered for each plant size, for each site. One concept, "Base Case, Terminus to Terminus", is for Plant Switchyard to Southern California Regional Delivery Point (Victorville) transmission. This would be all new construction, with no interconnections or joint use of facilities other than at the two Termini. Figure 4-1 shows the "Base Case" routes for the four sites. The other concept differs in detail from site to site, but is always based on interconnection and/or joint use of facilities. Such use may not prove feasible.

The Electric Switchyard costs, which are the same for each of the four sites, are shown in Table 4-1.

4.2 Environmental Impacts

All four sites are in relatively uninhabited areas and the probable transmission line routes to the Los Angeles area lie through relatively uninhabited areas. Many years of experience operating similar transmission lines in similar areas show very slight hazard to humans, very slight human objection to esthetic impact, and no significant adverse effects on vegetation or climate. Transmission lines offer perches to birds, and large birds are occasionally electrocuted; the transmission routes selected will not pass through nesting areas of endangered species of large birds. No positive or negative effect on the migration or survival of smaller birds by transmission lines has been determined.

Construction of transmission lines involves construction of roads which then offer access by motorcycles and off the road vehicles to new areas; the new activity by these vehicles can then have damaging effects on plant life, ground dwelling animals, archaeological sites, and soil compaction and cover causing increased runoff and erosion. Good construction practice includes removal of all construction roads not needed for subsequent maintenance and restoration of the land to its previous condition. New roads needed for maintenance access for the line are properly designed and constructed, properly maintained, and

Figure 4-1. - Possible transmission corridors

TABLE 4-1. - ELECTRIC SWITCHYARD CONSTRUCTION COSTS *

ITEM	Common For All Sites					
	50 MVA 138 kV	100 MVA 138 kV	250 MVA 230 kV	500 MVA 345 kV	750 MVA 345 kV	(2) 500 MVA 345 kV
Site Procurement & Preparation	\$200,000	\$200,000	\$700,000	\$800,000	\$800,000	\$800,000
Fencing, Buildings & Roads	100,000	100,000	200,000	300,000	300,000	300,000
Equipment Foundations	150,000	150,000	300,000	400,000	400,000	500,000
Equipment Structures	200,000	200,000	550,000	800,000	800,000	1,000,000
Electrical Grounding System	100,000	100,000	180,000	300,000	300,000	300,000
Aux. Power & Control Systems	400,000	400,000	1,150,000	1,800,000	1,800,000	1,800,000
Engineering, incl Field Engrg	140,000	140,000	200,000	350,000	350,000	400,000
Miscellaneous	415,000	465,000	1,250,000	2,000,000	2,000,000	2,000,000
Main Power Transformer	500,000	760,000	1,500,000	2,400,000	3,200,000	4,800,000
Start-up Transformer	65,000	110,000	235,000	300,000	400,000	600,000
House Transformer	130,000	200,000	500,000	1,200,000	1,300,000	1,300,000
Power Circuit Breakers	300,000	350,000	525,000	1,000,000	1,000,000	1,300,000
Disconnect Switches	125,000	150,000	225,000	260,000	260,000	360,000
Miscellaneous Power Equipment	75,000	75,000	150,000	240,000	240,000	340,000
Total	\$2,900,000	\$3,400,000	\$7,665,000	\$12,150,000	\$13,150,000	\$15,700,000
Less, For main, house & Startup transformers & related equip- ment (plant components).	895,000	1,300,000	2,735,000	4,800,000	5,800,000	7,700,000
Net cost, switchyard only	2,005,000	2,100,000	4,930,000	7,350,000	7,350,000	8,000,000
Switchyard cost/kVa	\$ 40.10	\$ 28.00	\$ 19.72	\$ 14.70	\$ 9.80	\$ 8.00

* Also see back-up sketches immediately following this table.

							CITY OF HURBANK
							PUBLIC SERVICE DEPARTMENT
N.					BY	CHECK APP'D DATE	DRAWING NO
	REVISIONS						
DRAWN KWC	SCALE NONE	CHECK	APP'D	DATE 12-1-76			

NO.	REVISIONS				DATE	APPROVED	CHECK	SCALE	DRAWN	KWC	DATE	CITY OF BURBANK PUBLIC SERVICE DEPARTMENT
	BY	CHECK	APPROVED	DATE								

GENERATING UNIT:
100 MVA
SWITCHYARD:
138 KV. 650 KV. B.I.L.

GENERATING UNIT:
250 MVA.

SWITCHYARD:
230 kV, 900 kV. B.I.L.

CITY OF BURBANK PUBLIC SERVICE DEPARTMENT					
DRAWING NO.					
NO.	REVISIONS			BY	CHECK APP'D DATE
DRAWN KWC	SCALE NONE	CHECK	APP'D	DATE 12-1-76

GENERATING UNIT:
500 MVA

SWITCHYARD:
345 kV. 1300 kV B. I. L.

CITY OF BURBANK PUBLIC SERVICE DEPARTMENT						DRAWING NO.
NO.	REVISIONS	BY	CHECK	APP'D	DATE	
DRAWN KWC	SCALE NONE	CHECK	APP'D	DATE 12-1-76

GENERATING UNIT:
750 MVA
SWITCHYARD:
345 kV. 1300 kV B.I.L.

						CITY OF LURDANK PUBLIC SERVICE DEPARTMENT	
						DRAWING NO.	
NO.	REVISIONS			BY	CHECK	APP'D	DATE
DRAWN KWC	SCALE NONE	CHECK	APP'D	DATE 12-1-76

GENERATING UNIT:
 2 @ 500 MVA, 1000 MVA TOTAL
 SWITCHYARD:
 345 kV. 1300 kV. B. I. L.

						CITY OF BURBANK PUBLIC SERVICE DEPARTMENT	
						DRAWING NO. S-6	
NO.	REVISIONS				BY	CHECK	APP'D
							DATE
DRAWN KWC		SCALE NONE	CHECK	APP'D <i>[Signature]</i>	DATE 12-8-76		

closed to unauthorized public access as much as possible.

Present studies resulting from concern over effects of electrostatic fields on human and animal life are confined to voltages in excess of those considered for this project.

The main impact from transmission lines in uninhabited areas is esthetic. Proper route selection minimizes esthetic intrusions by locating lines away from scenic sites and scenic highways, and avoiding conspicuous locations such as hilltops. When lines must occupy scenic vistas, the impact can be minimized by locating the right-of-way optimally with respect to the direction of view and properly routing access roads. It is proposed to use natural wood poles for low voltages and galvanized gray steel towers for high voltages, and gray conductors and gray insulators for all voltages, which further minimizes esthetic impact. An archaeological survey would precede final route selection and construction.

4.3 General Considerations

The previous discussion has described characteristics and costs of new project-owned transmission lines directly from the site to Victorville Substation. In the discussion that follows, interties, wheeling agreements, and other alternatives are explored. These alternatives are all conjectural in that, while they follow reasonable and expected industry operating procedures and methods, in few cases have other utilities involved been consulted as to their ability and willingness to cooperate in such joint operations.

The purpose in presenting this discussion is to suggest flexible transmission arrangements for the following situations:

- The plant may begin operating as a pilot plant, with plans to go ahead and build a full size plant contingent on operating experience at lower output levels.
- The plant may be constructed in stages with delays in between to allow for design optimization based on operating experience.
- The main project-owned transmission lines may be delayed in construction due to design difficulties, construction difficulties, or environmental litigation.

In each of these eventualities, it would be desirable to market small amounts of power over a temporary transmission path which is to be superseded at a later date by project-owned facilities.

Also, interties with local utilities should be considered for other reasons:

- A non-firm intertie wheeling path agreement could provide backup in the eventuality of the project-owned transmission lines being out of operation for a time.
- Displacement operation, where power generated in Utah is utilized in Utah while power which would normally be imported into the Utah area is sent to Southern California instead, may reduce total losses, and presupposes an intertie operation agreement.
- A Utah source of power intertied with the Utah power system can improve the reliability of the local power system, an additional compensation to Utah residents for permitting the plant and its lines to be built in their community.
- The plant will require construction power from the local power supply system; if the supply station is planned with eventual intertie operation in mind, re-design and re-construction can be minimized.

The costs of project-owned transmission lines given in Table 4-2 represent reasonable estimates of costs of transmission under most likely circumstances. Intertie contract operation is unlikely to reduce these costs, since all Southwestern utilities have been experiencing load growth and existing transmission lines are loaded to capacity. There is no spare capacity available at low cost. However, intertie operation may have cost benefits in the following ways:

- Intertie operation might allow faster startup, since new construction required would be local and of small dimensions. Modification of large bulk transmission lines to effect an increase in capacity would not involve construction on entirely new routes, but light construction on existing routes. This would minimize delay due to environmental reporting and litigation.
- Joint use and ownership of new large bulk transmission lines reduces total losses and can reduce costs for each participant over that of many smaller lines, and minimizes environmental impact in many cases.
- Intertie operation changes the relative distribution of costs between initial costs and operating costs, permitting some optimization of cash flow. Cost figures given in the following discussion are only for the purpose of evaluating this possibility by suggesting capital costs required, with remaining costs to be paid in operating costs and wheeling

TABLE 4-2. - FIRST COST: BASE CASE ELECTRIC TRANSMISSION, TERMINUS TO TERMINUS

		Line Length km. (miles)	50 MW	100 MW	250 MW	500 MW	750 MW	1000 MW
ROOSEVELT HOT SPRINGS								
Transmission Voltage			138 kV	220 kV	345 kV	345 kV	(2) 345 kV	(2) 345 kV
Roosevelt Switchyard			\$ 2,005,000	\$ 4,930,000	\$ 7,350,000	\$ 7,350,000	\$ 7,350,000	\$ 8,000,000
Roosevelt-Paragonah Line Segment	82	(51)	1,683,000	3,366,000	6,375,000	6,375,000	12,750,000	12,750,000
Paragonah-McCullough Line Segment	304	(189)	6,237,000	12,474,000	23,625,000	23,625,000	47,250,000	47,250,000
McCullough-Victorville Line Segment	261	(162)	7,095,000	14,190,000	26,875,000	26,875,000	53,750,000	53,750,000
Victorville Substation*			<u>1,995,000</u>	<u>3,500,000</u>	<u>6,900,000</u>	<u>8,850,000</u>	<u>9,350,000</u>	<u>10,000,000</u>
Total	647	(402)	\$ 19,015,000	\$ 38,460,000	\$ 71,125,000	\$ 73,075,000	\$130,450,000	\$131,750,000

fees. In no case are they to be understood as total costs, or to suggest significantly lower total costs in comparison with project-owned transmission.

4.4 Construction Power

Construction power for the project will presumably come from a Utah Power and Light 46-kV line which crosses the property. During construction, testing, startup, and pilot operation, small amounts of generated power could conceivably be fed into the 46-kV system through this line also. It may be determined to retain this capability when the plant becomes fully operational in order to provide reliable service continuity to local loads, including the City of Milford, considering that the support of local residents and property owners may be a significant factor in obtaining necessary permits to build the plant. Considering problems in power flows and other operational constraints, generation into the 46-kV system would be limited to the case of the 50 or 100 MW plant operation.

Cost of 46-kV construction service transformer station (increment to be added to switchyard):

46-kV Transformer Size	Plant Size	Cost ⁴
20 MVA ¹	50 MW	\$480,000
20 MVA ¹	100 MW	480,000
25 MVA ²	250 MW (construction service only)	430,000
25 MVA ²	500 MW (construction service only)	430,000
None ³	750 MW (construction service only)	180,000
None ³	1000 MW (construction service only)	180,000

¹ 46-kV to 138-kV (based on major transmission voltage of 138-kV)

² 46-kV to 138-kV

³ Assuming 46-kV in-plant auxiliary power distribution system

⁴ Includes estimated 3-mile 46-kV pole line construction

Cost of additional equipment required to enable feeding power into 46-kV system (50 and 100 MW plants only):

Communications, control and protective devices \$50,000

4.5 Base Case Transmission, Terminus to Terminus

For plant sizes from 50 MW through 600 MW, a base case approach has been estimated based on a single transmission circuit between the power plant switchyard and the Southern California Regional Delivery Point (Victorville). For plants from 605 MW through 1000 MW, the base case was estimated for two lines. Table 4-3 shows cost estimates for the Roosevelt Hot Springs base case. Table 4-4 gives the transmission losses. Figure 4-1 shows the base case line(s) routing.

4.6 Transmission Concepts Based on Interconnections and/or Joint-Use Facilities

For a plant size of 50 to 200 MW, it is proposed to construct two 138-kV lines, parallel to the existing 46-kV for at least part of the route, 27 kilometers east to connect with Utah Power and Light's 138-kV line which connects Sigurd Substation to Beaver Substation. The line will be broken into two segments joined at the Roosevelt Substation to form a Sigurd-to-Roosevelt line and a Roosevelt-to-Beaver line. This arrangement assumes the agreement and cooperation of Utah Power and Light Company, which should be forthcoming in consideration that by tying into Roosevelt Power Plant they obtain an alternate power source and therefore improve reliability on their 138-kV system. (See Figure 4-2.)

Some cash payments to UPL may be required for them to make engineering studies and revisions in their substations; these payments may be offset by payments from UPL to Roosevelt for energy or standby capacity service to the UPL system in the future. Also, UPL may require some cash payment for their work in arranging an outage to permit the line junction to be constructed.

This concept assumes that the energy sent to Victorville will be a result of displacement involving Intermountain Power Project, Intermountain Consumer

TABLE 4-3. - ANNUAL COST OF TRANSMISSION

Site, plant Capacity	Voltage	First Cost	Annual *, Capital Cost	Annual O & M Cost	Total Annual Cost	MWh at Busbar/Year	Percent Losses	MWh at Victorville	Mills/kWh ** Transmission
		A	B	C	D = B + C	E	F	$G = E \times \left(\frac{100-F}{100}\right)$	H = D/G
ROOSEVELT HOT SPRINGS									
647 km (402 miles)									
50 MW	138 kV	\$ 19,015,000	\$1,381,400	\$112,440	\$ 1,493,840	372,555	17%	309,200	4.83
100 MW	220 kV	38,460,000	2,794,000	191,280	2,985,280	745,110	7%	692,950	4.31
250 MW	345 kV	71,125,000	5,167,000	306,600	5,473,600	1,862,775	7%	1,732,400	3.16
500 MW	345 kV	73,075,000	5,308,800	318,300	5,627,100	3,725,550	9%	3,414,800	1.65
750 MW	(2) 345 kV	130,450,000	9,477,000	359,490	9,836,490	5,588,325	10%	5,029,500	1.96
1000 MW	(2) 345 kV	131,750,000	9,751,500	367,290	10,118,790	7,451,100	9%	6,780,500	1.49

*6 percent, 30 years

A from Table 4-2

F from Table 4-5

E = plant size x 8766 x .85

** Does not include cost of losses

TABLE 4-4. - CALCULATION OF TRANSMISSION LOSSES FOR BASE CASE, TERMINUS TO TERMINUS

ASSUMPTIONS AND BASIC CALCULATIONS

Site, Distance to Victorville	MW/MVA Sent	Nom. Line Voltage	Nom. Max. Line Amps	Conductor Size ACSR, Resistance	kW Losses at Nominal Load	MWh/Year Losses	Losses as % of Total Generation
ROOSEVELT HOT SPRINGS,	50/60	138 kV	250	954 kcm, 45	8,440	62,800	17%
402 Miles	100/120	220 kV	316	(2) 954/ ϕ , 23	6,890	51,300	7%
	250/300	345 kV	502	(2) 954/ ϕ , 23	17,390	129,500	7%
	500/600	345 kV	1003	(2) 1510/ ϕ , 14.5	43,700	325,200	9%
(2 lines)	750/900	345 kV	753 x 2	(2) 954/ ϕ x 2, 23	78,250	582,600	10%
(2 lines)	1000/1200	345 kV	1003 x 2	(2) 1510/ ϕ x 2, 14.5	174,700	650,400	9%

Assumptions:

8760 hours/year, 85% plant capacity

FIGURE 4-2

Power Association, and Utah Power and Light facilities, and the purchase of an "interest" in the IPP-Victorville DC line and facilities.

Cost of 138-kV Roosevelt Switchyard:

Plant Size	Cost
50 MW	\$2,005,000
100 MW	2,100,000

Cost of total 27 km (17 miles) (minimum) 138-kV double circuit transmission (34 miles minimum total):

Plant Size	Cost
50 or 100 MW	\$2,125,000

Payments to Utah Power and Light for studies, outages, equipment revisions:

Plant Size	Cost
50 or 100 MW	\$ 150,000

An apportioned share of IPP DC line facilities costs must be added.

Utah Power and Light has indicated interest in upgrading the 138-kV Sigurd-Beaver Line to 230-kV, or perhaps constructing a new 230-kV Sigurd-Paragonah Line on the same or nearby right-of-way. This higher voltage level would serve a plant output of up to 300 MW. If the connection is to the 230-kV line instead of the 138-kV line, the costs given above are changed as follows:

Costs of 230-kV Roosevelt Switchyard:

Plant Size	Cost
250 MW	\$4,930,000

Cost of 54 km (34 miles) of 230-kV transmission:

Plant Size	Cost
250 MW	\$2,278,000

Payments to Utah Power and Light for studies, outages, and equipment revisions:

Plant Size	Cost
250 MW	\$150,000

This concept is also based on displacement of energy, involving IPP, ICPA, and UPL facilities, and the purchase of an "interest" in the IPP-Victorville DC line and facilities.

For plant output greater than 200 MW (for the 138-kV transmission), or 300 MW (for the 230-kV scheme), it is proposed to construct 345-kV lines 82 kilometers south to Paragonah Substation. This is a proposed point of delivery for power from the proposed IPP plant to the ICPA system. It is assumed that a substantial amount of the power from Roosevelt will be used by the ICPA system members serving St. George, Utah and Ely, Nevada, and other local communities, and that the remainder of the plant output will be transferred over the planned 345-kV Paragonah-IPP line and then transferred to Los Angeles via the IPP-Victorville 500-kV DC line.

That portion of ICPA's IPP entitlement that is displaced by Roosevelt power will also be transmitted to the Los Angeles area over the IPP DC line, requiring that the DC line be increased in capacity by an amount equal to the total interest in the Roosevelt plant held by Los Angeles area utilities, which will require cash payments to IPP for re-design and additional construction, as well as their agreement to such an arrangement. An additional 345-kV circuit from Paragonah to IPP will be required for Roosevelt plant net outputs to Los Angeles of 750 MW or greater. Cost of 82 kilometers (51 miles) double or single-circuit 345-kV Roosevelt-Paragonah transmission line:

Plant Size	Cost
750 or 1000 MW	\$12,750,000 double circuit
500 MW	6,375,000 single circuit

Cost of 345-kV Roosevelt Switchyard:

Plant Size	Cost
500 MW	\$7,350,000
750 MW	7,350,000
1000 MW	8,000,000

Cost of additions to Paragonah 345-kV Substation:

Plant Size	Cost
500, 750 or 1000 MW	\$1,500,000

Cost to add an additional 345-kV Paragonah-IPP line:

Plant Size	Cost
750 or 1000 MW	\$5,100,000

Cost of required additional capacity in the IPP-Victorville line:

Plant Size	Cost
500 MW ¹	\$ 86,000,000
750 MW ¹	129,000,000
1000 MW ²	180,000,000

¹ Includes additional converter stations costs and costs for higher capacity lines

² Includes additional converter station costs and costs for additional line security

4.7 Other Possibilities

Should IPP not be built, it would be necessary to establish a firm transmission path to Victorville Substation from Paragonah Substation. It may be possible to work out a wheeling agreement, whereby the entire output of Roosevelt Plant will be served to the ICPA and UPL systems at Paragonah (or

Sigurd Substation) and power will be delivered to the Los Angeles area over transmission lines belonging to UPL, SCE, Nevada Power Company, and the Los Angeles Department of Water and Power. LADWP has indicated informally that up to 300 MW firm capacity may be available from McCullough Substation (near Las Vegas) if a modification to their transmission lines were performed. Transmission lines between Paragonah and McCullough, a distance of 320 km (200 miles) do not appear to have sufficient available capacity for any significant amount of additional energy. New transmission lines would have to be built, and substantial cash payments would be required, in contract negotiations with four or five utilities. In addition, for more than 300 MW, additional transmission lines would have to be built from McCullough to Victorville.

It may be possible to work out a trade-off agreement, whereby the entire output of Roosevelt Plant will be served to the ICPA and UPL systems as before, in trade for hydroelectric capacity at Hoover and Glen Canyon; this hydroelectric energy would be transmitted to Victorville Substation over existing lines belonging to LADWP. Informal discussions with LADWP suggest that up to 300 MW capacity may be available at relatively low cost from McCullough Substation (near Hoover Dam) to Victorville Substation. For amounts of power greater than 300 MW, new transmission lines would have to be constructed.

The negotiation of a wheeling agreement for about 200 MW from Glen Canyon Dam may be possible as there are existing high capacity transmission lines that connect the Glen Canyon generating station with McCullough Substation. For firm transmission paths to serve a plant of 200 MW or more, new transmission lines would have to be constructed.

SECTION 5.0

SEISMICITY

The data presented below is an early site review based on information obtained from published sources. Field geologic studies, exploratory borings or laboratory testing has not been initiated for this review nor has a specific site spectral response analysis been done.

Because Roosevelt Hot Springs is within an area of moderate to high seismicity, any proposed plant structure and/or transmission system constructed in this area could be subject to some structural damage depending upon the degree of seismicity and related effects of fault movement.

5.1 Definitions of Active Fault

An active fault has been defined by the California Council on Intergovernmental Relations in the General Plan Guidelines, September, 1974, as: A fault that has moved in recent geologic time and which is likely to move again in the relatively near future. For geologic purposes, there are no precise limits to recency of movement or probable future movement that define an 'active fault'. Definitions for planning purposes extend on the order of 10 000 years or more back and 100 years or more forward. The exact time limits for planning purposes are usually defined in relation to contemplated uses and structures.

On the other hand, the Atomic Energy Commission (1973), as a part of their geologic siting criteria for nuclear power plants, has defined a capable (active) fault as one which has exhibited one or more of the following characteristics:

- Movement at or near the ground surface at least once within the past 35 000 years or movement of a recurring nature within the past 500 000 years

- Microseismicity instrumentally determined with records of sufficient precision to demonstrate a direct relationship with the fault
- A structural relationship to a capable fault according to either of the above characteristics such that movement of one could be reasonably expected to be accompanied by movement on the other.

For engineering purposes, a fault should be considered active if movement is now occurring or is likely to occur within the lifetime of the structure, or if such movement could cause damage to the structure.

The possibility of surface rupture or of large earthquakes on a particular fault can, in principle, usually be determined from seismologic, geologic, and geodetic data, such as earthquake history, the distribution of epicenters, and the ages of displacements. However, in practice, all or part of the data are often completely lacking for almost all faults. In any event, faults which are active, based on geologic data, such as offset of Holocent materials, present a potential seismic hazard at least over the next 100 years.

Because published seismic-rating of faults reported herein is in terms of magnitude or intensity, the relationship of these terms to seismicity is defined as:

Magnitude: Magnitude is an objective, instrumentally determined rating of the size (1-10) of an earthquake. Magnitude is calculated from the wave amplitude recorded by seismographs at any distance from the source of an earthquake. Each upward step of one magnitude means a ten-fold increase in the amplitude of the recorded waves because the scale is logarithmic. The scale has no arbitrary "ceiling", but 8.9 appears to be the largest magnitude of any known earthquake.

Intensity: Intensity is a qualitative, noninstrumental rating of the degree of shaking at a specified place. The earthquake intensity at each locality shaken by an earthquake is rated on the basis of an "earthquake intensity scale." The Modified Mercalli Intensity Scale of 1931 is the one most commonly used today in the United States. In this scale, the grades of intensity are indicated by Roman numbers from I to XII.

5.2 Effects Other Than Ground Shaking

Major seismic-related effects which could affect the proposed plant structures besides ground shaking during an earthquake are liquefaction, subsidence, landslides and ground rupture.

Liquefaction: This phenomenon is defined as the transformation of a granular material from a solid state into a liquefied state as a consequence of increased pore-water pressure due to ground vibration or shaking caused by earthquakes. Conditions which control liquefaction include permeability, grain size and depth of the water table. For example, in coarse sands and gravels with no drainage impedance, pore pressures may dissipate so rapidly that a liquefaction condition cannot develop. With the water table at depths below 50 feet, no significant increase of pore pressure or its effect is noted for near surface materials. Liquefaction could occur in thick alluvial deposits where the water table is close to the surface.

Subsidence: This is a relatively rare phenomenon which involves the rapid lowering of the ground surface due to internal collapse of nonconsolidated materials or collapse of a subsurface void. This conceivably could occur in the thick alluvial deposits but substantiating evidence is not available.

Landslides: Slides and rock falls are types of ground failure that can occur during an earthquake. The landslides may occur in unconsolidated sloping ground due to rapid increases in pore pressure and resultant loss of shear strength or in steep ground underlain by consolidated and/or cemented materials, or in severely jointed-fractured rock. These phenomena are more apt to impair transmission systems than the power plant structures because of terrain considerations in plant design.

Ground Rupture: In most observed earthquakes, at least in California, ground rupture generally is limited to zone a few hundred feet wide along the trace of the last known movement. However, the possibility does exist for sympathetic ground rupture to occur along unknown secondary or tertiary faults that might underlie alluvial deposits of the Roosevelt Hot Springs areas.

5.3 Seismicity of Utah, With Emphasis on Roosevelt Hot Springs

The earthquake epicenter map of Utah is shown on Figure 5-1. About 95 percent of the faults shown are high-angle normal faults of the Basin and Range type, Cenozoic in age (Cook and Smith, 1967). Utah lies along the Intermountain Seismic Belt, a zone of pronounced earthquake activity that extended north from Arizona through Utah, eastern Idaho and into western Montana. Most of Utah's recorded earthquakes have occurred along the boundary between the Basin and Range and the Colorado Plateau-Middle Rocky Mountain physiographic provinces (Cook and Smith, 1967).

An active seismic zone intersects this seismic belt northward from Cedar City (Figure 5-2). Seismic activity along this zone is coincident with Tertiary age rhyolites and an E-W zone of calderas (Petersen, 1977, Per. Com.).

The Sevier and Tushar fault zones (Figure 5-2) are the most active seismic areas of Utah (Cook and Smith, 1967). The historic seismic activity of the Roosevelt Hot Springs and Cove Fort areas of southwestern Utah shows a relatively low level when compared to these areas. However, five shocks with maximum estimated Mercalli intensity VI occurred in the Beaver Lake Mountains 18 km northwest of Milford in 1908 (Williams and Tapper, 1953). And, as late as 1966, an earthquake of magnitude 4.9 was located near the Milford area (NOAA Historical File of Earthquakes).

The north end of the Hurricane Fault Zone (Figure 5-1) has experienced sporadic earthquake activity with intensities as large as V in both the Beaver and Cove Fort areas in past years (Cook and Smith, 1967). Locations of some of the major fault zones in Utah are shown on Table 5-1.

Roosevelt Hot Springs is shown on zone 3 in the Uniform Building Code seismic risk map of the United States, and, therefore, could experience an earthquake of intensity VIII ($M 6.0^+$). Maximum acceleration data are not available for the Roosevelt Hot Springs area. However, effective peak acceleration of approximately 0.1 g is indicated for the KGRA on the seismic risk map (Figure 5-3).

Figure 5-1

Figure 5-2. - Major fault zones of Southwestern Utah

TABLE 5-1. - LOCATIONS OF SOME MAJOR FAULT ZONES IN UTAH

Name of fault or fault zone	Location
Beaver Mountains	Beaver Mountains, Southwestern Utah
Bear Lake	Bear Lake, Northern Utah
Clarkston	Clarkston Mountain, Northern Utah
Dayton	Northern Utah
Crawford Mountains	Crawford Mountains, Northern Utah
East Cache	Cache Valley, Northern Utah
Fish Springs	Fish Springs Range, West central Utah
Hansel Valley	Hansel Valley, Northern Utah
Hurricane	Southwestern Utah
Mineral Mountains	Mineral Mountains, Southwestern Utah
Sevier	South Central Utah
Thousand Lake	Central Utah
Tushar (Elsinore)	South central Utah
Wasatch	North central Utah

SOURCE: Cook and Smith, 1967.

Seismic risk map showing effective peak acceleration (California Applied Technology Council) in Civil Engineering, December, 1976.

Figure 5-3

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SECTION 6.0

CLIMATE

The Roosevelt Hot Springs area of Utah is considered arid to semiarid because the average rainfall is under 10 inches per year. The mean of the record rainfall is 8.57 inches. The general cause of the aridity is descending air. Heated by compression as it descends, the air becomes increasingly able to retain water vapor, and so tends to evaporate moisture from the valley rather than precipitate moisture. The general flow of air is from the west and has been stripped of moisture as it crosses the Sierra Nevada. Temperature averages vary from 25°F in January to 75°F in July (See Table 6.1).

Data on wet bulb temperature was obtained from the Cedar City Station, which is about 80 miles south of Roosevelt Hot Springs.

	1½ Level
Wet bulb (°F)	65
Dry bulb (°F)	94

The wet bulb temperature of 65°F is believed reliable because other Utah cities have similar wet bulb temperatures at the 1½ level. (Provo 67°F; Salt Lake City, 67°F; Dupuay, 65°F; Hill AFB, 65°F). At Cedar City, the temperature dips below -1°F only 88 hours out of the year.

Table 6-2 presents the total evaporation and wind movement at Milford, Utah.

TABLE 6-1. - PRECIPITATION AND AVERAGE TEMPERATURE OF THE MILFORD VALLEY, 1966-1972.

Year	Total Precipitation												Annual
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
1966	0.57	0.88	0.42	0.59	0.28	0.11	0.15	0.40	0.25	0.99	0.34	2.45	7.43
1967	1.07	0.20	1.10	0.41	0.55	2.43	1.42	0.32	2.60	0.22	0.52	0.83	11.67
1968	0.17	0.87	1.08	1.33	0.46	0.15	0.97	0.98	0.12	0.93	0.27	0.83	8.16
1969	1.63	1.27	1.17	1.76	0.27	1.22	1.36	0.64	0.44	0.90	0.63	0.34	11.63
1970	0.23	0.35	0.86	1.09	0.08	0.28	1.38	0.76	1.33	0.27	0.74	0.45	7.82
1971	0.25	1.30	0.31	0.91	1.06	0.15	0.48	1.59	0.49	2.47	0.20	1.33	10.54
1972	0.05	0.01	0.00	0.96	0.02	0.66	0.04	2.52	0.62	2.61	0.95	2.21	10.65
Mean of Record	0.62	0.78	0.98	0.84	0.66	0.43	0.73	0.74	0.57	0.82	0.63	0.77	8.57

Year	Average Temperature												Annual
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
1966	24.9	28.9	38.6	47.6	59.8	66.1	74.9	73.4	64.1	49.3	41.5	26.0	49.6
1967	21.1	33.6	42.5	42.8	54.4	62.1	75.3	75.7	64.2	52.3	41.8	19.6	48.8
1968	24.1	39.5	41.5	42.7	54.6	67.2	74.3	67.9	61.0	50.9	37.9	25.2	48.9
1969	33.0	32.4	35.1	48.2	61.2	63.1	74.9	77.1	66.7	44.1	36.0	31.8	50.3
1970	31.0	37.8	37.0	41.7	57.1	66.1	75.1	75.9	59.2	46.0	40.0	30.1	49.7
1971	29.8	30.4	38.4	46.7	52.9	66.1	75.7	74.2	58.7	45.0	34.8	25.1	48.2
1972	29.1	35.7	44.3	47.6	56.7	68.2	75.7	70.5	61.0	49.6	34.9	15.8	49.1
Mean of Record	25.6	32.1	39.4	47.7	56.6	65.6	74.4	72.2	62.3	50.1	37.1	27.7	49.2

Source: Local Climatological Data: Milford, Utah: U. S. Department of Commerce, NOAA Environmental Data Service, 1972.

TABLE 6-2. - TOTAL EVAPORATION AND WIND MOVEMENT OF THE MILFORD VALLEY, 1975-76

Station		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Milford WED AP	EVAP	-	-	-	6.308	8.418	12.28	14.55	14.07	9.91	6.508	-	-	-
	WIND	-	-	-	4140	3743	3047	3066	3002	2422	29008	-	-	-
	MAX	-	-	-	55.7	67.1	77.3	85.0	80.5	75.7	63.7	-	-	-
	MIN	-	-	-	24.3	39.2	47.3	55.1	50.7	45.9	36.8	-	-	-

Source: National Climactic Center
 NDAA for Milford, Utah