COLORADO RIVER BASIN

SALINITY CONTROL PROJECT

Paradox Valley Unit

DEFINITE PLAN REPORT

September 1978

UNITED STATES
DEPARTMENT OF THE INTERIOR
Cecil D. Andrus, Secretary

BUREAU OF RECLAMATION
R. Keith Higginson, Commissioner

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UPPER COLORADO REGION
N.W. Plummer, Regional Director

SUMMARY SHEETS

Paradox Valley Unit

Colorado River Basin Salinity Control Project

LOCATION

The Paradox Valley Unit would be located in Montrose and San Miguel Counties of southwestern Colorado in the Upper Colorado River Basin.

PLAN

The unit would be designed to reduce the salinity of the Dolores and Colorado Rivers by pumping brine ground water from a well field located along the Dolores River in Paradox Valley and thus preventing it from surfacing in the riverbed. A test well field has already been installed as part of a design data collection program, and other facilities required for brine treatment and disposal would be added during unit construction.

The brine would be piped from the well field to a nearby hydrogen sulfide stripping plant, where potentially toxic and corrosive gas would be converted into sulfur. An operational headquarters would be constructed at the site of the stripping plant. The treated brine and sulfur would be piped from the stripping plant to the proposed Radium Evaporation Pond for disposal. The pond would be located in Dry Creek Basin to the southeast of the well field, and eight pumping plants would be installed on the pipeline to lift the brine over the divide between Paradox Valley and the basin.

To reduce adverse impacts on wildlife, a wildlife area would be developed near the evaporation pond and other areas temporarily disturbed by construction would be seeded with plant species valuable as wildlife habitat. Since the wildlife area was not included in the unit plan when it was authorized, the approval of the appropriate congressional committees would be required. Also included as part of the unit would be a cultural resource program to collect and preserve archaeological information from two sites located within the proposed evaporation pond.

EFFECTS ON COLORADO RIVER (average annual)

Stream depletion (acre-feet)	3,950
Decrease in salt load (tons)	180,000
Effects on salt concentration at Imperial Dam (mg/l)	
Increase from concentrating effect of stream depletion	0.4
Decrease from reduction of salt load	18.6
Net decrease	18.2

ESTIMATED COSTS

Construction costs (January 1977 prices)	
Salinity control	
Brine well field	$1,900,000
Hydrogen sulfide stripping plant	2,300,000
Brine pipeline	5,900,000
Brine pipeline pumping plants	4,800,000
Radium Dam, Dike, and Evaporation Pond	33,000,000
Transmission lines and substations	590,000
Permanent operating facilities	175,000
Operation and maintenance housing	390,000
Capitalized movable equipment	1,010,000
Service facilities	820,000
Depreciation and salvage	-1,570,000
Investigations (Reclamation fund)	456,000
Wildlife mitigation	610,000
Subtotal	50,381,000
Cultural resource program	9,000
Total	50,390,000
Annual equivalent cost of construction	3,175,000
Annual operation, maintenance, and replacement costs (1974-76 prices)	332,300
Total annual costs	3,507,300
Annual equivalent cost per mg/l of net salinity decrease at Imperial Dam	192,700

COST ALLOCATIONS (100-year period at 5 5/8 percent interest)

	Construction costs	Annual operation, maintenance, and replacement costs
Reimbursable costs		
Salinity control facilities	$12,595,000	$84,600
Nonreimbursable costs		
Salinity control facilities	37,786,000	247,700
Cultural resource program	9,000	
Subtotal	37,795,000	247,700
Total	50,390,000	332,300

REPAYMENT OF REIMBURSABLE COSTS (50-year repayment period)

	Construction costs	Annual operation, maintenance, and replacement costs
Lower Colorado River Basin Development Fund	$10,706,000	$70,200
Upper Colorado River Basin Fund	1,889,000	12,400
Colorado Division of Wildlife		2,000
Total	12,595,000	84,600

PROJECT FEATURES

	Number	Depth (feet)	Capacity (cfs)
Wells			
Brine production wells	18	48-155	0.1-1.1
Ground water monitoring wells	68	20-300	
		Length (miles)	
Brine pipeline		20.5	5
Brine pipeline pumping plants	8		5.26

	Radium Dam	Radium Dike
Dams (feet)		
Height above streambed	87	56
Crest length	8,300	7,500
Evaporation Pond		
Capacity (acre-feet)		
Flood control	18,700	
Inactive	62,060	
Dead	6,040	
Total	86,800	
Surcharge	6,540	
Maximum water surface area (acres)	3,750	

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CONTENTS (Continued)

Reports of Cooperating Agencies

Fish and Wildlife Service

Bureau of Mines

INTRODUCTION

This report presents the results of definite plan studies on the Paradox Valley Unit of the Colorado River Basin Salinity Control Project. Located in southwestern Colorado in the Upper Colorado River Basin, the unit would be designed to reduce the introduction of salt into the Colorado River through one of its major tributaries, the Dolores River. The unit was authorized for construction by the Colorado River Basin Salinity Control Act of 1974 (Public Law 93-320) as part of a basinwide program to control salinity levels in the Colorado River while the Colorado River Basin States and the Republic of Mexico continue to develop and use their apportioned shares of water from the river and its tributaries. Title I of the Act, which was directed toward controlling the salinity of river water below Imperial Dam for use in the United States and Mexico, authorized the construction of a desalting complex and other measures to ensure acceptable salinity levels. Title II, which was directed toward salinity control in the United States above Imperial Dam, authorized the construction of the Paradox Valley Unit and three other units. It also directed that planning reports be expedited on 12 additional units. A thirteenth unit has been added for study since the passage of the act. Preliminary information and cumulative impacts for the 16 original units in Title II have been presented in a final environmental statement on the Colorado River Water Quality Improvement Program (FES 77-15). The statement was prepared by the Bureau of Reclamation in the Department of the Interior and the Soil Conservation Service in the Department of Agriculture.

CHAPTER I

UNIT SETTING

Location and Present Development

The Paradox Valley Unit would be located in Montrose and San Miguel Counties of southwestern Colorado, just east of the Colorado-Utah State line. The unit area would consist of Paradox Valley on the Dolores River and the northwestern part of Dry Creek Basin to the southeast in the San Miguel River drainage. The San Miguel is a tributary of the Dolores, which in turn is a tributary of the Colorado River. The Dolores River picks up 205,000 tons of salts annually in Paradox Valley, primarily from surfacing brine ground water.

The only communities in Paradox Valley are the very small farming towns of Paradox (population 200) and Bedrock (population 80). Other communities in the vicinity are Nucla (population 1,000), Uravan (population 650), and Naturita (population 1,000), all located on or near the San Miguel River to the east of the valley. There is no permanent population in the northwestern part of Dry Creek Basin. The nearest commercial centers are Moab, Utah, 60 miles to the northwest of Bedrock; Montrose, Colo., 70 miles to the northeast; Grand Junction, Colo., 100 miles to the north; and Cortez, Colo., 100 miles to the south.

Although relatively isolated, the unit area is served by a network of Federal and State highways and county and local roads. Colorado State Highway 90, Utah State Highway 46, U.S. Highways 163 and 6, and Interstates 15 and 70 provide access to Moab and to Salt Lake City, Utah, about 300 miles northwest. Colorado State Highways 90 and 141, U.S. Highways 6 and 50, and Interstate 70 provide access to Montrose, Grand Junction, and Denver (about 260 miles east of Grand Junction).

The nearest standard gage rail service is located in Grand Junction and Montrose. Commercial air and bus service is available in Grand Junction, Montrose, Moab, and Cortez.

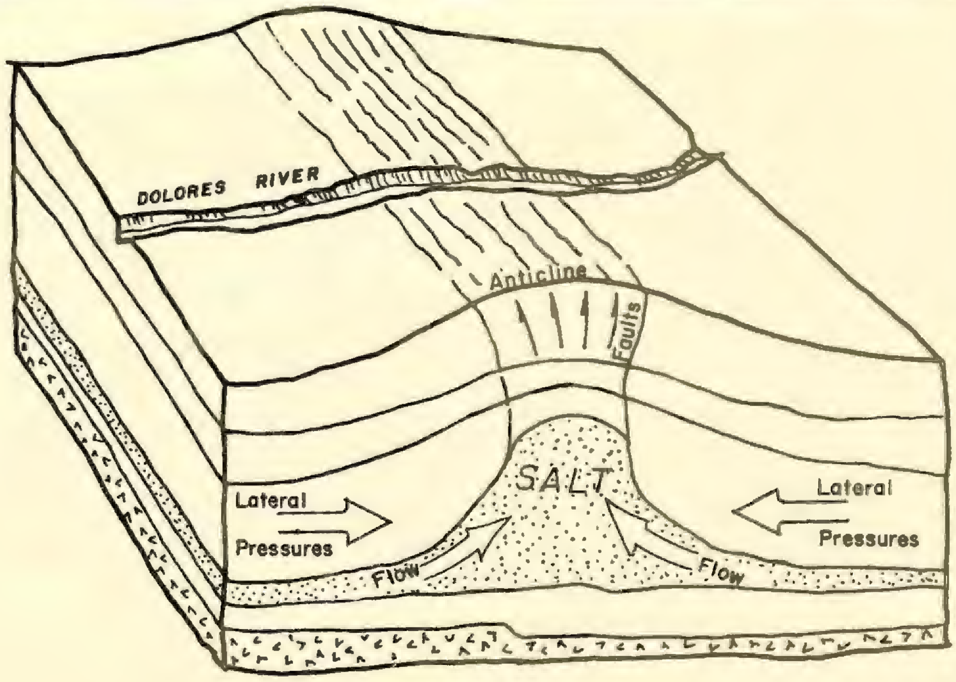
Agriculture is the main economic activity of the unit area. About 2,500 acres are under irrigation in the western half of Paradox Valley, with a water supply provided by local wells and by West Paradox Creek and Buckeye Reservoir in the La Sal Mountains to the northwest. Livestock and livestock feeds provide the principal source of income, although some malting barley is grown as a cash crop. The eastern half of the valley provides a limited amount of range in the winter and spring, and Dry Creek Basin also provides some sparse grazing.

Two sawmills located near the town of Paradox process timber from the La Sal Mountains to the northwest and the Uncompahgre Plateau to the east, but these operations provide little employment. Mining also contributes to the local economy. Carnotite, a mineral containing vanadium and the radioactive elements uranium and radium, is mined on the mesas surrounding Paradox Valley. This activity has increased considerably in recent years. Most of the ore is shipped to a processing plant in Uravan, which uses brine from a well in Paradox Valley in the production of uranium and vanadium. Brine from a second well is sold for use in drilling operations in the area. Inactive mines and claims are located in Dry Creek Basin and other nearby areas, and exploratory drilling is occurring in the basin.

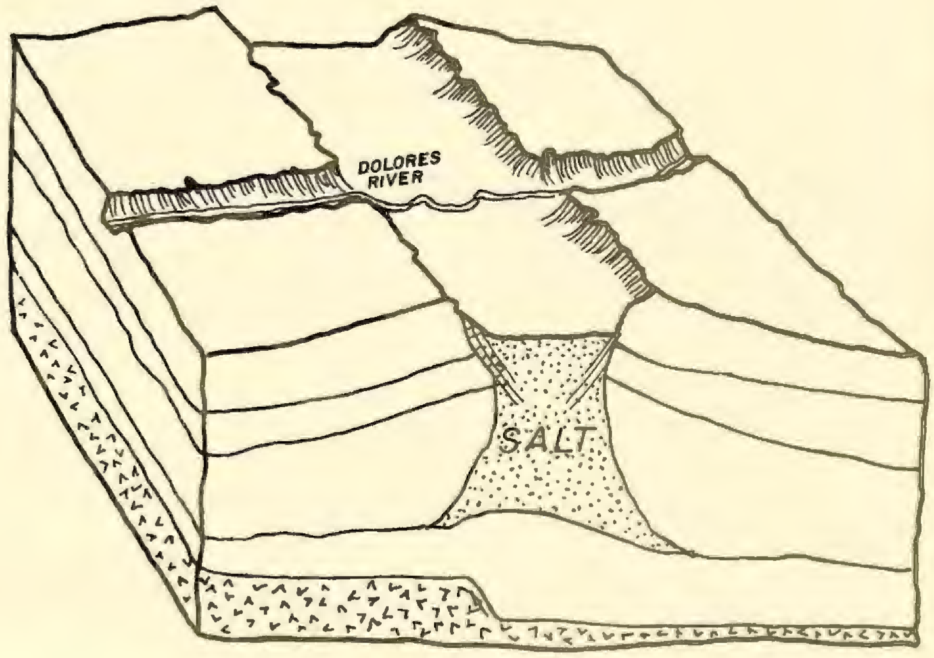
Topography and Geology

Paradox Valley is about 24 miles long on a northwest-southeast axis and from 3 to 5 miles wide and has a relatively flat floor enclosed by steep walls of sandstone and shale. The Dolores River crosses the valley near its midpoint in a level and broad flood plain but flows through deep and narrow canyons both upstream and downstream from the valley. Dry Creek Basin, southeast of the valley, is a relatively shallow and gently sloping basin about 15 miles long and 5 miles wide. Elevations vary from under 5,000 feet in the valley to about 6,300 feet in the basin and 7,000 feet on the divide between the two. The most prominent features in the vicinity are the La Sal Mountains in the Manti-La Sal National Forest, which rise to an elevation of about 12,000 feet and border Paradox Valley on the northwest.

Formed from a collapsed salt anticline, or elongated swell, the valley lies above a residual gypsum cap that covers a formation of salt and salt-rich shale beginning at a depth of about 600 to 1,000 feet and extending downward for about 14,000 feet. The drawing on the following page illustrates the formation of the valley. Briefly stated, the emergence of mountainous uplifts on each side of the area placed intense lateral pressures on the intervening sedimentary formations, causing faulting and fracturing along weak zones. Upon the easing of the lateral pressures, the weight of the sedimentary strata caused a deeply buried layer of salt-rich material to move upward by plastic flow into the faulted and weak areas to create an anticline. As the pressures eased, the crest of the anticline gradually dropped downward in fault blocks. While these activities occurred, the Dolores River remained in its flood plain across the anticline and, in combination with other erosional forces, removed the collapsing materials to form the valley. The sides of the valley are now characterized by numerous faults, slides, and collapsed structures.



EARLY STAGE



PRESENT STAGE

PARADOX ANTICLINE
STAGES OF DEVELOPMENT
Colorado River Basin Salinity Control Project
Paradox Valley Unit

Aerial view of Paradox Valley with La Sal Mountains in background. The Dolores River flows across the valley from left to right.

The river has deposited considerable amounts of alluvium in the flood plain to replace soluble salts that ground water has carried into the stream from the underlying salt formation. Measured at a depth of up to 129 feet in places, this material consists of silty sands on the surface and poorly graded sands with clay-filled gravels and cobbles appearing at increasing depths. Discontinuous clay lenses occur at random intervals throughout the deposits.

Water Resources

Streams

The Dolores River originates in the San Juan Mountains of Colorado to the southeast of the unit area and flows generally to the northwest for about 165 miles to Paradox Valley and for another 70 miles to its confluence with the Colorado River northeast of Moab, Utah. Small tributaries in the unit area include La Sal Creek, which enters from the northwest about 5 miles upstream from Paradox Valley, and West and East Paradox Creeks, which enter from the northwest and southeast within the valley. East Paradox Creek is intermittent, however, and has essentially no effect on the riverflow. A small amount of the flows of the river and most of the flows of West Paradox Creek are diverted and used for irrigation in the western half of the valley.

Portions of the Dolores River have been recommended for inclusion in the National Wild and Scenic River System, based upon studies made by the U.S. Departments of Agriculture and the Interior and the Colorado Department of Natural Resources pursuant to a 1975 amendment to the Wild and Scenic Rivers Act of October 2, 1968. Paradox Valley was specifically excluded from the studies. The agencies recommended that a 105-mile reach of the river immediately above Paradox Valley be included in the system and that the reach from just below the valley to the Utah State line not be included until further studies were completed.

The San Miguel River, which originates in the San Juan Mountains and flows to the northwest, joins the Dolores River about 4 miles downstream from Paradox Valley. The only significant tributary of the San Miguel River in the unit area is Dry Creek, an intermittent stream draining Dry Creek Basin.

The streams in the area generally exhibit the large fluctuations characteristic of streams in southwestern Colorado, with very high runoff during the spring because of melting snow in the mountains and very low base flows or no flows after midsummer. Occasional high flows also occur in the summer and fall from afternoon thunderstorms but are of very short duration.

Ground water

Brine ground water is believed to underlie the entire length of Paradox Valley at varying depths and rises to the surface at two general areas in and adjacent to the bed of the Dolores River. In addition to its high salinity, the brine contains hydrogen sulfide gas (H_2S), which is released when the water surfaces and has an objectionable rotten egg odor. A significant layer of relatively fresh ground water overlies the brine in western Paradox Valley and diminishes in thickness toward the river, where it surfaces.

Climate

The climate of the unit area is characteristic of semiarid southwestern Colorado, with low precipitation and humidity, abundant sunshine, moderately high evaporation rates, and wide ranges between daily high and low temperatures. The prevailing winds are from the southwest and are fairly strong in the spring.

The Bureau of Reclamation has maintained weather stations at Bedrock and in Dry Creek Basin since 1975. During this time, the average annual precipitation has been about 8 inches at both locations. June is normally the driest part of the year, and July through October is the wettest, primarily because of afternoon thunderstorms. Temperatures vary from daytime highs of over 100° F at Bedrock and over 90° F at Dry Creek Basin during July to nighttime lows of below -20° F during January.

Vegetation

Vegetation in the project area varies according to elevation, precipitation, soil, land use, and other factors. The Dolores River supports riparian vegetation characterized by cottonwood and forestiera upstream from the brine seeps and tamarisk downstream, with forbs and grasses found in both sections. Rushes are found in marshy areas along the stream. Much of western Paradox Valley contains irrigated pasture and crops, primarily alfalfa and small grains. In both Paradox Valley and Dry Creek Basin, extensive semiarid areas with saline soils are characterized by greasewood, seablite, winterfat, snakeweed, and other salt-tolerant plants. Sagebrush is found on the higher slopes throughout the area and is associated with a large variety of grasses wherever overgrazing has not occurred. Pinyon-juniper woodlands characterize the mesas and high slopes. No endangered or threatened plants have been identified in the unit area.

Fish and Wildlife

Fish

In the vicinity of Paradox Valley the Dolores River and West Paradox Creek support primarily nongame fishes, including the speckled dace, flannelmouth sucker, roundtail chub, mottled sculpin, red shiner, bluehead sucker, fathead minnow, black bullhead, and channel catfish. Because of the influx of saline ground water in the valley, fish inhabit the reach of the river immediately downstream only when the streamflow is high enough to dilute the salt and move into other reaches or tributaries whenever low flows result in high salinity.

Fish habitat in the Dolores River below Paradox Valley is at times significantly altered by the San Miguel River, which augments the flow and greatly improves the water quality of the river in the summer and fall. Fishes occurring below the confluence include the flannelmouth and bluehead suckers, black bullhead, roundtail chub, cutthroat and rainbow trout, channel catfish, sand shiner, green sunfish, carp, and largemouth bass. There are no fisheries in Dry Creek Basin. No endangered or threatened fishes or aquatic invertebrates are known to inhabit the streams in the unit area.

Wildlife

Big game mammals in the project area include the mule deer, elk, pronghorn, black bear, and mountain lion. The mule deer is a year-round resident, but the elk is present in significant numbers only in the winter and spends the summer in the La Sal Mountains and in mountains to the south of Dry Creek Basin. The pronghorn is found in small numbers in Dry Creek Basin and other open basins in the area, and the Colorado Division of Wildlife plans to increase the population by trapping and transplanting from other parts of Colorado. Both the black bear and mountain lion also have very small populations and are only occasionally seen in the unit area, with the former found primarily at the higher elevations in the La Sal Mountains and the latter primarily in the canyons and mesas southwest of Paradox Valley. Small game mammals, furbearers, varmints, and nongame mammals are found throughout the area.

Over a hundred species of birds, including both resident and migrant populations, have been identified in the area. Large concentrations of passerine birds are found in riparian vegetation along the Dolores River and West Paradox Creek during the spring and summer, and waterfowl and shorebirds are particularly numerous on the river and adjacent marshy areas in winter and during spring and fall migrations. Gamebirds such as the ringneck pheasant and mourning dove are common on the agricultural land of western Paradox Valley, and small populations of sage grouse inhabit Dry Creek Basin. The canyons of the Dolores River above and below the valley are important nesting areas for certain raptors, such as the red-tailed hawk, golden eagle, and prairie falcon. These and other species, including the marsh hawk and rough-legged hawk, use the croplands of western Paradox Valley, the desert shrublands of eastern Paradox Valley and Dry Creek Basin, and other relatively open habitat for hunting.

Amphibians are present along the Dolores River, West Paradox Creek, and Dry Creek and at stock watering ponds in eastern Paradox Valley and Dry Creek Basin. Among the common species are the western spadefoot toad, red-spotted toad, Woodhouse's toad, and leopard frog. Reptiles, including several species of lizards and snakes, are common in the area.

The peregrine falcon and bald eagle are the only threatened or endangered species known to inhabit the unit area. A mating couple of peregrines nested and produced one offspring during the spring of 1977. The bald eagle inhabits the area in the winter and is an infrequent visitor in the summer. It is not known to nest in the project area.

Cultural Resources

Fort Lewis College in Durango, Colo., working under a contract with the Bureau of Reclamation, has surveyed the area of possible project influence and identified 22 prehistoric and historic sites, none of which is listed in the National Register of Historic Places. Seventeen of these sites consist of lithic scatter on the surface, with little evidence that the material extends to any appreciable depth. The sites probably remain from temporary encampments or hunting stations used by the Ute Indians before the late 1880's, when the tribes were moved to reservations outside the area. The five other sites date from the early settlement of the area. North of the Dolores River in Paradox Valley is a three-walled stone structure that remains from a cabin, with associated trash. To the southwest of the river is a grave with a headstone dated 1891, enclosed by a wire fence. The remaining three sites were found in Dry Creek Basin and consist of homestead buildings and corrals settled between 1910 and 1920.

CHAPTER II

PARADOX VALLEY HYDROLOGY

Water Resources

Streams

Surface water measurements for the Paradox Valley Unit were begun late in 1971 with the establishment of three stream gaging stations: on the Dolores River at Bedrock (where it enters the valley), on the river near Bedrock (where it leaves the valley), and on West Paradox Creek 2.6 miles above the creek's confluence with the river. Continuous flow measurements have been taken at the two stations on the river, and the following discussion is based upon data for the full water years of 1972 through 1976. Measurements on West Paradox Creek were discontinued in 1973 because of difficulties maintaining the station, and records are available only for the full water years 1972 and 1973. No data have been obtained for East Paradox Creek, which is intermittent and has very little effect on the river.

The recorded flow of the Dolores River at Bedrock averaged 299,400 acre-feet annually during the 5-year study period, varying from a high of 715,800 acre-feet in water year 1973 to a low of 89,200 acre-feet in water year 1974. About 83 percent of the average annual runoff occurred from spring snowmelt in April, May, and June. Daily flows also varied considerably, from a maximum of 9,280 cubic feet per second (cfs) on April 30, 1973, to a minimum of 0 on September 13, 1974.

At the station near Bedrock the river had an average annual flow of 313,500 acre-feet during the 5-year study period, with a maximum of 748,400 acre-feet in water year 1973 and a minimum of 89,200 acre-feet in water year 1974. The increase of 14,100 acre-feet in average annual flow as the river crosses the valley can be attributed to inflows from West Paradox Creek, East Paradox Creek, and fresh and brine ground water surfacing in the valley. Daily riverflows were recorded at a maximum rate of 9,500 cfs on April 30, 1973, and a minimum rate of 0.5 cfs on August 1, 1972.

The annual flows of West Paradox Creek were recorded at 3,700 acre-feet in water year 1972 and 9,400 acre-feet in water year 1973 for an average of 6,600 acre-feet. Daily flow rates varied from a high of 82 cfs in May to a low of 2.5 cfs in July and August. This stream does not generally have the same drastic variations in flow as the Dolores River because the runoff is partially regulated by Buckeye Reservoir, a 1,600-acre-foot structure located northwest of Paradox Valley in the upper part of the drainage area (see the Frontispiece Map). Water is stored in the reservoir during high spring runoff and released for irrigation in western Paradox Valley during the summer.

The average monthly and annual flows for the three stream gaging stations are shown in the following table.

Average runoff in Paradox Valley
(acre-feet)

	Dolores River at Bedrock (1972-76)	Dolores River near Bedrock (1972-76)	West Paradox Creek (1972-73)
October	5,500	6,500	500
November	3,000	3,300	400
December	3,800	4,000	400
January	3,900	4,100	400
February	4,500	4,900	400
March	11,000	12,200	400
April	58,600	62,700	1,100
May	120,600	124,700	1,400
June	70,700	72,100	900
July	15,700	16,600	300
August	1,000	1,200	200
September	1,100	1,200	200
Total	299,400	313,500	6,600

Ground water

Ground water observations in Paradox Valley were begun in 1971, with measurements of water table levels and piezometric heads in deep aquifers in private wells. To obtain additional information on subsurface geology and ground water conditions, subsequent studies included drilling exploratory holes in 1972, drilling and pumping from test wells in 1973, 1975, and 1976, and installing a network of observation wells and piezometers to monitor water table levels and piezometric heads. In the summer of 1977, 18 additional test wells were drilled and pumped as part of a design data collection program that is scheduled for completion in 1980. This program, which will include extensive pump tests, is described later in this chapter.

As stated in Chapter I, brine ground water, which apparently underlies all of Paradox Valley, surfaces in and near the Dolores River channel in two general areas extending from the middle of the valley downstream to the river's exit from the valley. The depth to brine appears to increase upstream and west of the river, as indicated by measurements of brine at about 100 feet in an existing well located about a mile to the west. To the east of the river along the valley floor, the top of the brine layer is at about the same level as the river, as measured in the Bureau's observation wells. Although it is impractical to directly measure the brine inflow to the river, since it occurs as many small springs and seeps, the Bureau estimates that it varies from about 0.2 to 2.1 cfs and averages 0.8 cfs, based upon measurements of salt loading in the river. The flow exhibits a certain degree of seasonal fluctuation, generally being at its highest sometime during the spring or summer and at its lowest during the fall and winter.

A significant layer of comparatively fresh water which overlies the brine in western Paradox Valley varies from 10 to 40 feet below the ground surface, depending upon location, and is pumped from wells for irrigation. Estimated to be at least 100 feet thick about a mile west of the river, the lens gradually thins out closer to the river in the area of the surfacing brine. This water also surfaces as seeps and springs in the river and, combined with the brine, results in a total contribution to the river of between 1.5 and 4 cfs.

The brine and freshwater aquifers have a variety of potential recharge sources, including runoff from the La Sal Mountains, irrigation return flows from western Paradox Valley, seepage from West Paradox Creek, precipitation, and surface and subsurface runoff from the valley walls. Because brine evidently circulates through the salt core at depths of 650 feet or more before surfacing, it probably originates from the farthest recharge sources, while the fresh water originates from nearer sources.

Water Quality

Streams

Analyses of water quality conditions in the valley were based on sampling conducted at the three stream gaging stations from 1972 to 1976. Water quality samples collected weekly from the Dolores River at Bedrock (1.5 miles above the brine surfacing areas) during the 5-year study period had an average flow-weighted salinity of 264 milligrams per liter (mg/l). Individual samples varied from 140 to 3,700 mg/l, the lower readings normally occurring during high spring runoff and the higher ones during the very low flows of late summer and early fall. The annual salt load at this location averaged about 107,000 tons. The total dissolved solids consisted primarily of sodium, chloride, bicarbonate, calcium, and sulfate.

Samples from the river near Bedrock (1.5 miles below the brine surfacing areas) for the same study period had a flow-weighted average salinity of 729 mg/l, with individual readings varying from 170 to

166,000 mg/l. The high value occurred during a time of very low flow when the only water in the river channel was surfacing ground water. The annual salt load of the river averaged about 312,000 tons, or 205,000 tons more than at Bedrock. Bureau investigations indicate that this large increase is contributed by ground water (about 198,000 tons) and West Paradox Creek (about 7,000 tons), as discussed below. The total dissolved solids included predominantly sodium and chloride.

West Paradox Creek had an average flow-weighted salinity of about 800 mg/l according to samples collected during the 5-year study period. Individual analyses ranged from a minimum of 260 mg/l during high runoff to a maximum of 1,970 mg/l during low runoff. The creek contributed an estimated 7,000 tons of salt annually to the Dolores River, consisting primarily of calcium and sulfate.

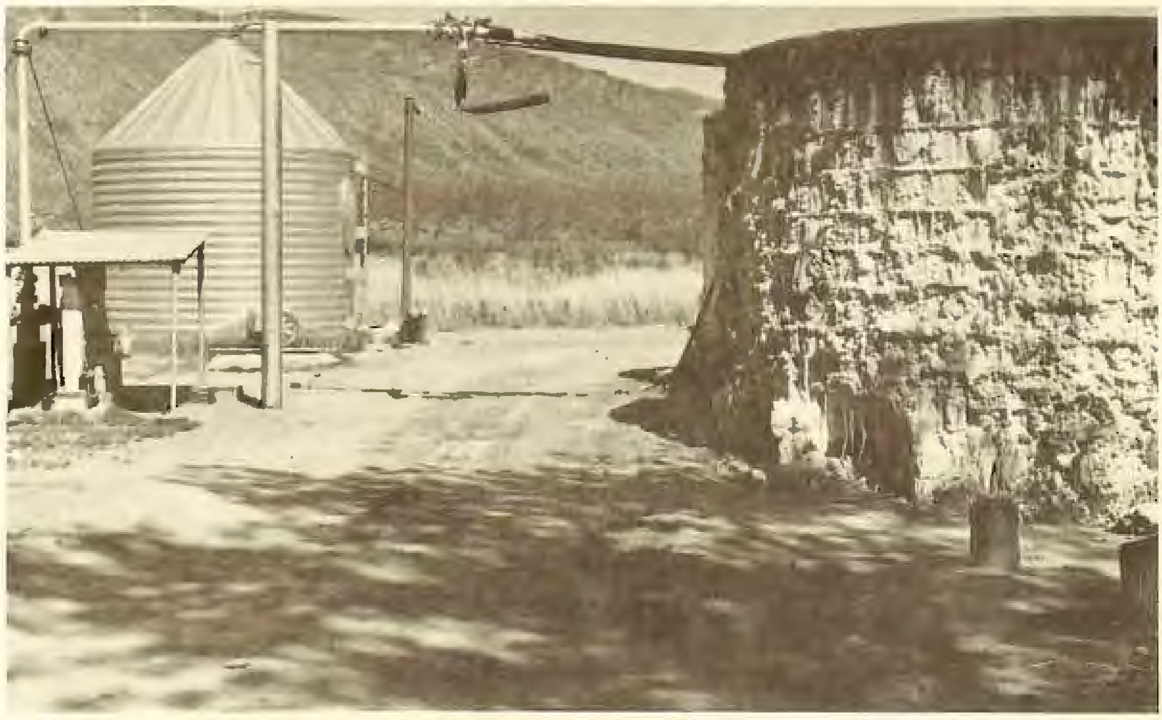
The following table shows the average concentrations of samples at the three water quality stations, including major constituents and total dissolved solids.

Chemical analysis of water samples--1972-1976
(mg/l)

	Dolores River at Bedrock	Dolores River near Bedrock	West Paradox Creek
Flow-weighted average TDS	264	729	800
Calcium	80	165	137
Magnesium	25	109	81
Sodium	117	4,309	44
Potassium	6	225	5
Chloride	148	6,911	45
Sulfate	204	618	476
Carbonate	1	1	1
Bicarbonate	176	189	260
Average TDS	697	12,282	1,005

Ground water

Samples of brine ground water analyzed by the Bureau of Reclamation have varied from 117,500 mg/l in an open pit a half mile east of the river to 250,000 mg/l at brine seeps in the river channel and to about 260,000 mg/l in wells drilled near the river. The variations probably result from different degrees of mixing with fresher ground water in the area. About 93 percent of the total dissolved solids are sodium and chloride, and other salts and heavy metals are present in comparatively small quantities. The brine also contains dissolved hydrogen sulfide gas at concentrations of more than 100 mg/l, which is released as the brine surfaces and causes an objectionable odor at seepage areas and open wells near the river. The Bureau's studies indicate that this brine accounts for essentially all of the 198,000 tons contributed annually by surfacing ground water. An analysis of brine pumped by the Bureau from test well #1 (shown in the map on page 17) is shown on the following page.



Salt deposits coat brine storage tank 1 mile west of well field. Well at left center produces brine for commercial purposes.

The layer of relatively fresh ground water overlying the brine to the west of the river has a salinity of from 1,400 to 4,000 mg/l, depending upon location and time of year. Water from irrigation wells has varied in quality from 1,400 to 3,500 mg/l, and seeps along the river have varied from 1,500 to 4,000 mg/l. The predominant salts are calcium, magnesium, and sulfate, but large amounts of sodium and chloride are also found in water samples collected near the river because of mixing with the brine.

Design Data Collection Program

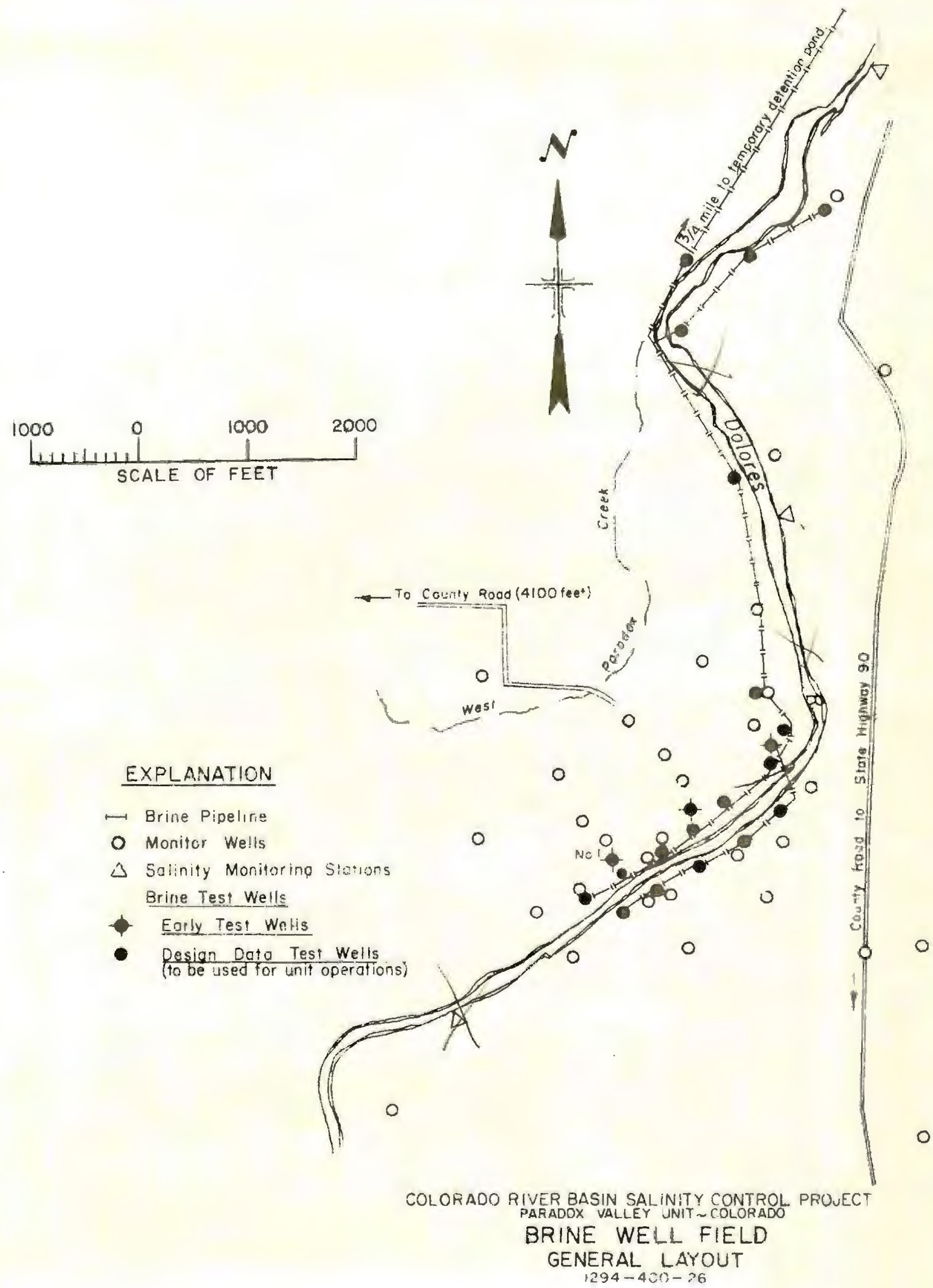
The Bureau of Reclamation is conducting a design data collection program scheduled for completion in 1980. The purpose of the program is to design and test a brine well field that will effectively lower the brine-freshwater interface near the Dolores River and thus eliminate most of the brine inflow to the river.

Chemical analysis of brine ground water (mg/l)

Total dissolved solids (at 105°C)	267,100
Calcium	1,400
Magnesium	1,708
Sodium	98,440
Potassium	5,161
Chloride	164,000
Sulfate	5,880
Carbonate	0
Bicarbonate	274
Cadmium	0.470
Chromium	.260
Copper	.220
Iron	2.400
Lead	2.900
Manganese	.370
Nickel	.230
Lithium	.130
Zinc	.620
Oil	.100
Radioactive strontium	2.300

As part of the program, 18 brine wells were drilled and individually pumped in short tests during the summer of 1977, as previously stated. Located along both sides of the river near the brine surfacing areas, the wells extend into the brine aquifer to depths ranging from 48 to 155 feet. Beginning in 1978 and continuing for about 1 to 1 1/2 years, the wells will be pumped in various combinations to determine the most effective pumping rate for individual wells and the entire well field. During these tests, the brine will be collected in a pipeline and discharged into a temporary detention pond located about 3/4 mile to the north and evaporated. The network of monitoring wells previously drilled in the river flood plain will provide data on any changes in the brine and fresh ground water at various depths, and pumping rates can consequently be varied to achieve the most desirable overall scheme for lowering the brine level. Changes in the flow and salinity of the river as it crosses the valley will be monitored by means of the two stream gaging and water quality stations previously mentioned as well as by five continuously recording electrical conductivity meters installed along the river in 1975 and 1976: at Bedrock, just upstream from the well field, within the well field, just downstream from the well field, and at the river's exit from the valley.

The map on the following page shows the general layout of the pump test wells, the monitoring wells, and the three salinity monitoring stations near the well field. It is anticipated that all of the test facilities except the brine detention pond and a short section of temporary pipeline to the pond would also be used during the permanent operations of the unit, with only slight modifications required in some cases and none in others. Detailed descriptions of the well field may be found in Chapter IV, "Plan of Development."


N
1000 0 1000 2000
SCALE OF FEET
EXPLANATION
Brine Pipeline
Monitor Wells
Salinity Monitoring Stations
Brine Test Wells
Early Test Wells
Design Data Test Wells
(to be used for unit operations)
3/4 mile to temporary detention pond
Dolores
Creek
Paradox
West
To County Road (4100 feet)
County Road to State Highway 90
No 1
COLORADO RIVER BASIN SALINITY CONTROL PROJECT
PARADOX VALLEY UNIT ~ COLORADO
BRINE WELL FIELD
GENERAL LAYOUT
1294-400-26

CHAPTER III

PROBLEMS AND NEEDS

Paradox Valley, with its total salt contribution of 205,000 tons annually, is a major source of salt to the Dolores River in the Colorado River Basin and increases the salinity of the river by about 21 mg/l at Imperial Dam. As a result of this and many other major sources, the river has historically had a high salt content, and the salinity has been gradually increasing as the riverflows have been developed for man's beneficial use.

The Colorado River at its headwaters in the mountains of central Colorado has a salt concentration of only about 50 mg/l. The salinity progressively increases downstream as a result of water diversions and salt contributions from a variety of sources and in 1977 averaged 820 mg/l at Imperial Dam, the last major diversion point in the United States. Unless control measures are undertaken, the concentration will continue to increase, reaching levels estimated by the Bureau of Reclamation at 1,150 to 1,210 mg/l at Imperial Dam by the year 2000. Water of 1,000 mg/l or less is generally considered to be satisfactory for irrigating most crops, although concentrations of 500 mg/l can have detrimental effects on salt-sensitive crops. On land with good drainage, water exceeding 1,000 mg/l can be used for crops with high salt tolerances. The U.S. Public Health Service recommends that public drinking water supplies should be less than 500 mg/l whenever water of this quality or better is available.

The salinity of the river results from two general causes--salt loading and salt concentration. Salt loading is the addition of salt to the river from such sources as erosion of saline geologic formations, irrigation return flows, and saline springs and seeps. The annual salt load of the river under present conditions is estimated at about 10 million tons just below Hoover Dam, 260 miles upstream from Imperial Dam. The salt concentrating effect occurs from consumptive use, which reduces the volume of water in the river without reducing the total amount of salt it carries. Examples include irrigation, municipal and industrial use, transpiration from native vegetation, and evaporation. As the water is used and reused several times along the length of the river, both of these effects contribute to the increasing salinity. The process is likely to continue, since the potential demands on the river exceed its dependable supply.

The high salt concentrations in the Lower Colorado River Basin adversely affect more than 14 million people and about 1 million acres of irrigated farm land in the United States. Affected the most severely are municipal and industrial water users in the Los Angeles-San Diego area and irrigators in southern California, particularly Imperial Valley, and Arizona. According to a recent study by the Bureau of Reclamation[1/], these users experience annual economic losses of $230,000 for each increase of 1 mg/l at Imperial Dam, consisting of $188,000 in direct impacts and $42,000 in indirect impacts. The losses associated with municipal and industrial use occur primarily from increased water treatment costs, accelerated pipe corrosion and appliance wear, increased soap and detergent needs, and decreased drinking water palatability. For irrigators, the higher concentrations cause decreased crop yields, altered crop patterns, increased leaching and drainage requirements, and increased management costs. Overall, the damages attributable to salinity were estimated at $53 million in 1973 and may reach an annual level of $124 million by the year 2000 with continued development of water resources and no measures for salinity control.[2/]

Salinity not only affects water users in the Southwestern United States but is also an important factor in international relations with Mexico, which is guaranteed an annual water supply of 1.5 million acre-feet of Colorado River water by a 1944 treaty. In 1973 the United States and Mexico agreed that the water delivered to Mexico at Morelos Dam would have a salinity of no more than 115±30 mg/l greater than the average salinity of Colorado River waters which arrive at Imperial Dam.

1/ Kleinman, Allan, et. al. 1974. Economic Impacts of Changes in Salinity Levels of the Colorado River. Bureau of Reclamation, Denver.

2/ Bureau of Reclamation and Soil Conservation Service, 1977. Final Environmental Statement: Colorado River Water Quality Improvement Program. FES 77-15. Departments of the Interior and Agriculture, p. I-12.

CHAPTER IV

PLAN OF DEVELOPMENT

General

The Paradox Valley Unit would be designed to control salinity by pumping brine ground water from a well field located along both sides of the Dolores River in Paradox Valley and thus prevent it from surfacing in the riverbed. The brine from the wells would be pumped to a hydrogen sulfide stripping plant to the east of the river, where the toxic gas would be removed, and would then be pumped to Radium Evaporation Pond in Dry Creek Basin, where the salt deposits remaining after evaporation would be permanently retained. To reduce adverse impacts on wildlife, a wildlife area would be developed near the evaporation pond, and other areas temporarily disturbed by construction would be seeded with plant species valuable as wildlife habitat. Since the wildlife area was not included in the unit plan when it was authorized, the approval of the appropriate congressional committees would be required. Also included as part of the unit would be a program to collect and preserve archaeological information from sites located within the proposed evaporation pond. An operational headquarters would be constructed at the site of the hydrogen sulfide stripping plant.

The Bureau of Reclamation's Western Colorado Projects Office would administer the facilities for salinity control and be responsible for their annual operation, maintenance, and replacement. It is anticipated that the Colorado Division of Wildlife would administer the wildlife area.

The Bureau estimates that the unit would effectively remove up to 180,000 tons of salt annually, or about 90 percent of the salt now entering the river in Paradox Valley. The overall effect of the unit would be to decrease the salinity of the Colorado River at Imperial Dam by 18.2 mg/l, or about 2.2 percent of the 1977 salinity level. The reduction attributable to salt removal would actually be 18.6 mg/l but would be slightly offset by an increase of 0.4 mg/l caused by an average annual stream depletion of about 3,950 acre-feet.

Project Features

Introduction

Designs and estimates discussed in this report are of feasibility grade and are based on the extreme condition that 5 cfs of brine with a salinity of up to 260,000 mg/l would be pumped constantly during a 100-year project life. Final design capacities cannot be determined, however, until the design data collection program now underway is completed, which is scheduled for 1980. The program is expected to indicate that a pumping rate of less than 5 cfs would suffice as a long-term average and that the salinity of the water pumped would average less than 260,000 mg/l. A long-term operational rate of 5 cfs for all of the facilities is unlikely since it is estimated that an average brine inflow of 0.8 cfs at 260,000 mg/l now produces essentially all of the 198,000 tons of salt entering the river each year from ground water, as discussed in Chapter II.

If the design data collection program shows that a pumping rate of about 2 cfs or less would effectively control the brine inflow, the Bureau would reanalyze alternative means of brine disposal, including deep well injection and other evaporation pond sites. These alternatives are discussed in Chapter VI of this report.

Brine well field

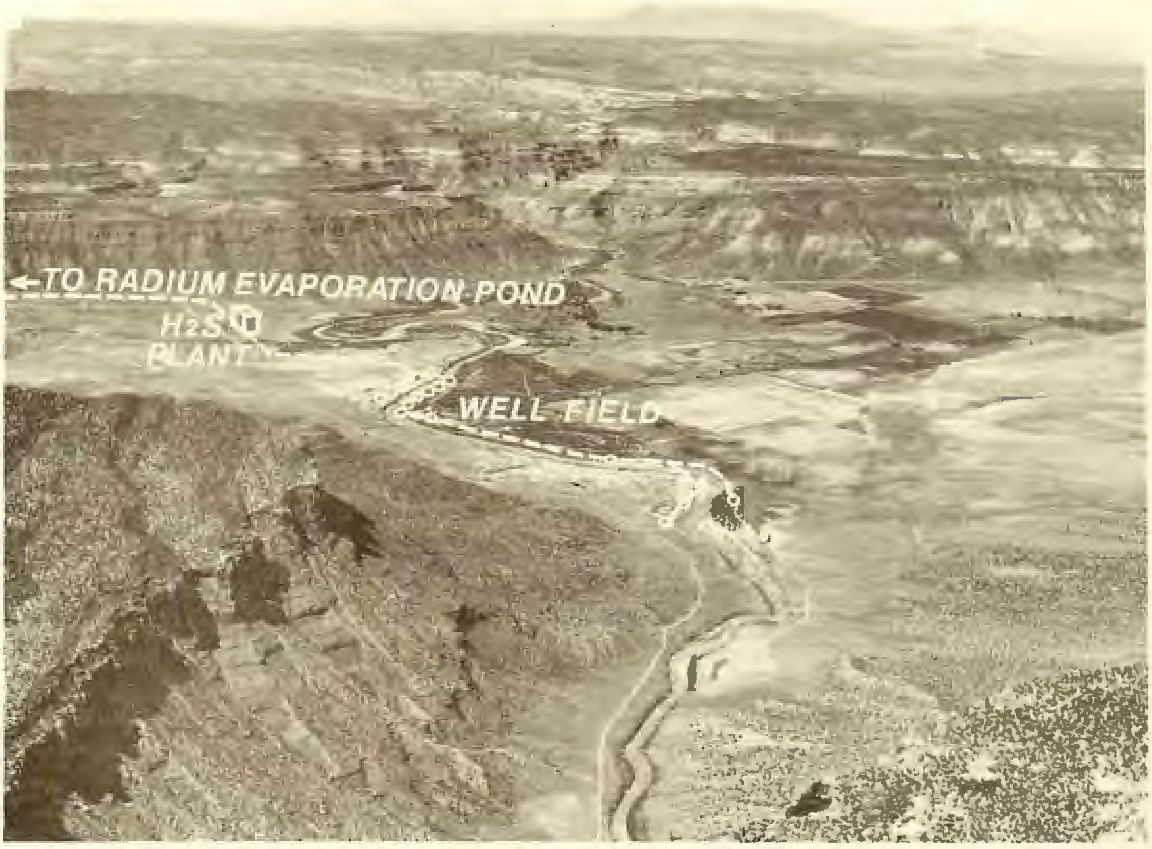
Brine Production Wells

To reduce the salt inflow by 180,000 tons, an estimated 18 production wells would be required; 10 along the west side of the river and 8 along the east side. These wells have been drilled as part of the design data collection program for the unit. Unit cost estimates include provisions for installing 5 additional wells to cover the possibility that more than 18 wells could be required for long-term operations.

Seventeen of the wells have been drilled into the alluvial aquifer of sand and gravel to depths of between 48 and 77 feet, and the other well extends into cavities in the residual gypsum cap to a total depth of about 155 feet. The wells have a working diameter of 12 inches, and the lower 15 to 40 feet consist of well screens to allow the brine ground water to enter. Gravel packing has been placed around each well for its entire depth, both for stabilization and to prevent fine sand from entering the screens. Water table observation tubes 1 1/4 inches in diameter are located on the outside of each well screen, perforated for at least the lower 25 feet to observe the drawdown caused by pumping.

Electric pumps varying in capacity from 0.1 to 1.1 cfs would be installed at the wells. The discharge line for each pump would include control valves, a connection for a flow meter, and a tap to periodically collect brine to be chemically analyzed.

The wellheads, which would extend about 4 feet above the ground, would be housed in cinderblock structures 8 feet high and about 9 feet long on each side, with a concrete pad as a base. The roofs of the structures would be removable to facilitate maintenance and replacement. Electric control panels would be installed in the buildings so that each well could be operated individually at the site and to monitor power use to determine efficiency.



Artist's concept of brine well field.

A system of reinforced plastic mortar pipe or some other pipe resistant to salt corrosion, buried with a minimum cover of 3 feet, would be installed to collect the brine from the pump discharge lines at the wells and convey it to the hydrogen sulfide stripping plant. The system would consist of pipelines on both sides of the river and would have a total length of 3.1 miles, consisting of 830 feet of 4-inch pipe, 1,200 feet of 6-inch pipe, 1,700 feet of 8-inch pipe, 7,350 feet of 10-inch pipe, 400 feet of 12-inch pipe, and 4,700 feet of 14-inch pipe.

About 7 miles of existing roads would be improved to provide access to the well field. The roads would be about 12 feet wide and surfaced with gravel.

Ground Water Monitoring Wells

A total of 68 ground water monitoring wells have been drilled near the brine production wells on both sides of the river and would be regularly used to determine the effects of the pumping on the water table, the fresh water-brine interface, and the brine movement in the aquifer. The information would be used to establish the most effective pumping rates and patterns for the production wells. In addition to these wells, other wells drilled during previous investigations would be monitored as required to evaluate the effect of pumping. Additional wells would be drilled during the design data collection program as needed.

The monitoring system contains two types of wells. The first consists of 39 shallow observation wells, generally about 25 feet deep and 1.5 inches in diameter with 10-foot well screens placed between 10 and 25 feet deep to allow ground water to enter. The wells would be used to observe the water table. In addition, electrical conductivity meters could be lowered into the wells to measure changes in conductivity with depth, which would indicate the approximate location of the freshwater-brine interface.

The second type of well contained in the monitoring system consists of 29 deep wells which generally contain three pipes. Each pipe extends to a different depth and has a section of well screen at the bottom. A shallow pipe, screened from the 5- to 25-foot zone, would be used to observe the water table and the brine-freshwater interface; a second pipe is screened near the base of the alluvial aquifer, between 56 and 120 feet deep, and would be used to measure the brine piezometric head in that zone; a third, screened in the gypsum bedrock between 215 and 300 feet deep, would also be used to measure the brine piezometric head. A grout seal has been placed between the pipes to prevent the water in these three zones from intermixing in the well. Electrical conductivity meters and occasional samples would be used to monitor water quality in the various zones.

The wellheads, which have a maximum height of about 4 feet above ground, have steel caps to prevent debris from entering and to discourage vandalism. Water levels in the water wells and pipes would be checked periodically during project operation. Some of the piezometer pipes would be equipped with automatic recorders for continuous measurements.

Dolores River Monitoring System

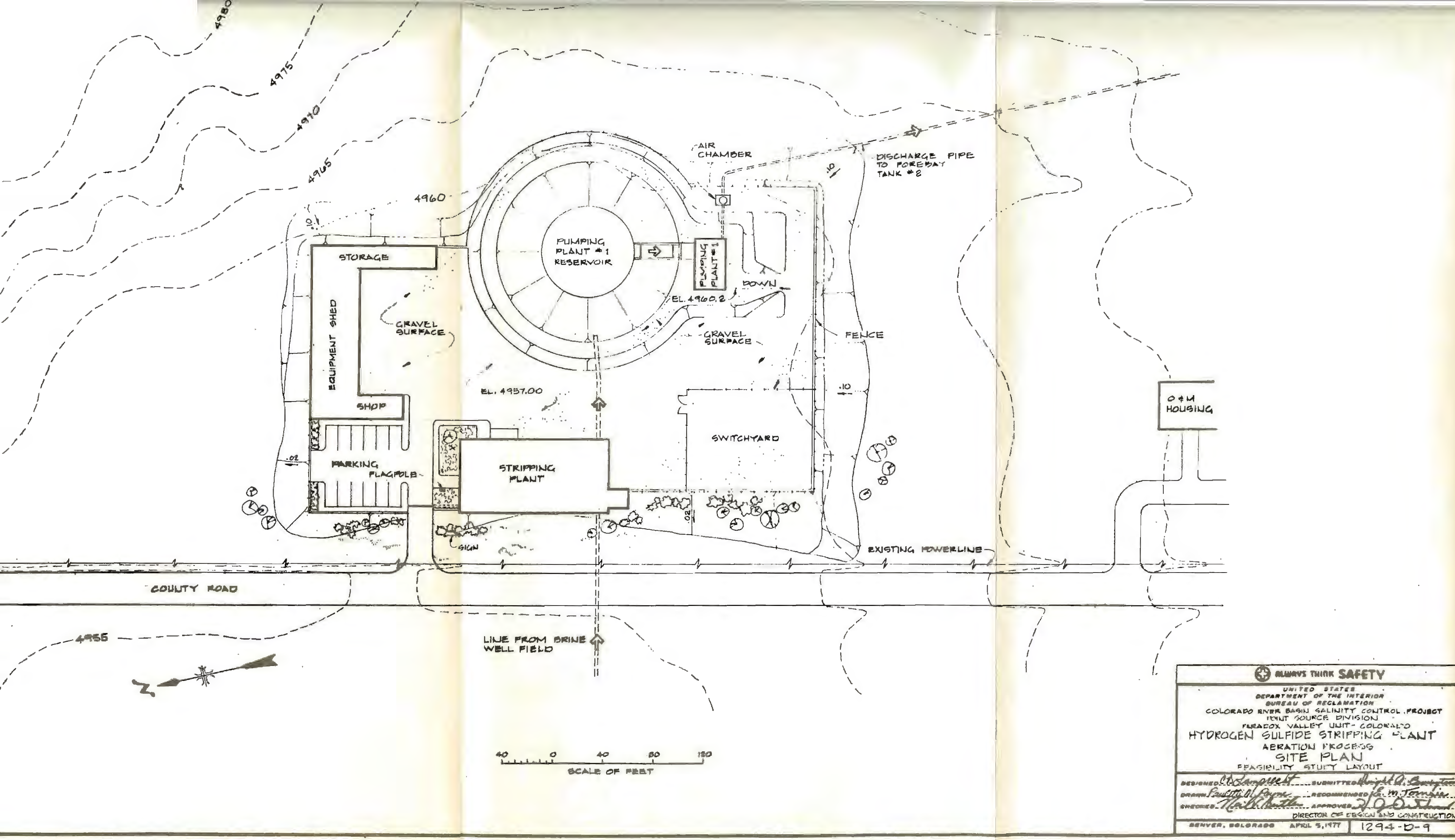
As previously discussed in Chapter II, a river monitoring system has been installed to assess the changes in streamflow and water quality that would occur as a result of pumping the brine ground water. The system includes five electrical conductivity meters which have been installed along the east side of the river within the well field, immediately upstream and downstream from the well field, and adjacent to the stream gaging stations located at the entrance and exit of the valley. These meters operate automatically to provide a continous record of any changes in conductivity as the river flows through the valley. Samples are collected at the two gaging stations when they are serviced and are used to analyze the chemical composition of the water entering and leaving the valley and to periodically calibrate the meters.

Hydrogen sulfide stripping plant

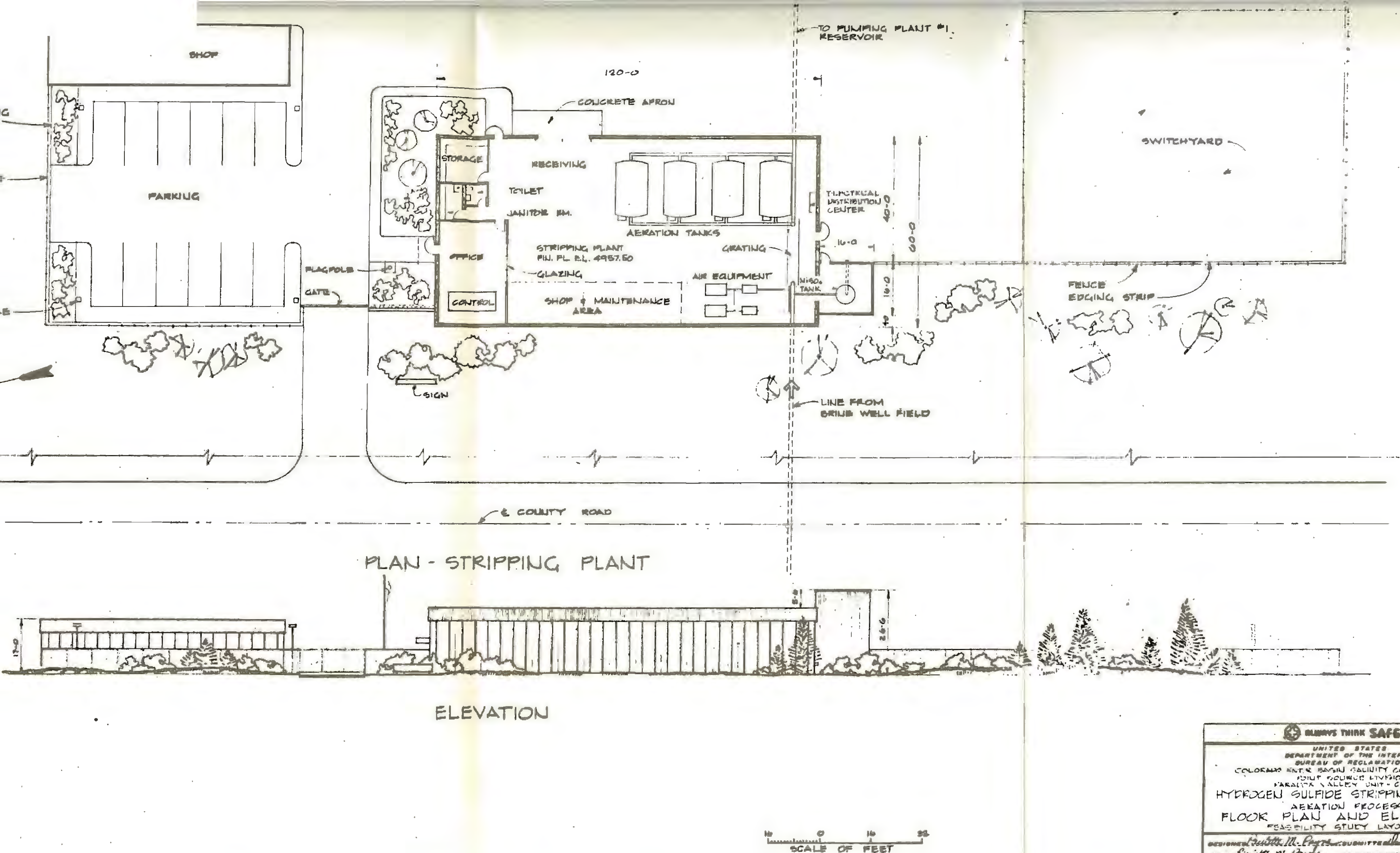
The hydrogen sulfide (H_2S) stripping plant would be located adjacent to a county road on the east side of the river, about 1 mile south of the brine well field. The plant building, in addition to housing the treatment facilities, would contain areas for storage, operation and maintenance, and receiving equipment and supplies. The building would be constructed of precast concrete tee panels and would be 184 feet long, 60 feet wide, and 21 feet high. The plant would be located adjacent to other unit facilities discussed later in this chapter, including permanent operation facilities, a substation, and the first pumping plant for the brine pipeline to Radium Evaporation Pond. About 0.4 mile of an existing county road would be paved to provide access. The entire site is shown in the feasibility layout on the following page.

The toxic H_2S gas would be removed from the brine to prevent it from being released into the atmosphere at the evaporation pond and also to protect the brine pipeline and pumping plants from its very corrosive effects. The gas would be oxidized by means of an aeration process, producing water and sulfur in solid form, which would be piped to the evaporation pond with the brine. A solution of nickel sulfate would be added to the brine to act as a catalyst in the oxidation process. Based upon a maximum brine flow of 5 cfs, the plant would produce about 760 pounds of sulfur each day, while reducing the H_2S concentration from more than 100 mg/l to levels as low as 0.02 mg/l.

As the feasibility design on page 26 shows, the brine would be treated in four aeration tanks. Brine entering the plant would be conveyed to the tanks under a minimum pressure of 20 pounds per square inch through a system of 10-inch-diameter pipes constructed of corrosion-resistant aluminum bronze. Turnouts with motor-operated valves would allow the brine to be fed at different rates into the individual tanks and would ensure the continued operation of three tanks if one were shut down for maintenance or repairs. The pipe system would also collect treated brine from the tanks and could completely bypass them if necessary for emergencies. The treated brine would be discharged into the forebay reservoir of the first pumping plant on the pipeline to the evaporation pond.



4980
4975
4970
4965
4960
4955
AIR CHAMBER
DISCHARGE PIPE TO FOREBAY TANK #2
PUMPING PLANT #1 RESERVOIR
PUMPING PLANT #1
EL. 4960.2
DOWN
STORAGE
EQUIPMENT SHED
SHOP
GRAVEL SURFACE
GRAVEL SURFACE
FENCE
EL. 4957.00
SWITCHYARD
STRIPPING PLANT
PARKING
FLAGPOLE
SIGN
O & M HOUSING
EXISTING POWERLINE
COUNTY ROAD
LINE FROM BRINE WELL FIELD
N
40 0 40 80 120
SCALE OF FEET
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER BASIN SALINITY CONTROL PROJECT
POINT SOURCE DIVISION
PARADOX VALLEY UNIT - COLORADO
HYDROGEN SULFIDE STRIPPING PLANT
AERATION PROCESS
SITE PLAN
FEASIBILITY STUDY LAYOUT
DESIGNED
SUBMITTED
DRAWN
RECOMMENDED
CHECKED
APPROVED
DIRECTOR OF DESIGN AND CONSTRUCTION
DENVER, COLORADO
APRIL 5, 1977
1294-D-9



ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
COLORADO RIVER BASIN SALINITY CONTROL PROJECT
POINT SOURCE DIVISION
PARADOX VALLEY UNIT - COLORADO

HYDROGEN SULFIDE STRIPPING PLANT
AERATION PROCESS
FLOOR PLAN AND ELEVATION
FEASIBILITY STUDY LAYOUT

DESIGNED .... SUBMITTED ....
DRAWN .... RECOMMENDED ....
CHECKED .... APPROVED ....
DIRECTOR OF DESIGN AND CONSTRUCTION

DENVER, COLORADO | APRIL 8, 1977 | 1294-D-10

The nickel sulfate solution would be injected into the brine piping system upstream from the aeration tanks. A storage hopper and transition hopper, containing the chemical in dry form, would have a combined capacity of about 373 cubic feet, which would suffice for about 1 year of operation at the maximum brine flow of 5 cfs. Automatically released from the hoppers, the chemical would be mixed with fresh water in a 50-gallon solution tank, then pumped into the brine pipe. The water would be obtained from wells drilled near the rimrock southeast of the site to supply operational houses for the unit, which are described in a later section of this chapter.

The four cylindrical aeration tanks, each about 17 feet in length, 10 feet in diameter, and 10,000 gallons in capacity, would be lined with coal-tar epoxy for protection against salt corrosion. Each tank would contain 92 porous domes at the bottom for diffusing air through the brine and a pressure relief valve on top for releasing high pressure air. A 30-inch-diameter manhole located at one end would provide access for maintenance.

Compressed, dried, and filtered air would be supplied to the porous domes in the tanks at 20 pounds per square inch by two rotary-screw air compressors and two air purification systems, connected to the tanks by standard 3-inch-diameter steel pipelines. Aluminum bronze check valves at the connections would prevent the corrosive brine from entering these lines. Air would be carried from the relief valve on the tanks to an outside vent by a 6-inch-diameter galvanized steel pipe.

A fully automatic control system would be installed in the stripping plant building and would consist of a remote terminal unit with a microprocessor located in the treatment room of the plant and two microcomputers (one as a backup) located in an office and control room. With the computer, the plant could be operated either automatically or manually. Provisions would be made for continuous monitoring to prevent H_2S gas from reaching toxic levels in enclosed work areas.

Brine pipeline

A pipeline 20.5 miles in length would convey the brine from the hydrogen sulfide stripping plant to Radium Evaporation Pond. The pipe, which would be buried with a minimum cover of 3 feet, would be reinforced plastic mortar or some other suitable pipe resistant to salt corrosion. For the first 14.3 miles to the top of the divide between Paradox Valley and Dry Creek Basin the brine would be pumped through 15-inch-diameter pipe, and for the remaining 6.2 miles it would flow by gravity through 18-inch-diameter pipe. The brine would discharge through a baffled outlet of reinforced thermosetting resin into an open channel extending about 1,000 feet into the evaporation pond area. This channel, which would be earthlined and protected with riprap, would convey the brine away from the pipe, thus preventing salt deposits from forming around the outlet and causing unnecessary maintenance problems.

Brine pipeline pumping plants

Eight pumping plants along the pipeline would lift the brine through a total elevation of about 2,040 feet between the stripping plant and the divide between Paradox Valley and Dry Creek Basin. Each of the plants would be fully automatic and would operate with two horizontal centrifugal pumps, with the exception that two vertical turbine pumps would be installed at Pumping Plant No. 1. Each pump would have a rated capacity of 2.63 cfs, with a dynamic head of 366 feet at Pumping Plant No. 1 and 275 feet at each of the other pumping plants. The pumps would be housed in one-story concrete structures that would also contain movable overhead cranes for maintenance and replacement. The plant sites would be fenced and would also contain forebay reservoirs or tanks, air chambers, and substations. Gravel would be placed on surface areas not occupied by structures.

Pumping Plant No. 1 would be located adjacent to the stripping plant and would include a forebay reservoir with a diameter of 71 feet and a capacity of 2 acre-feet. The reservoir would be lined with 10-mil polyvinyl chloride to prevent leakage and would have float levels to govern the operation of the pumps. Pumping Plants Nos. 2 through 8 would have forebay regulating tanks with float levels to govern pumping operations. Constructed of reinforced fiberglass, each tank would be about 26 feet high and 31 feet in diameter, with a capacity of about 0.5 acre-foot.

An air chamber, or surge tank, at each plant site would absorb the pressure fluctuations caused by changes in flow through the brine pipeline. These structures would vary from about 4 to 9 feet in diameter and 7 to 15 feet in height.

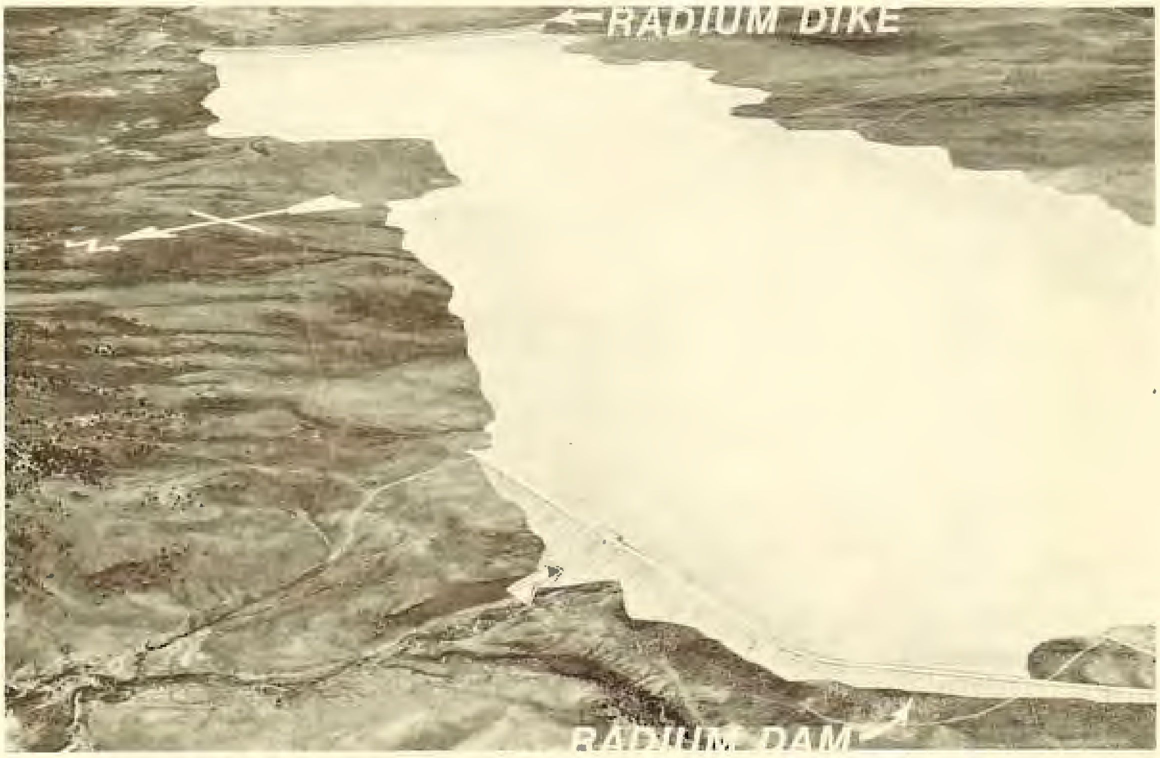
Radium Dam, Dike, and Evaporation Pond

Design Data

Radium Evaporation Pond, which would be formed by the construction of Radium Dam on an intermittent tributary of the West Fork of Dry Creek and Radium Dike on an intermittent tributary of the main stem of Dry Creek, would cover an area of up to 3,630 acres in the two drainages and across a very low saddle between the two. The pond, at a water surface elevation of 6,338 feet, would have a capacity of 86,800 acre-feet, consisting of 65,700 acre-feet for the disposal of brine and deposited salts, 2,400 acre-feet for sediments from storm runoff, and 18,700 acre-feet for flood storage. The flood storage would be sufficient for the design maximum annual inflow of 22,200 acre-feet, assuming that a minimum of 3,500 acre-feet would be evaporated during the same year. The flood storage would be large enough to retain and evaporate all runoff entering the pond from the surrounding drainage area, since no water must be allowed to spill and possibly contaminate local ground or surface water. As a standard Reclamation safety factor, however, a surcharge capacity of 6,540 acre-feet would be provided on top of the flood control pool to temporarily store flood flows. The surcharge, combined with a spillway capacity of 50 cfs, would protect against an inflow design flood with a peak flow of 39,300 cfs and a 3-day volume of 6,600 acre-feet. At the top of the surcharge, the pond would have a capacity of 93,340 acre-feet and a maximum surface area of 3,750 acres.

Most of the pond site is underlain by impermeable Mancos Shale, up to 600 feet or more deep in some places, which would prevent any seepage of brine. Early reconnaissance studies indicated that two areas totaling 640 acres on the northeastern side have only thin remnants of Mancos Shale and eolian soils underlain by generally fractured Dakota Sandstone and were considered to require lining with a blanket of clay derived from Mancos Shale or some similar impervious material. Further investigations by Bureau geologists found that much of the areas had 5 feet or more of in-place weathered shale and soils probably not requiring a blanket. An area of less than 100 acres adjacent to the dam and dike may need a partial blanket to achieve the required thickness of 5 feet. The present feasibility designs and cost estimates, however, are based on a blanket covering the entire 640 acres. The blanket would have a thickness of 5 feet and a total volume of about 5,200,000 cubic yards.

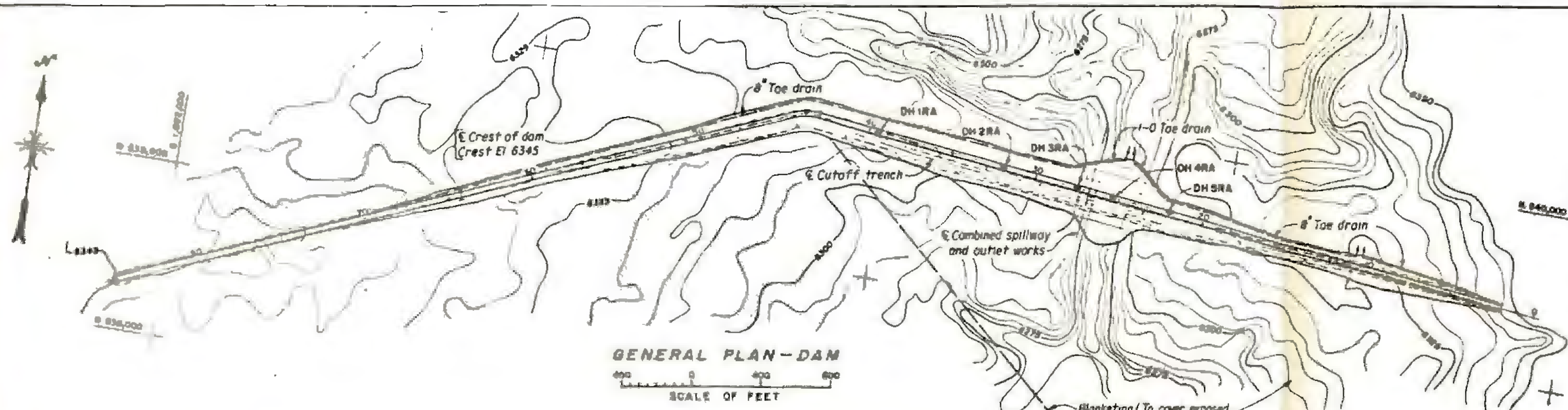
Radium Dam would be a rolled earth, sand, gravel, and rockfill structure with a volume of about 1,480,000 cubic yards of material. The crest, at an elevation of 6,345 feet, would be about 87 feet high above the drainage channel, 30 feet wide, and 8,300 feet long. A 3-foot layer of riprap on the upstream face and a 1-foot layer of sand and gravel on the downstream face would protect the structure against erosion. A combined spillway and outlet works would be located in the left abutment. The spillway would have a maximum discharge of 50 cfs and, like the surcharge capacity, has been included as a standard Reclamation safety factor even though all inflows to the pond would be retained and evaporated. The inlet structure would be at elevation 6,338 feet on the face of the dam, and would connect with a vertical concrete conduit extending about 66 feet downward from the inlet. The bottom of this conduit would connect with a 6-foot-diameter, flat-bottomed concrete conduit extending through the base of the dam and ending in a stilling basin. The outlet works, with a capacity of 810 cfs, would include an intake structure at the toe of the dam at elevation 6,274 feet and a 6-foot-diameter concrete conduit extending under the dam to connect with the flat-bottomed spillway and would be operated by means of manual hoists on the crest of the dam. The outlet works would be designed to provide temporary flood drainage during construction. Also included as a safety measure would be piezometers and settlement instruments in the dam. These facilities would be used to monitor any changes in the dam as the pond filled.



Artist's concept of Radium Evaporation Pond

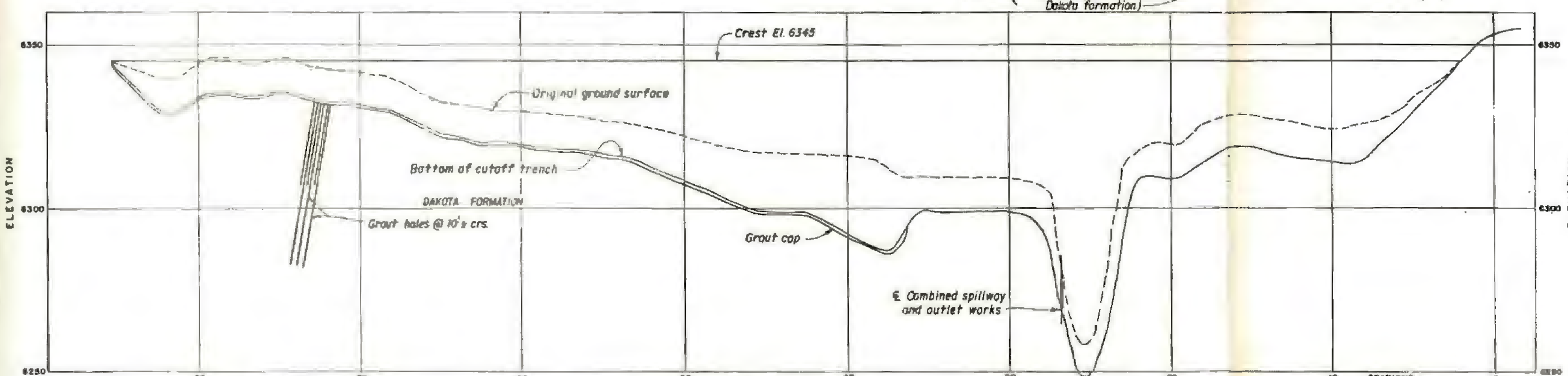
Radium Dike would be a rolled earth, sand, gravel, and rockfill structure with a total volume of about 1,004,000 cubic yards of material. The crest, at elevation 6,345 feet, would be 56 feet above the drainage channel, 30 feet wide, and 7,500 feet long. To protect the structure, a 3-foot layer of riprap would be placed on the upstream face and a 1-foot layer of sand and gravel would be placed on the downstream face. Data pertaining to the dam and dike are shown in the design drawing on the following page.

Eight ground water monitoring wells would be drilled adjacent to the pond to measure the water table, hydraulic pressure, and water quality, thus indicating whether brine was seeping into local ground water. Two wells would be located immediately downstream from the dam on each side of the tributary of the West Fork of Dry Creek, and two would be located just downstream from the dike on each side of the tributary of the East Fork. Three wells would be drilled between the dam and dike on the north side of the pond, and another would be located

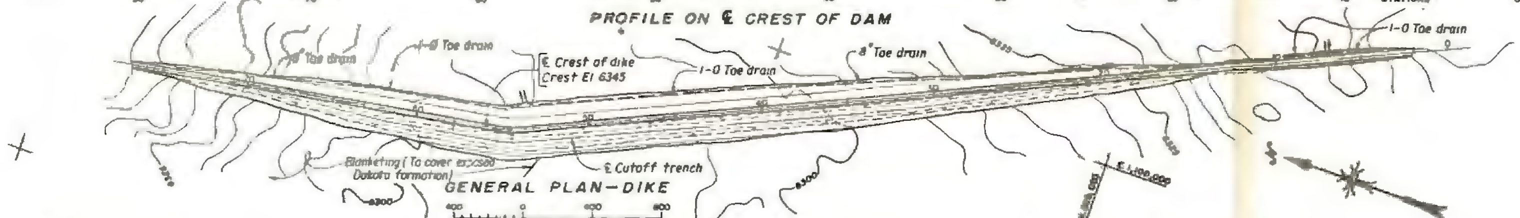


GENERAL PLAN—DAM

SCALE OF FEET

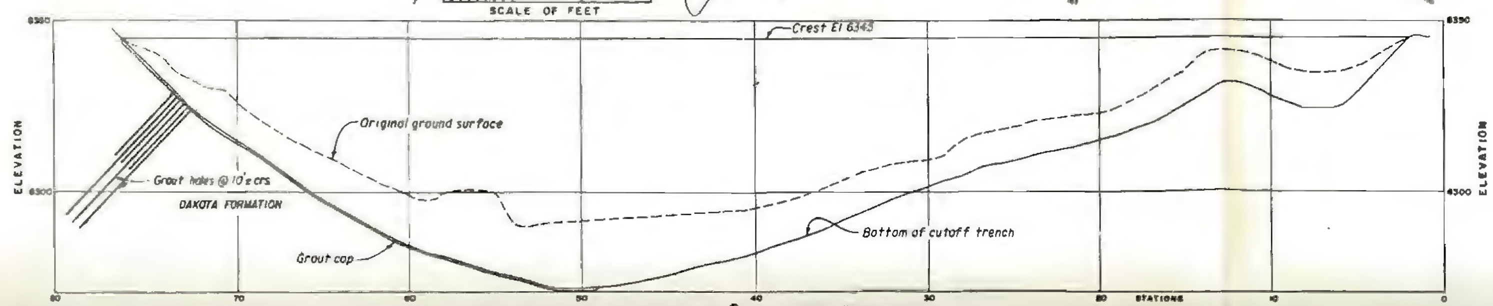


PROFILE ON ℄ CREST OF DAM



GENERAL PLAN—DIKE

SCALE OF FEET

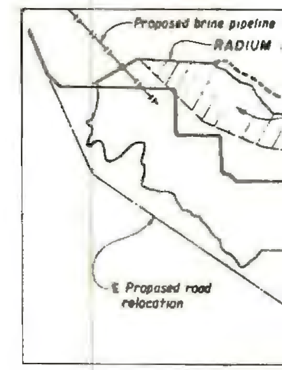


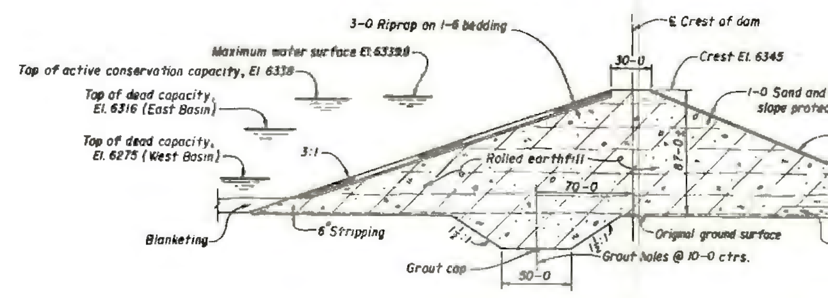
PROFILE ON ℄ CREST OF DIKE

RESERVOIR CAPACITY ALLOCATIONS

PURPOSE	ELEVATIONS	CAPACITY ACRE-FEET
Active conservation	6275 to 6338	80,760
Dead (East basin)	Strmbd (6291) to 6316	5,920
Dead (West basin)	Strmbd. (6247) to 6275	120
Total reservoir capacity		86,800*

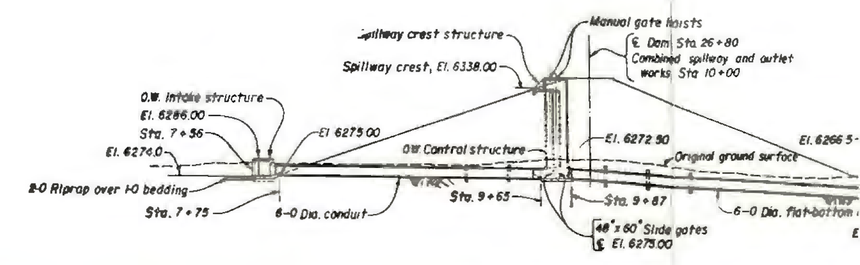
*Includes 2400 a.f. for 100 year sediment deposition
A surcharge of 6340 a.f. (Max WS El. 6339.8) in combination with a spillway discharge of 50 c.f.s. is provided to protect against the inflow design flood which has a peak of 39,300 c.f.s. and a 3-day volume of 6660 a.f.





MAXIMUM SECTION—DAM AND DIKE

SCALE OF FEET



PROFILE ALONG ℄ COMBINED SPILLWAY AND OUTLET WOR on the south side. Each well would contain one pipe 25 feet deep and another about 60 feet deep. The shallow pipe would have a screen from 5 feet to 25 feet to permit observation of the water table, and the deep pipe would have a 5-foot screen on the bottom to measure the piezometric head below the water table in the aquifer. Readings and sampling would be conducted monthly, but the frequency would be altered in the future depending upon operational needs. If any leakage occurred through the dam or abutments, it would be collected and recycled back into the pond.

About 3.5 miles of a gravel-surfaced county road in the pond site would be relocated. The replacement, 4.2 miles of improved gravel road, would follow the right-of-way line around the south, southwest, and west sides of the pond. Clearing of vegetation, primarily sagebrush, would be required in the areas of the dam, dike, impervious blanket, and roads.

The pond area would be accessible by way of two gravel roads constructed from the relocated county road. One road, about 2.6 miles in length, would extend from the west side and cross the crest of the dam. The other road would be 1.5 miles in length and would extend from the south and cross the dike.

Operations

The evaporation pond would fill gradually during the 100-year useful life of the unit. In the early years of operation, the volume of brine in the pond would grow fairly rapidly, because the surface area would not be large enough for annual evaporation to exceed annual inflow. After about 25 years, over 50 percent of the total volume would be occupied by brine and deposited salts. As the pond filled, however, the expanding surface area would cause a gradual increase in evaporation, and the rate of filling would consequently decline. The pond would grow to about 70 percent of the total capacity after 50 years and 75 percent after 75 years. The inundated area would consist largely of brine in the early years, with few deposited salts. In later years, however, the pond would consist primarily of salt deposits covered occasionally by a thin layer of brine.

The average annual inflow is estimated at about 6,200 acre-feet over the 100-year period and would consist of brine, precipitation on the pond surface, and runoff from the drainage area around the pond. The brine inflow, assuming the maximum pumping rate of 5 cfs, would be essentially constant at about 3,600 acre-feet annually. Contributions to the pond from precipitation and runoff would fluctuate considerably both seasonally and annually but are estimated at an average of 2,600 acre-feet annually over a 100-year period. About 350 acre-feet of this water would otherwise enter the San Miguel River, with the rest lost through evapotranspiration in the Dry Creek drainage. Generally, this inflow to the pond would increase as the size of the pond increased, since the pond would capture all of the direct precipitation on the water surface but only part of the runoff from the surrounding area, with the rest lost through evapotranspiration. After the pond reached its maximum surface area, it would receive an average of about 3,300 acre-feet of precipitation and natural runoff annually, all of which would be evaporated.

The evaporation rate at the pond would average about 29 inches annually, based upon 37 years of records at a weather station in Montrose. Although this station is about 500 feet lower in elevation than the pond site, the effect on evaporation would be offset by the windier conditions found in Dry Creek Basin. The Bureau of Reclamation has maintained a weather station at the site since 1975, but the two full years of data obtained so far are insufficient for long-term predictions. They do indicate, however, that evaporation was higher than at Montrose for the same period.

The total amount of water evaporated each year would gradually increase as the surface area of the pond increased and is estimated at about 2,750 acre-feet in the 6th year of operations and 6,190 acre-feet in the 25th year. After about 30 years the annual evaporation would exceed the annual inflow, and the brine accumulated in earlier years would be slowly evaporated until it disappeared in about the 75th year. After this time, essentially all of the water reaching the pond each year would be evaporated, although there would be some carryover from year to year because the evaporation would be at its lowest in the winter. During the summers, a higher rate of evaporation would result in the exposure of a salt flat over much of the area. When full after 100 years the pond would have an average evaporation potential of about 8,000 acre-feet annually to dispose of storm runoff.

Evaporation would increase the salinity of the brine from 260,000 mg/l initially to saturation at about 350,000 mg/l. This concentration would be reached after about 6 years and would be maintained for the rest of the unit life, with only minor short-term changes from high storm runoff and seasonal differences in precipitation and evaporation rates. The precipitation of salts would begin when the brine reached saturation, and the volume of the salts in the flooded area would gradually increase with respect to the volume of brine.

Transmission lines, substations, and power requirements

Electric power for the unit facilities would be obtained from the Colorado River Storage Project by means of the project's Shiprock-to-Curecanti, 230-kilovolt transmission line. The power would be wheeled to the unit area by the Colorado Ute Electric Association and conveyed to the facilities by existing powerlines of the San Miguel Power Association.

The pumps at the brine production wells would use power tapped from an existing line about 250 feet east of the well field and distributed to the pumps by about 1.6 miles of new lines. The transmission poles, made of wood, would be about 30 feet high and would have single or double crossarms about 8 feet long. Generally, each well would have a separate transformer, although in some instances two adjacent wells would share one.

The hydrogen sulfide stripping plant, operation and maintenance facilities, and brine pipeline pumping plants would use power from a transmission line that parallels the pipeline alignment. The stripping plant and Pumping Plant No. 1, located adjacent to each other, would be served by a single tap and an underground transmission line about one quarter mile in length connected to a substation at the stripping plant site. Each of the other seven pumping plants would have an individual tap, an underground line no more than one quarter mile long, and a substation. The operation and maintenance facilities would share the tap and underground lines to the hydrogen sulfide plant, with a transformer located at each house.

The operation of the unit would require a total of about 15,200,000 kilowatt-hours of electric energy each year, based upon a maximum year-round capacity of 5 cfs for the brine well field, hydrogen sulfide stripping plant, and brine pipeline pumping plants. The power demand for the unit would total about 1,745 kilowatts. The power needs of the stripping plant would be incidental since the brine would enter the plant already under pressure from the well field pumps. Power for the operation and maintenance facilities would also be incidental. The table below shows the requirements for each of the facilities.

Unit power requirements

Facility	Power demand (kilowatts)	Average annual energy requirements (kilowatt-hours)
Brine well field	124	1,081,000
Brine pipeline pumping plants		
No. 1	260	2,270,000
No. 2	200	1,720,000
No. 3	200	1,750,000
No. 4	200	1,720,000
No. 5	200	1,720,000
No. 6	200	1,720,000
No. 7	190	1,700,000
No. 8	190	1,670,000
Total	1,764	15,351,000

Permanent operating facilities

The operating headquarters for the unit would be located adjacent to the hydrogen sulfide stripping plant and would include a parking area and a building containing a shop, equipment, and a storage area (see the design layout on page 25). The site would be fenced and landscaped. Four three-bedroom houses for permanent operating personnel would be constructed just south of the site.

Temporary construction camp

A temporary camp would be established to serve as the construction headquarters of the unit and to provide temporary housing for the government construction force, which would vary from a minimum of 4 employees in the first year of work to a maximum of about 50 in the fifth year. The camp would be located near the proposed sites of the hydrogen sulfide stripping plant and the permanent operation and maintenance housing. An estimated 17 all-electric trailers would be required during the peak year. Power would be obtained from an existing transmission line adjacent to the site. A 2,000-foot telephone line, wells for domestic water, and a septic system would be installed for use in both the temporary camp and the permanent operation and housing facilities.

Cultural resource program

As stated in Chapter I, 22 archaeological sites have been identified in the vicinity of the unit. Twenty of the sites have been avoided through planning and design considerations. The two remaining sites lie within the proposed evaporation pond and a program of data collection and evaluation would be undertaken at each of the sites. At one site, an area of lithic scatter, the program would consist of collecting materials from the surface, testing for the depth of cultural materials, and determining cultural affiliation if possible. The program for the second site, the remains of a homestead ranch, would consist of gathering historical information, surface mapping, collecting materials, and photographing the site. If the results were to indicate that either site would yield significant information, a mitigation plan would be developed in accordance with "Procedures for the Protection of Historic and Cultural Properties," (36 CFR 800). If needed, this plan would be implemented prior to construction.

Wildlife program

To compensate for anticipated losses in wildlife populations caused by the inundation of habitat during a 100-year period of operations, about 3,660 acres of public and private land around the evaporation pond would be developed and managed for wildlife. The development would be similar to that recommended by the Fish and Wildlife Service in a memorandum of January 21, 1977 (a copy of which is attached to this report). This measure would compensate for losses of many species, such as deer, pronghorn, and sage grouse, but it would not be effective for all species now found at the site. Consisting of 1,320 acres within the evaporation pond right-of-way and 2,340 acres acquired specifically for wildlife, this area would be improved by construction of five small water retention structures of about 2 acres each to collect runoff and by planting and fertilizing species that are desirable for forage, such as wheatgrass, Indian ricegrass, wild rye, smooth brome, and fourwing saltbush. Fences would be installed to exclude unmanaged livestock. In addition to these measures, borrow areas and other areas disturbed during construction would be shaped to fit the surrounding topography, seeded, and fertilized to promote the growth of new vegetation. As previously stated, congressional approval would be required for the wildlife program since the original authorization of the unit did not include wildlife mitigation.

The Fish and Wildlife Service in a memorandum of December 6, 1977 (a copy of which is attached), recommended that responsibility for public lands acquired for the wildlife area be retained by the Bureau of Land Management in cooperation with the Colorado Division of Wildlife. It is anticipated that the area would be operated by the State agency, however, since it has informally expressed a desire to manage the area, which has consequently been designed to adjoin nearby land already under the Division's jurisdiction and thus facilitate an integrated management program.

In a memorandum of October 18, 1977 (also attached to this report), the Fish and Wildlife Service recommended that the unit plan include the development of marshy areas to increase the prey base for peregrine falcons. In order for the Bureau of Reclamation to participate in such a plan to enhance the existing habitat, the development would have to be consistent with the salinity control program authorized by Congress. If future consultation between the Bureau of Reclamation, the Fish and Wildlife Service, the Colorado Division of Wildlife, and the Bureau of Land Management indicates that the development should be proposed, detailed planning studies and appropriate justification should be completed before seeking Congressional approval.

Land Acquisition

The construction and operation of the unit would require the acquisition of 5,381 acres of privately owned land and the withdrawal of 2,510 acres of public land now administered by the Bureau of Land Management. In accordance with the Uniform Relocation and Assistance Act (Public Law 91-646) an additional 830 acres of private land may be acquired to avoid leaving the present owner with an uneconomical operating unit. Nearly all of the private land would be purchased in fee title, although easements would be obtained for part of the well field and along the brine pipeline. The following table shows the amount of land required for the construction of project features.

Project land acquisition

Feature	Land ownership (acres) Bureau of Land Management	Private	Total
Brine well field			
Withdrawn	60		60
Fee title		285	285
Easements		20	20
Hydrogen sulfide plant		6	6
Brine pipeline			
Withdrawn	125		125
Easements		74	74
Brine pipeline pumping plants	5	2	7
Radium Dam, Dike, and Evaporation Pond	1,250	3,700	4,950
Operating facilities		4	4
Wildlife area	1,050	1,290	2,340
Material source areas	20		20
Total	2,510	5,381	7,891

Project Water Rights

The operation of the unit would deplete the Dolores River at a rate of up to 5 cfs. During periods of normal or high riverflow, this depletion would not affect diversions downstream by holders of senior water rights, since the flows would still be sufficient to fulfill their rights. The Bureau would apply with the State of Colorado for a water right to deplete these surplus flows. In periods of low flow, however, the unit depletion would prevent the fulfillment of senior water rights and consequently could not be operated on the basis of the Bureau's junior right. As a result, arrangements would be made to compensate the affected users for reducing their diversion, to obtain senior rights necessary for the unit operation, or to augment the stream by exchange or some other means. The selection of a method would be made in coordination with the State of Colorado and could depend to a degree on the determination of the brine pumping rate during the design data collection program.

The Bureau would also file with the State for storage rights at Radium Evaporation Pond. The San Miguel Water Conservancy District already holds a conditional storage right at the site, since the Bureau had proposed in a 1966 report to build Radium Reservoir for irrigation and fish and wildlife enhancement as part of the San Miguel Project.[1/] Although the project was subsequently authorized by the Colorado River Basin Act of September 30, 1968 (Public Law 90-537) and is now under advance planning, the Bureau no longer proposes any developments in Dry Creek Basin as part of the project plan.

Protection of Unit Works from Flood Hazards

All project works have been designed for selected levels of flood protection. At the brine well field the pumps, with their associated electrical and mechanical equipment, would be located above the level of the 100-year flood. This flood would have no effect on the collection system, which would be buried, and the hydrogen sulfide stripping plant, which would be located outside the flood plain. At Radium Evaporation Pond, the surcharge capacity would provide protection against flood damage.

Sources of Construction Materials

Construction materials for the unit would include impervious and pervious fill, riprap, concrete aggregate, and ready-mix concrete. The following table shows the amount of impervious and pervious materials and riprap required for the dam, dike, and impervious blanket in the evaporation pond. The required quantities of concrete aggregate and ready-mix concrete have not been determined.

Borrow materials

	Quantity (cubic yards)			
Feature	Impervious fill	Pervious sand and gravel	Riprap	Total
Radium Dam	1,300,000	104,000	76,000	1,480,000
Radium Dike	900,000	60,000	44,000	1,004,000
Impervious blanket	5,200,000			5,200,000
Total	7,400,000	164,000	120,000	7,684,000

The impervious material for the dam, dike, and blanket would be obtained from within the high water line of the evaporation pond. Pervious material, concrete aggregate, and riprap would be obtained from a site located about 13 miles southeast of the evaporation pond. The pervious material and concrete aggregate would consist of gravel deposits, and the riprap would consist of a hard, dense, crystalline limestone occurring in massive but moderately broken beds. An existing

1/ Bureau of Reclamation. San Miguel Project, Colorado: Feasibility Report, February 1966.

road would provide access. Ready-mix concrete for the unit facilities would be purchased from commercial sources.

Operation and Maintenance

General

The salinity control facilities of the unit would be operated and maintained by the Bureau of Reclamation. It is anticipated that the wildlife area at the evaporation pond would be maintained by the Colorado Division of Wildlife.

The unit facilities, including the brine production wells, monitoring system, hydrogen sulfide stripping plant, and pipeline pumping plants, would be operated automatically from the office and control room at the stripping plant. Information on the operating conditions of these facilities and malfunction warnings would be telemetered to the control room so that adjustments and maintenance could be made promptly. In addition to periodic checks and maintenance of this equipment, the normal operations would include readings at the monitoring wells, stream gaging stations, and water quality stations in Paradox Valley and also at the piezometers and settlement instruments installed in Radium Dam and Dike.

Most replacements for the unit would be part of normal maintenance, but some major replacements, including the H_2S stripping plant works, transmission lines and substations, and supervisory control and associated communications equipment, would be separate items. Since the unit would operate continuously year-round, standby pumps would be used to replace malfunctioning units during repairs, thus ensuring that the pipeline would be shut down for only a short time. At the well field and stripping plant, individual units could be shut down for repairs or normal maintenance without seriously affecting the continued operation of the remaining units.

Operation and maintenance at the evaporation pond would be minimal. In addition to the reading of the instruments in the dam, dike, and nearby observation wells, the work would consist of erosion and weed control and road maintenance.

The wildlife area would require minimal maintenance. The required work would consist of upkeep on fences, water retention structures, and grass plots.

Personnel, equipment, and supplies

The operation and maintenance of the salinity control facilities would require four permanent employees: a superintendent, two plant mechanics/operators, and an electrical equipment repairman. Seasonal or part-time laborers may also be needed to maintain the buildings and grounds and to assist in large-scale maintenance and replacement. As discussed earlier, four houses for the permanent staff would be provided just south of the stripping plant.

Equipment required for the unit would include three pickup trucks, a flatbed truck, a dump truck, a grader, an industrial tractor, a crane, and small miscellaneous items. Special equipment used only occasionally would be rented. Supplies would include nickel sulfate and miscellaneous items.

Power

The power requirements for the unit would be about 15,351,000 kilowatt-hours annually, as previously stated, with a demand requirement of 1,764 kilowatts. The estimated costs of power for the unit are based upon present CRSP rates of 3.4 mills per kilowatt-hour and $1.34 per kilowatt-month, with a wheeling rate of 1.5 mills per kilowatt-hour.

Unit Costs

Construction costs

The estimated construction costs of the Paradox Valley Unit are $50,390,000 on the basis of January 1977 prices and feasibility designs which would provide a useful unit life of at least 100 years. The costs consist of $50,381,000 for salinity control (including $610,000 for the wildlife area) and $9,000 for the cultural resource program. The estimated costs of the individual facilities and programs are shown on pages 41 through 43.

Annual operation, maintenance, and replacement costs

The annual operation, maintenance, and replacement costs of the unit are estimated at $332,300 annually, based upon 1974-76 prices. The costs include $330,300 for the salinity control facilities and $2,000 for the wildlife area at Radium Evaporation Pond. The table on page 44 contains a summary of the costs.

PROJECT COST ESTIMATE

Feasibility Estimate

INSTRUCTIONS FOR USE OF THIS FORM ARE CONTAINED IN CHAPTER 6, PART 152 OF THE RECLAMATION INSTRUCTIONS.

OFFICE PREPARED BY: Western Colorado Projects Office Durango, Colorado

Date of Estimate October 27, 1977

Prices as of January 1977

Estimate Prices as of Oct. 1976

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	DESCRIPTION	CCE SHEET NUMBERS	LABOR AND MATERIALS BY CONTRACTOR Cost	LABOR AND MATERIALS BY GOVERNMENT Cost	FIELD COST Plant Account	TOTAL FIELD COST Identified Property	OTHER COSTS Identified Property	TOTAL COST Identified Property	TOTAL COST Property Class	TOTAL COST Identified Property
1			2	3	4	5	6	7	8	9	10	11
			PARADOX VALLEY UNIT, COLORADO RIVER BASIN SALINITY CONTROL PROJECT									
			TOTAL PROJECT COST								50,390,000	48,001,000
12			SPECIAL PLANTS								47,900,000	
	01		BRINE WELL FIELD					513,500	1,386,500	1,900,000		1,850,000
		100	Land and Rights	1	155,000		155,000					
		130	Structures and Improvements	1	120,000		120,000					
		140	Roads and Road Structures	2	20,000		20,000					
		152	Waterways	2	170,000		170,000					
		160	Pumps and Prime Movers	2	33,000		33,000					
		170	Accessory Electrical Equipment	3	15,500		15,500					
	02		HYDROGEN SULFIDE STRIPPING PLANT					1,713,100	586,900	2,300,000		2,300,000
		100	Land and Rights	4	3,100		3,100					
		130	Structures and Improvements	4	480,000		480,000					
		152	Waterways	6	230,000		230,000					
		180	Installed Supervisory Control and Communications Equipment	7	1,000,000		1,000,000					
	03		BRINE PIPELINE					4,530,000	1,370,000	5,900,000		5,700,000
		100	Land and Rights	8	30,000		30,000					
		152	Waterways	8	3,200,000		3,200,000					
		153	Waterway Structures	9	1,300,000		1,300,000					
	04		BRINE PIPELINE PUMPING PLANTS					3,670,550	1,129,450	4,800,000		4,700,000
		100	Land and Rights	11	1,050		1,050					
		130	Structures and Improvements	11	1,900,000		1,900,000					
		152	Waterways	16	830,000		830,000					
		160	Pumps and Prime Movers	21	620,000		620,000					
		170	Accessory Electrical Equipment	23	220,000		220,000					
		199	Miscellaneous Installed Equipment	24	99,500		99,500					
	05		RADIUM, DAM, DIKE, AND EVAPORATION POND					27,285,000	5,715,000	33,000,000		31,000,000
		100	Land and Rights	27	1,200,000		1,200,000					
		110	Relocation of Property of Others	27	180,000		180,000					
		120	Clearing Land	27	260,000		260,000					
		140	Roads and Road Structures	28	35,000		35,000					
		151	Dams	28	25,610,000		25,610,000					
			(1) Dam and Dike Structure	28	(25,000,000)		(25,000,000)					
			(2) Combined Spillway and Outlet Works	29	(610,000)		(610,000)					

7-1720 (6-72)
Bureau of Reclamation
Formerly Basic Estimate DC-1 Summary

INSTRUCTIONS FOR USE OF THIS FORM ARE CONTAINED IN CHAPTER 6, PART 152 OF THE RECLAMATION INSTRUCTIONS.

PROJECT COST ESTIMATE

Feasibility Estimate

OFFICE PREPARED BY:
Western Colorado Projects Office
Durango, Colorado

PROJECT PARADOX VALLEY UNIT, CO, CRBSCP
Date of Estimate October 27, 1977
Prices as of January 1977

Previous Estimate Prices as of Oct. 1976

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	DESCRIPTION	CCE SHEET NUMBERS	LABOR AND MATERIALS BY CONTRACTOR Cost	LABOR AND MATERIALS BY GOVERNMENT Cost	FIELD COST Plant Account	TOTAL FIELD COST Identified Property	OTHER COSTS Identified Property	TOTAL COST Identified Property	TOTAL COST Property Class	TOTAL COST Identified Property (Previous Estimate)
1			2	3	4	5	6	7	8	9	10	11
13			TRANSMISSION LINES, SWITCHYARDS, AND SUBSTATIONS								590,000	
	01		TRANSMISSION LINES AND SUBSTATIONS					456,000	134,000	590,000		580,000
		175	Station Equipment	31	430,000		430,000					
		184	Underground Conductors and Devices	31	26,000		26,000					
15			GENERAL PROPERTY								565,000	
	01		PERMANENT OPERATING FACILITIES					135,000	40,000	175,000		170,000
		130	Structures and Improvements	32	135,000		135,000					
	02		O&M HOUSING					303,100	86,900	390,000		390,000
		100	Land and Rights	33	2,100		2,100					
		130	Structures and Improvements	33	230,000		230,000					
		140	Roads and Road Structures	33	71,000		71,000					
13			CAPITALIZED MOVABLE EQUIPMENT								1,010,000	
	01		PERMANENT OPERATING FACILITIES EQUIPMENT					325,000	95,000	420,000		420,000
		220	Transportation Equipment	34	72,000		72,000					
		240	Tools, Shop and Garage Equipment	34	13,000		13,000					
		260	Power Operated Equipment	34	240,000		240,000					
	02		SERVICE FACILITIES EQUIPMENT					540,000	50,000	590,000		590,000
		210	Office Equipment	36	200,000		200,000					
		250	Laboratory Equipment	36	340,000		340,000					
15			SERVICE FACILITIES								820,000	
	01		TEMPORARY CAMP					350,000	70,000	420,000		410,000
		130	Structures and Improvements	37	350,000		350,000					
	02		CONSTRUCTION OFFICE					200,000	40,000	240,000		240,000
		130	Structures and Improvements	38	200,000		200,000					
	03		RADIUM FIELD STATION					135,000	25,000	160,000		155,000
		130	Structures and Improvements	39	135,000		135,000					
			DEPRECIATION	39	-780,000		-780,000	-780,000	-0-	-780,000	-780,000	-773,000
			SALVAGE	39	-790,000		-790,000	-790,000	-0-	-790,000	-790,000	-785,000

7-1720 (5-72)
Bureau of Reclamation
Formerly Basic Estimate DC-1 Summary

INSTRUCTIONS FOR USE OF THIS FORM ARE CONTAINED IN CHAPTER 6, PART 152 OF THE RECLAMATION INSTRUCTIONS.

PROJECT COST ESTIMATE

Feasibility Estimate

OFFICE PREPARED BY: Western Colorado Projects Office
Durango, Colorado

PROJECT: PARADOX VALLEY UNIT, CO, CRBSCP
Date of Estimate: October 27, 1977
Prices as of: January 1977

Previous Estimate Prices as of Oct. 1976

PROPERTY CLASS	IDENTIFIED PROPERTY	PLANT ACCOUNT	DESCRIPTION	CCE SHEET NUMBERS	LABOR AND MATERIALS BY CONTRACTOR Cost	LABOR AND MATERIALS BY GOVERNMENT Cost	FIELD COST Plant Account	TOTAL FIELD COST Identified Property	OTHER COSTS Identified Property	TOTAL COST Identified Property	TOTAL COST Property Class	TOTAL COST Identified Property
1			2	3	4	5	6	7	8	9	10	11
			OTHER PROJECT COSTS:								1,075,000	1,054,000
			INVESTIGATIONS - RECLAMATION FUND	39	455,600			455,600	400	456,000	456,000	456,000
			CULTURAL RESOURCE PROGRAM	39	8,100			8,100	900	9,000	9,000	8,000
			WILDLIFE PROGRAM					506,000	104,000	610,000	610,000	590,000
		100	Land and Rights	40	340,000		340,000					
		130	Structures and Improvements	40	166,000		166,000					
			(1) Fencing Right-of-Way at Radium	40	(61,000)		(61,000)					
			(2) Improvements to Land at Radium	40	(105,000)		(105,000)					

Annual operation, maintenance, and replacement costs	
Salinity control facilities	
Personnel	$94,900
Equipment	39,700
Supplies	27,800
Power	107,900
Major replacements	45,700
Pumping plant operation and maintenance costs	14,300
Subtotal	330,300
Wildlife area	2,000
Total	332,300

Financial and Economic Analyses

Benefits

Benefits from construction of the Paradox Valley Unit would accrue to users of Colorado River water both within and outside of the Colorado River Basin. As discussed in Chapter II, a Bureau of Reclamation study has estimated that water users in the Lower Colorado River Basin experience costs of about $230,000 annually for each mg/l of salinity in the range of 800 to 1,000 mg/l. Consequently, the salinity reduction of 18.2 mg/l attributable to the Paradox Valley Unit would result in tangible monetary benefits of about $4,186,000 annually for such users.

Other Colorado River water users, both within and outside the basin, would also benefit from the salinity reductions of the Paradox Valley and other units of the basinwide salinity control program. Because of the widespread and diffuse nature of these benefits, however, they cannot be fully quantified in monetary terms. Some of the benefits would occur directly, such as those that would be realized by users of water for culinary purposes and for irrigation. Additional benefits would occur indirectly, while others would be difficult to identify, particularly those accruing to users of fossil or other fuels processed with Colorado River water.

Cost allocation and repayment

In accordance with the Colorado River Basin Salinity Control Act, 75 percent of the total costs of construction, operation, maintenance, and replacement for each of the four authorized units of the salinity control program would be nonreimbursable. The remaining 25 percent would be reimbursable and would be allocated between the Lower Colorado River Basin Development Fund and the Upper Colorado River Basin Fund, with no more than 15 percent of the reimbursable costs allocated to the upper basin fund. The authorizing legislation also directs that the Secretary of the Interior, after consulting with representatives of the basin states who form the Colorado River Basin Salinity Control Advisory Council, make the final allocation of reimbursable costs on the basis of the benefits to be derived in each basin, the causes of salinity, and the availability of revenues in the two basin funds. The reimbursable costs would be repaid without interest within a 50-year period after the unit became operational. The nonreimbursable costs and the reimbursable costs to be repaid from each basin fund are shown in the table on the following page based upon an allocation of 15 percent of the reimbursable costs to the upper basin fund and 85 percent to the lower basin fund. The costs of the cultural resource program would be nonreimbursable under Public Law 93-291. The annual operation, maintenance, and replacement costs of the wildlife program would be repaid by the administering agency, which is expected to be the Colorado Division of Wildlife.

The Secretary of the Interior is authorized by the Salinity Control Act to increase the rates charged for electricity generated by the Colorado River Storage Project to provide revenues for repayment of the Upper Colorado River Basin's share of the reimbursable costs of the Paradox Valley Unit and other units authorized by the Act. Rates chargeable to cover such costs were included in a rate schedule (UC-F2) announced by the Assistant Secretary of the Interior on March 14, 1977. The nonreimbursable portion of the annual operation, maintenance, and replacements costs would be funded by annual congressional appropriations.

Cost per mg/l of salinity reduction

The annual cost for each mg/l of salinity reduction in the Colorado River at Imperial Dam is estimated at $192,700 annually, based upon an annual equivalent cost of $3,507,300 and an annual reduction of about 18.2 mg/l. The annual equivalent cost consists of the sum of the annual value of the capital investment amortized over the estimated 100-year useful life of the unit at an interest rate of 5 5/8 percent and the operation, maintenance, and replacement costs less costs of investigations made prior to authorization of the unit. The costs of investigations made prior to authorization have already been incurred and would have no bearing on the decision of undertaking construction. The capital investment includes construction costs and interest during construction at 5 5/8 percent interest over a 6-year construction period. The 5 5/8 percent interest rate was used as it was the rate in effect at the time of authorization in FY 1974. The annual cost for each mg/l of salinity reduction of the unit is shown on page 47.

Cost allocation and repayment summary
(Unit--$1,000)

Item	Construction costs	Interest during construction (5 5/8 percent for 6 years)	Annual operation, maintenance and replacement costs
Cost allocation			
Salinity control	$50,381	$6,269	$332.3
Cultural resource program	9		
Total	50,390	6,269	332.3
Repayment			
Reimbursable costs 1/			
Lower Basin Fund 2/	10,706		70.2
Upper Basin Fund 2/	1,889		12.4
Colorado Division of Wildlife 3/			2
Subtotal	12,595		84.6
Nonreimbursable costs			
Salinity control	37,786	6,269	247.7
Cultural resource program	9		
Subtotal	37,795	6,269	247.7
Total	50,390	6,269	332.3

1/ In accordance with the authorizing legislation, 25 percent of the total construction and operation, maintenance, and replacement costs would be reimbursable. The costs of the cultural resource program, however, would be nonreimbursable in accordance with Public Law 93-291. Congressional approval would be required for including expenditures for wildlife mitigation.

2/ In accordance with the authorizing legislation, not less than 85 percent of the reimbursable costs would be repaid by the Lower Colorado River Basin Development Fund, and not more than 15 percent would be repaid by the Upper Colorado River Basin Fund.

3/ It is assumed that all of the operation, maintenance, and replacement costs for the wildlife area would be repaid by the administering agency, which is expected to be the Colorado Division of Wildlife.

LINE NO.	PROGRAM ITEM	QUANTITY	ESTIMATED TOTAL	TOTAL TO SEPT. 30, 1977	FISCAL YEARS 1978 (ONDJFMAMJJAS)	1979 (ONDJFMAMJJAS)	1980 (ONDJFMAMJJAS)	1981 (ONDJFMAMJJAS)	1982 (ONDJFMAMJJAS)	1983 (ONDJFMAMJJAS)	BALANCE TO COMPLETE	LINE NO.
	1	2	3	4	5	6	7	8	9	10	11	
1	CONSTRUCTION PROGRAM											1
2	Brine Well Field	23 Wells	1,900,000	173,243	542,920	263,000	250,000	211,000	230,000	229,837		2
3	Hydrogen Sulfide Stripping Plant	5 Cfs	2,300,000	58,110	200,000	200,000	200,000	500,000	700,000	441,890		3
4	Brine Pipeline	20.5 Mi.	5,900,000	334,282			300,000	1,150,000	2,350,000	1,765,718		4
5	Brine Pipeline Pumping Plants	5 Cfs	4,800,000	721,253			300,000	1,000,000	1,700,000	1,078,747		5
6	Radium Dam, Dike and Evaporation Pond	86,800 AF	33,000,000	576,960	600,000	1,750,000	4,510,000	8,000,000	12,000,000	5,563,040	← Initial Storage	6
7	Transmission Lines and Substations		590,000					40,000	300,000	250,000		7
8	Permanent Operating Facilities		595,000	25,423	10,000	20,000	50,000	100,000	200,000	189,577		8
9	O&M Housing		390,000				50,000	100,000	240,000			9
10	Temporary Camp		420,000			40,000	250,000	130,000				10
11	Service Facilities, Depreciation and Salvage		-580,000	21,408	20,000	85,000	430,000	260,000	-270,000	-1,126,408		11
12	TOTAL CONSTRUCTION COST		49,315,000	1,910,679	1,372,920	2,358,000	6,340,000	11,491,000	17,450,000	8,392,401		12
13	Other Project Costs 2/		1,075,000	455,600			360,000	109,000	150,000	400		13
14	TOTAL PROJECT COST		50,390,000	2,366,279	1,372,920	2,358,000	6,700,000	11,600,000	17,600,000	8,392,801		14
15	Consolidated Expenditures and Credits		-479,000	-468,154						-10,846		15
16	TOTAL EXPENDITURES		49,911,000	1,898,125	1,372,920	2,358,000	6,700,000	11,600,000	17,600,000	8,381,955		16
17	Undelivered Orders			37,511	-37,511							17
18	TOTAL OBLIGATIONS 1/		49,911,000	1,935,636	1,335,409	2,358,000	6,700,000	11,600,000	17,600,000	8,381,955		18
19	Funds Available				1,335,409							19
20	Funds Required					2,358,000	6,700,000	11,600,000	17,600,000	8,381,955		20
21												21
22												22
23												23
24												24
25												25

NOTES:
1. Definite Plan Report scheduled for submission December 1977.
2. Repayment Contract - none required.
3. Land Certification - none required.
4. Draft Environmental Statement - scheduled for filing with Council on Environmental Quality March 1978.
5. Salinity Reduction - 180,000 tons/year.

1/ Total to September 30, 1977, includes $1,280,133 advance planning

RECOMMENDED: ______ (Operating Office Head) ______ (Date)

RECOMMENDED: ______ (Regional Director) ______ (Date)

RECOMMENDED: ______ (Chief, Div. of P C & F) ______ (Date)

APPROVED: ______

PF-2 (3-76)

UNITED STATES
DEPARTMENT OF THE INTERIOR
Bureau of Reclamation

CONTROL SCHEDULE

COLORADO RIVER BASIN SALINITY CONTROL PROJECT

PARADOX VALLEY UNIT

Durango, Colorado Dec. 7, 1977 UC

CHAPTER V

ENVIRONMENTAL ANALYSIS

Introduction

This chapter contains a summary of the anticipated environmental impacts of the Paradox Valley Unit. More detailed information is available in a draft environmental statement (INT DES 78-19) which was filed with the Environmental Protection Agency (EPA) on May 11, 1978. A final environmental statement accommodating comments on the draft and including additional information where necessary would have to be on file with the EPA for 30 days before a decision could be made on whether or not to proceed with construction.

Environmental Impacts

Unit setting

The Paradox Valley Unit would have both short- and long-term impacts on the local setting. Construction work would temporarily detract from the natural landscape. Although revegetation would be accomplished by reseeding along the alignments of the buried pipelines and cleared areas surrounding surface structures, recovery would occur slowly because of the arid climate, particularly where pinyon-juniper woodland would be removed along the pipeline.

The surface facilities of the unit would alter the landscape over a longer period of time. Only the hydrogen sulfide stripping plant and brine pipeline pumping plants would be visible from highways and communities in the valley. The pipeline would create a long-term scar on the divide between the valley and Dry Creek Basin. The evaporation pond, although located in the more isolated Dry Creek Basin, would have the largest adverse effect, gradually creating a salt flat of about 3,630 surface acres at the end of the 100-year period of unit operation.

Economic and social conditions

The improved water quality resulting from the unit would have total economic benefits of about $4,186,000 annually in the Lower Colorado Basin, based upon an estimated reduction in salinity of 18.2 mg/l and a benefit value of $230,000 per mg/l of reduction. This improvement would have a major beneficial impact on more than 14 million municipal and industrial water users, particularly in the Los Angeles-San Diego area, and on about one million acres of irrigated farmland in southern California and Arizona. The savings associated with municipal and industrial use would occur primarily from decreased costs for water treatment, reduced pipe corrosion and appliance wear, decreased use of soaps and detergents, and improved palatability of drinking water. For irrigators, the salinity reduction would result in increased crop yields, more uniform crop patterns, decreased leaching and drainage requirements, and decreased management costs.

The influx of construction workers would increase the population of the unit area by an average of about 9 percent (252 people) during the 6-year construction period, with a maximum increase of 18 percent (540 people) in the fifth year. In the long term the unit would have essentially no effect on population.

The expenditure of unit construction funds would stimulate the economy of the unit area and of nearby commercial centers such as Moab, Montrose, Grand Junction, and Cortez. Salaries would total about $15 million, with a peak of $5 million in the fifth year for construction for 340 workers, and a good portion of this money would be spent for goods and services within or near the area. In addition, about 79 jobs annually would be created indirectly to provide these goods and services. Reclamation experience with similar projects indicates that most of the direct employment would be filled by workers from outside the unit area. Most of the indirect employment would occur in nearby commercial centers and would be filled by residents of those areas.

Nearly all of the construction force would reside in mobile homes, since housing vacancies are extremely scarce in the area. Temporary strains would be placed on utilities, educational and health facilities, police and fire protection, and other community services. As a result, levels of service would temporarily decrease.

Air quality and noise levels

The unit would not have adverse long-term effects on air quality or noise levels, although the use of heavy machinery and blasting during construction would temporarily cause increases in dust and noise. The hydrogen sulfide stripping plant would have a localized beneficial effect on air quality by essentially eliminating the offensive odor of the gas near the Dolores River.

Mineral development

Radium Evaporation Pond and the surrounding wildlife area would have possible adverse effects on future mineral development for uranium deposits that apparently underlie the site at depths of 900 to 1,500 feet. Because of this possibility, the Bureau of Mines has recommended in an attached report that another site be sought for the evaporation pond. The Bureau of Reclamation has not been able to identify another desirable site in Dry Creek Basin, however, and at any rate the entire basin appears to be underlain by the same uranium-bearing formation. The only alternative site capable of handling 5 cfs of brine would be in Sinbad Valley, a collapsed salt anticline located north of Paradox Valley. This site would be considerably more expensive than the proposed one and poses serious geological problems of its own, as discussed in more detail in Chapter VI.

Union Carbide Corporation holds mineral rights at the pond site and has been conducting exploratory drilling to determine whether or not there are any large enough deposits to warrant commercial extraction. The Bureau has maintained contact with the corporation concerning the Paradox Valley Unit and submitted a copy of the draft environmental statement for its review. Although the evaporation pond would not physically preclude uranium development, it would restrict the possible locations of surface mining structures and, consequently, increase the costs of extraction. The amount of the increase and whether or not it would effectively prohibit development would depend upon the presence, magnitude, and location of any significant ore bodies. Since this information is not available, the extent of the pond's impact, or whether there would in fact be any significant impact, cannot be ascertained.

Water resources

The unit would deplete the lower Dolores and Colorado Rivers by a maximum of 3,950 acre-feet annually consisting of 3,600 acre-feet of brine and 350 acre-feet of precipitation and natural runoff at the evaporation pond site. Although an average of about 2,600 acre-feet of precipitation and runoff would actually be evaporated each year, as discussed in Chapter IV, the Bureau estimates that only about 350 acre-feet would have otherwise entered the Dolores River through the San Miguel River. The remaining 2,250 acre-feet would be lost through evapotranspiration in the Dry Creek drainage area under natural conditions.

Water quality

By removing 180,000 tons of salt annually, the unit would reduce the salinity of the lower Colorado River by about 18.2 mg/l, based on 1976 modified conditions of development in the river basin. These conditions use available hydrologic records on the period 1941-74 and assume that all projects constructed or under construction as of 1976 had been under full scale operations for the entire period of record. The reduction in salinity would be more noticeable upstream, with an estimated reduction of 30 mg/l just below the confluence of the Colorado and Dolores Rivers. The unit would have a dramatic effect on salt concentrations in the Dolores River, with average reductions of 474 mg/l just below the brine well field and 304 mg/l just below the mouth of the San Miguel River.

The unit would have no effect on nutrients, coliform bacteria, or heavy metals. It would also have no effect on turbidity in the long term, although construction work may temporarily increase turbidity levels in Paradox Valley.

Fish

The unit would have a major beneficial impact on the 7 miles of the Dolores River from Paradox Valley to the mouth of the San Miguel River by reducing the average annual salinity level from 729 mg/l to about 255 mg/l. Fishes such as the speckled dace, flannelmouth sucker, bluehead sucker, roundtail chub, red shiner, fathead minnow, and black bullhead could inhabit this reach whenever sufficient flows were available (estimated at about three out of every four years under future conditions). The unit would also slightly improve the year-round fishery that now exists in the 63 miles of the Dolòres River between the confluence of the San Miguel River and the confluence of the Colorado River. Fisheries in the Colorado River would not be significantly affected, since the change in salinity would be relatively small.

Wildlife

Unit construction would temporarily disturb wildlife because of noise, dust, blasting, the movement of men and equipment, and the temporary removal of vegetation in work areas. The more mobile and adaptable species would move from the construction sites to adjacent habitat that is already at its carrying capacity, which would lead to losses of animals and a deterioration of the habitat. Other species would incur direct losses at the work sites.

The only big game species significantly affected in the long term by the unit would be the mule deer and the pronghorn. The evaporation pond would gradually inundate 3,630 acres of range now used by deer in the winter and pronghorn year-round, but this acreage is small compared to the total range in the area. The pronghorn population is now limited by predation and livestock competition, however, and not by a lack of available range. The development of the proposed wildlife area would potentially compensate for any big game losses at the site and would also provide better pronghorn habitat than now exists.

The only small game mammal identified in the area, the desert cottontail, would probably benefit slightly from the unit. Revegetation along the pipeline alignment and the development of the wildlife area would provide a habitat of better quality than is now found in the area. Furbearers such as the long-tailed weasel, gray fox, striped skunk, and badger would also benefit slightly from these changes in habitat. Among other furbearers the beaver and muskrat would benefit from additional riparian and submerged vegetation resulting from the reduced salinity in the river. The only varmint affected would be the raccoon, which would also benefit from the increased vegetation along the river. Nongame mammals would not be significantly changed in terms of population density, but habitat modifications would alter the species composition by favoring certain species, such as the deer mouse and western harvest mouse, over others.

The unit would have beneficial impacts on some raptors and adverse impacts on others but would cause a slight overall decrease in raptor use of the area. Hunting habitat would generally be improved for most species. The only game bird significantly affected would be the sage grouse, which could increase in population as a result of the wildlife area around the evaporation pond. Waterfowl and shorebirds would be beneficially affected by improved habitat along the Dolores River, but waterfowl could possibly suffer losses at the evaporation pond. Studies now being conducted indicate that prolonged exposure to the brine would be dangerous because of dehydration and hypothermia, but that the birds would not be likely to remain on the pond long enough to be harmed. Field studies are planned to determine the impacts of the pond, and the results will be available for review by any interested parties.

The unit would generally have no significant impacts on nongame birds, since the improved riparian vegetation on the Dolores River and the wildlife area would largely compensate for habitat losses. Revegetation along the pipeline would alter species diversity but would not affect species density.

Amphibians would benefit from the unit. Brine pools and salt deposits along the river would be replaced by freshwater pools filled during spring floods, and the water retention structures in the wildlife area would also provide some habitat for amphibians. Reptiles would experience overall declines in populations, although a few species could benefit from the habitat modifications. Generally, revegetation along the pipeline and the development of the wildlife area would compensate for losses caused by clearing and inundation. In addition, the gradual improvement of riparian habitat along the Dolores River downstream of the well field would also benefit wildlife.

Threatened or endangered species

The peregrine falcon and the bald eagle are the only threatened or endangered species of fish or wildlife identified in the unit area. Possible effects on an active peregrine falcon aerie in the unit area have been investigated by the Fish and Wildlife Service, in accordance with requirements of Section 7 of the Endangered Species Act. The Service reports that the improved riparian vegetation resulting from the unit could enhance hunting areas for the falcon. The unit in all likelihood would not jeopardize the falcon or adversely effect its critical habitat (see attached letter of October 18, 1977). The Bureau of Land Management will initiate a monitoring program and close the nesting area seasonally (March 1 to August 1) to public use and development. Based on recommendations of the Fish and Wildlife Service the Bureau of Reclamation, Bureau of Land Management, Fish and Wildlife Service, and Colorado Division of Wildlife would cooperate to ensure adequate protection, determine the extent of breeding area, and identify the exact aerie location. Habitat for the bald eagle would be slightly decreased, but the area is not considered to be essential for the species. No nesting areas have been observed.

Cultural resources

One prehistorical site and one historical site would be inundated by the evaporation pond. Neither site has been listed on nor formally evaluated for eligibility for the National Register of Historic Places. As discussed in Chapter IV, an evaluation and, if necessary, a mitigation program would be undertaken as part of the unit construction.

Land ownership and use

As discussed in Chapter IV, a total of about 7,891 acres, including 5,381 acres of private land and 2,510 acres of public land now administered by the Bureau of Land Management, would be acquired for unit features. Nearly all of the private land is in San Miguel County, and the acquisition for the unit would reduce county tax revenues by less than 1 percent.

The acquisition of private land would adversely affect two landowners who would lose a total of 4,990 acres in Dry Creek Basin. One owner has a small ranching operation and would lose over half of his land, with a resulting decrease in grazing permits on nearby public land. Consequently, the operation could become uneconomical if replacement land with adequate grazing permits could not be found. The uneconomical unit, which would total about 830 acres, would be acquired as part of the project if the owner so desires. The second owner has an estensive operation and would be affected much less seriously, although his income would be slightly reduced.

Unavoidable Adverse Effects

The unit structures, although located in a relatively isolated area, would alter the local setting and would be visually unattractive to some people. The greatest change would be at the evaporation pond site and would occur fairly slowly as the pond filled.

The influx of construction workers over a 6-year period would adversely affect social conditions by placing temporary strains on utilities, educational and medical facilities, police and fire protection, and other community services. Long-term economic impacts would be potential improvements in habitat for pronghorns, furbearers, varmints, and for some species of small game and nongame mammals, raptors, and gamebirds.

The gains of the unit would occur at the expense of some long-term environmental losses. The unit structures would permanently disrupt the existing scenery of the area. Radium Evaporation Pond could restrict future exploration and development of potential uranium deposits underlying the site. The unit would also result in long-term losses by removing 3,658 acres for use for livestock grazing and wildlife habitat. Although the resulting impacts on wildlife populations would be mitigated, there would still be long-term reductions for certain species of nongame mammals, game and nongame birds, raptors, and reptiles. There could also be losses of waterfowl at the evaporation pond, but studies on this impact are not completed. Two archaeological sites would be permanently lost.

To a certain degree the construction and operation of the unit would foreclose some options for future development of resources. The funds, fuels, power, labor, materials, and land required for the unit would not be available for other uses. Water depleted from the river, although insignificant, would not be available for alternative uses.

Irreversible and Irretrievable Commitment of Resources

The operation of the unit as planned would require an irreversible commitment of up to 3,950 acre-feet of water annually and a total of 7,891 acres of land now used primarily for livestock grazing and wildlife habitat. The commitment of land would include 3,876 acres for salinity control facilities, 3,660 acres for a developed wildlife area, and 355 acres of additional right-of-way. About 15,200,000 kilowatt-hours of electricity annually would be committed to project operations and would be unavailable for other potential uses. Also committed would be two archaeological sites and the existing scenery of the unit area, as well as the funds, fuel, power, labor, and materials required for construction and operation.

CHAPTER VI

ALTERNATIVES

Introduction

The Bureau of Reclamation has studied several methods of reducing the salt contributions in Paradox Valley, but has been generally unable to identify economically feasible alternatives to the proposed plan. Alternatives studied have questionable effectiveness and stability, and would be considerably more expensive than the proposed plan. In most cases the alternative would have to be constructed and operated for a long period of time to determine whether or not it would be effective.

This chapter discusses two alternatives to the proposal. In one plan, Radium Evaporation Pond would be replaced by a pond in Sinbad Valley to the north of Paradox Valley, which is the only other site in or near the unit area that would be suitable for disposing of brine at a maximum rate of 5 cfs. The site has serious geological problems, however, and is of questionable feasibility. The other plan is based upon diverting the Dolores River into a lined bypass channel to be constructed across Paradox Valley. The brine ground water would continue to surface in the natural flood plain of the river and would form an evaporation pond in the middle of the valley. The feasibility of this plan is also questionable, as discussed in more detail below. The estimated costs of the proposed plan and the two alternatives are shown in the following table. The cost per mg/l of salinity reduction is based on the assumption that each plan would reduce the salinity of the Colorado River at Imperial Dam by 18.2 mg/l.

Cost summary of alternatives

	Construction costs (January 1977 prices)	Annual equivalent cost 1/	Cost per mg/l of salinity reduction
Proposed plan	$50,390,000	$3,498,000	$192,200
Alternative plans			
Sinbad Valley Evaporation Pond	162,500,000	10,484,000	576,000
Dolores River bypass channel	56,000,000	3,700,000	203,300

1/ Includes the capital investment and interest during construction amortized over a 100-year period at 5 5/8 percent interest and annual operation, maintenance, and replacement costs.

The Bureau also considered three alternative methods which were discarded because of doubtful practicality and which are therefore not included in this chapter. One of these would involve desalting the moderate and low flows of the Dolores River immediately downstream from the brine area, returning the desalted water to the river channel and piping the effluent to Radium Evaporation Pond for disposal. The surfacing brine itself could not be treated, since it is already saltier than the plant effluent from a desalting plant. This alternative would remove much less salt than the proposal, would have excessively high construction and operation costs, and would require large amounts of electric power.

The second method would be to establish a freshwater lake over the zone of brine inflow to develop a positive head over the aquifer and thus reduce or prevent brine inflow into the river. This method would require the construction of a dam with outlet works and would inundate a large acreage of bottom and agricultural land and a number of farm homes in the Bedrock town area. Consequently, due to the high cost to investigate, the large adverse environmental impact to the area, and most of all the inability to determine the overall effectiveness for a number of years, the method was rejected.

The third method would be to identify the source or sources of ground water recharge, then drill wells and pump the fresh water before it comes in contact with the salt dome beneath Paradox Valley. The potential recharge area is very large, however, including West and East Paradox Valley, the valley walls, and the nearby La Sal Mountains; and the amount of recharge that must be specifically identified is quite small at about 1 cfs. Recharge may also be diffused over the entire area rather than restricted to within smaller localities. As a consequence, identifying and controlling the recharge would be very costly with only limited results.

In addition to studying alternatives to the proposed plan, the Bureau has considered several measures that may be feasible if the design data collection program shows that a well field pumping rate of about 2 cfs rather than the proposed rate of 5 cfs would effectively remove most of the salt now entering the river. As pointed out in Chapter IV, the data collection program could demonstrate that a pumping rate of less than 5 cfs would be sufficient. If the well field proves to be highly efficient, a long-term rate in the range of 2 cfs would control the brine, since the brine inflow is estimated at an average of 0.8 cfs and a maximum of 2.1 cfs. Consequently, the Bureau has estimated the effects of modifying the proposed plan by reducing the design capacities of the unit facilities and has also formulated several alternatives for brine disposal that may be possible at a reduced pumping rate. Three of these alternatives would replace Radium Evaporation Pond with alternative ponds, and another would involve the injection of brine into deep wells. In each case the brine well field, hydrogen sulfide stripping plant, and modified brine pipelines would be required.

The estimated construction costs and the cost effectiveness of the small-scale plans are shown in the following table, based on the assumption that the reduction in salinity would be about 18.2 mg/l for each plan. Costs have not been estimated for deep well injection, however, since it is not possible to determine the number of disposal wells required for a 100-year period of unit operations. The alternative plan of constructing the Dolores River bypass channel is also shown, since its capacity, costs, and effectiveness are based upon the flow of the Dolores River rather than a brine pumping rate.

Cost summary of small-scale plans
(well field pumping rate of 2 cfs)

	Construction costs (January 1977 prices)	Annual equivalent cost 1/	Cost per mg/l of salinity reduction
Modified Radium Evaporation Pond	$34,800,000	$2,379,000	$130,700
Modified Sinbad Valley Evaporation Pond	108,400,000	6,754,000	371,100
East Paradox Valley Evaporation Pond	58,700,000	3,910,000	214,800
West Paradox Valley Evaporation Ponds	35,400,000	2,330,000	128,000
Deep Well Injection	Unknown 2/	Unknown 2/	Unknown 2/
Dolores River Bypass Channel	56,000,000	3,700,000	203,300

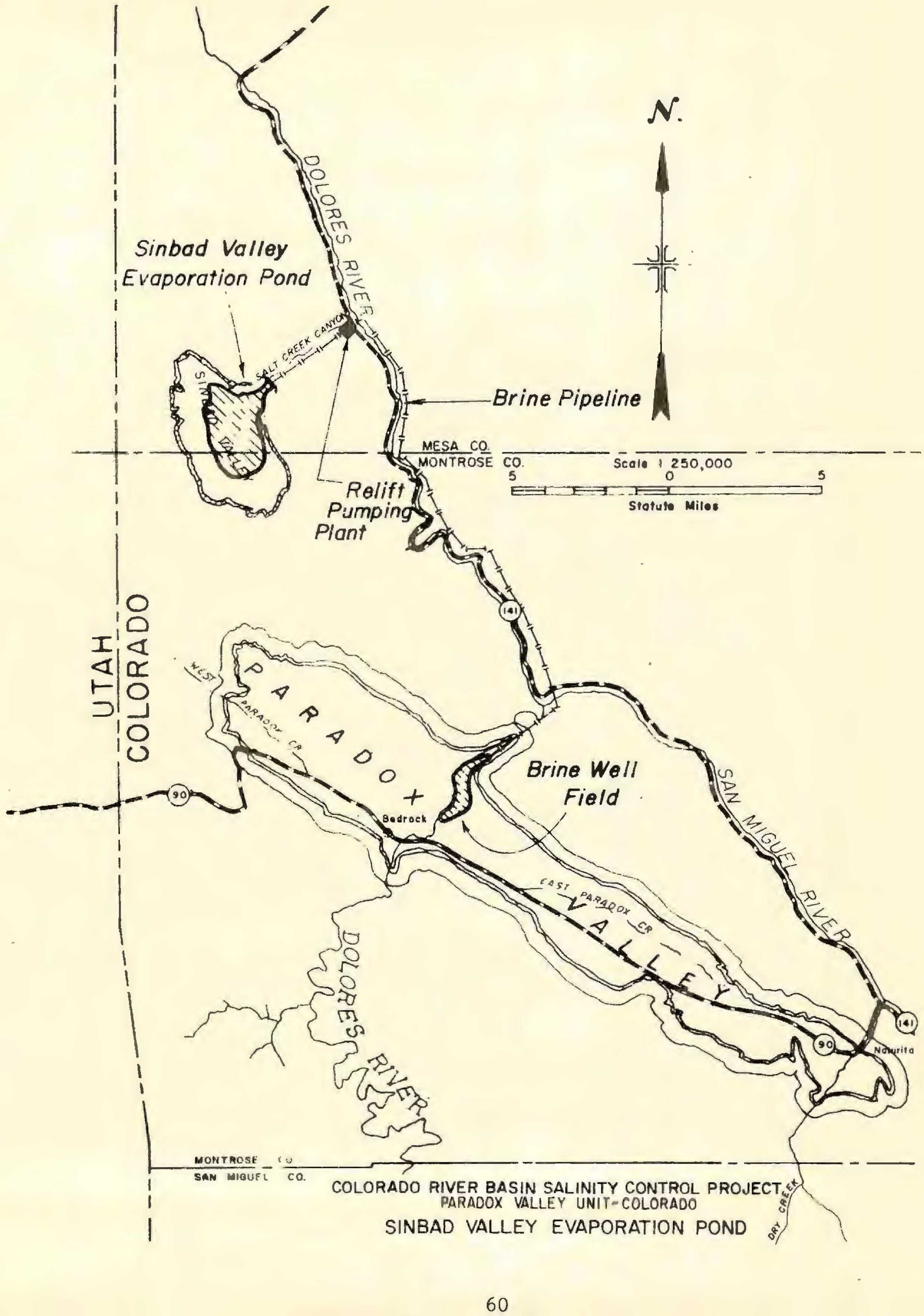
1/ Includes the capital investment and interest during construction amortized over a 100-year period at 5 5/8 percent interest and annual operation, maintenance, and replacement costs.

2/ The Bureau estimates that each injection well would cost about $3.5 million, as discussed later in this chapter, but cannot determine the total number of wells required or the total cost of the plan.

Alternatives to the Proposed Plan

Sinbad Valley Evaporation Pond

This alternative would involve pumping 5 cfs of brine from the existing well field to an evaporation pond in Sinbad Valley, a collapsed salt anticline located about 13 miles north of the well field. After being pumped from the wells, the brine would be collected and piped to


N.
Sinbad Valley
Evaporation Pond
SALT CREEK CANYON
SINBAD VALLEY
DOLORES RIVER
Brine Pipeline
MESA CO.
MONTROSE CO.
Relift
Pumping
Plant
Scale 1 250,000
5
0
5
Statute Miles
UTAH
COLORADO
WEST PARADOX CR.
PARADOX
Bedrock
Brine Well
Field
SAN MIGUEL RIVER
EAST PARADOX CR.
VALLEY
DOLORES RIVER
Naturita
MONTROSE CO.
SAN MIGUEL CO.
DRY CREEK
COLORADO RIVER BASIN SALINITY CONTROL PROJECT
PARADOX VALLEY UNIT-COLORADO
SINBAD VALLEY EVAPORATION POND

an adjacent hydrogen sulfide stripping plant on the west side of the Dolores River for treatment. Because of very rugged terrain between the plant and the pond site, the brine would then be conveyed in a buried pipeline for about 26 miles downstream along the Dolores River and about 3.7 miles up Salt Creek, an intermittent stream which drains Sinbad Valley and joins the river. A high-lift pumping plant would be required near the confluence of the two streams to lift the brine through a total vertical distance of about 1,060 feet into the pond, with power obtained from an existing transmission line along the river about 1 mile to the east.

The evaporation pond would be formed by the construction of a large earthfill dam across Salt Creek on the downstream side of the valley. About 413 feet high and 1,440 feet long at the crest, the dam would contain an estimated 9,800,000 cubic yards of material (about four times as much as Radium Dam and Dike combined). The pond, which would have a useful life of 100 years at the maximum brine discharge rate of 5 cfs, would have a total capacity of about 245,000 acre-feet (over twice as large as the proposed Radium Evaporation Pond), but a surface area of only 2,280 acres (about one third smaller). The additional capacity would be required for two reasons. First, the pond would have to store and evaporate a larger volume of average annual precipitation and surface runoff than occurs in Dry Creek Basin. Second, because of the valley's steep topography a large capacity would be necessary to create an adequate surface area for evaporation. Even as now designed, the surface area would not be large enough for annual evaporation to equal the average annual inflow of brine, precipitation, and surface runoff during the 100-year period of operations. Consequently, the pond would consist primarily of brine with a small amount of deposited salt at the end of the unit life, and only after a long period of time would all of the water evaporate and leave an exposed salt flat.

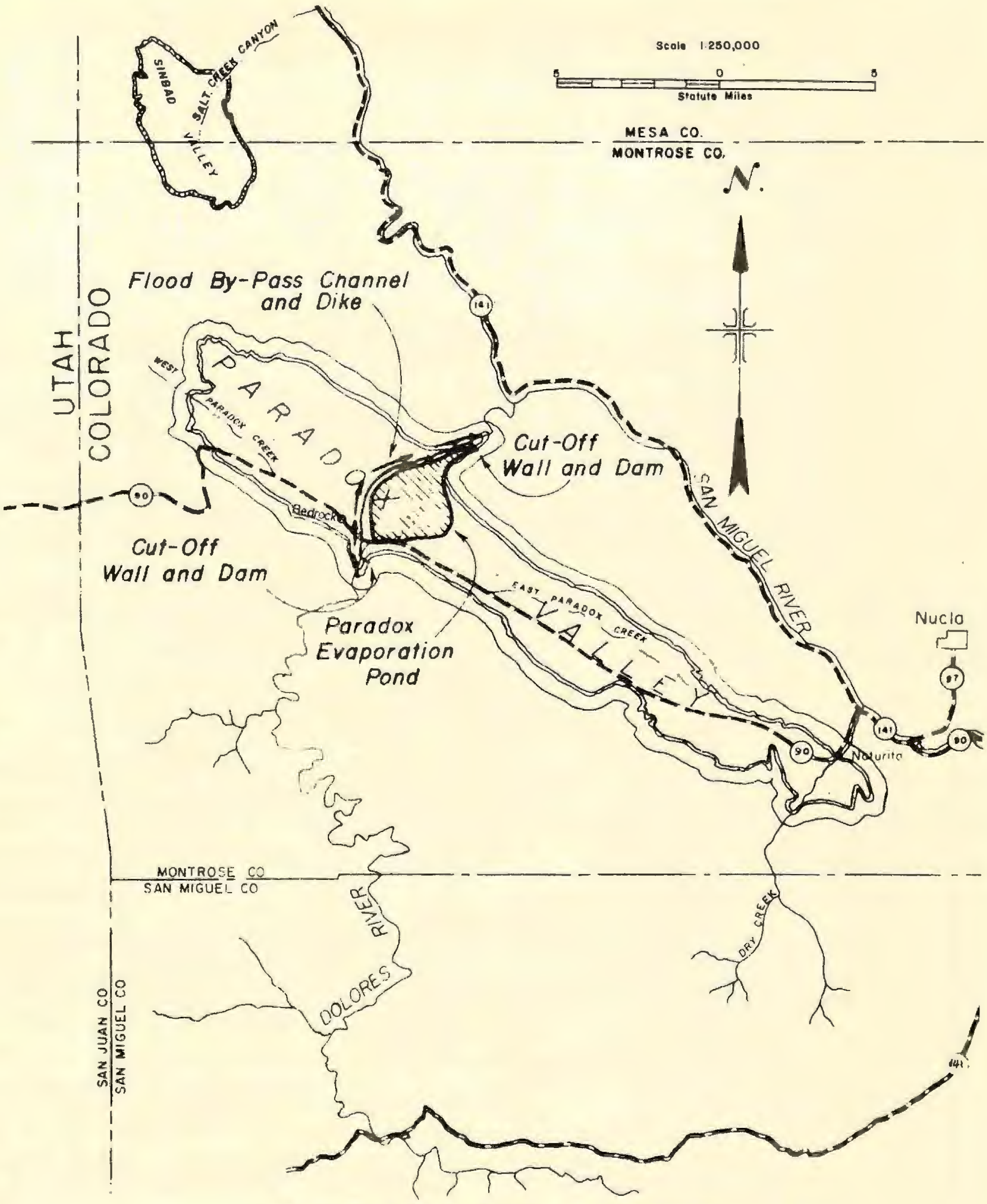
Because of serious geologic problems, the construction of an evaporation pond in the valley would probably not be feasible. The dam would require a large amount of material, and there is no known quantity of suitable material in the area. Large scale seepage could also be a severe hazard, and an expensive lining would be required for the pond. The valley floor is the residual cap of a salt dome, composed of gypsum and soluble materials like those found beneath Paradox Valley, and would consequently be unacceptable for a pond basin. The valley walls would also be highly capable of transmitting water, since the strata dip away from the pond site, are highly fractured, and are characterized by collapsed fault blocks. The estimated costs cf the alternative are summarized in the tabulation on the following page.

Construction costs (January 1977 prices)	
Brine well field	$1,600,000
H_2S stripping plant	2,200,000
Brine pipeline	7,000,000
Pumping plant	1,700,000
Evaporation pond	150,000,000
Total construction costs	162,500,000
Interest during construction	18,500,000
Total investment	181,000,000
Annual costs	
Amortized investment (100 years at 5 5/8 percent interest)	10,200,000
Operation, maintenance, and replacement costs	240,000
Power	44,000
Total	10,484,000
Per mg/l of salinity reduction	576,000

Dolores River bypass channel

This alternative would involve diverting the Dolores River out of its natural channel, routing it across Paradox Valley in a channel constructed of impervious material, and allowing the brine and fresher ground water to evaporate in the natural flood plain where they now surface. Intermittent flows of East Paradox Creek would also be evaporated, but the flows of West Paradox Creek would be diverted into the bypass channel, which would be located to the west of the present riverbed.

At the upstream side of the valley an earthfill diversion dam 80 feet high and 1,000 feet long at the crest, combined with a cutoff wall, would force all of the surface and subsurface flows of the river into the bypass channel, which would have a total length of about 5 miles. The eastern bank of the channel, with a height of about 52 feet above the natural riverbed, would prevent the maximum probable riverflow of 74,200 cfs from spilling into the brine evaporation area. The western bank would be lower, about 22 feet high, and would contain the estimated 25-year flood of 11,600 cfs. Although larger flows would spill over the western bank away from the natural river channel and temporarily inundate up to 900 acres, the water would drain out as the flood receded. An impervious lining of compacted earth would be placed on the bottom and lower sides to handle flows of 3,000 cfs or less, which occur about 95 percent of the time. With larger flows the water level would rise into the unlined portion of the banks, where some seepage would occur, but the infrequency and short duration of such occurrences would keep losses to a minimum. At the downstream side of the valley, the channel would end with a concrete drop structure that would discharge the flows into the natural riverbed. A second dam and cutoff wall would be



COLORADO RIVER BASIN SALINITY CONTROL PROJECT
PARADOX VALLEY UNIT COLORADO

DOLORES RIVER BYPASS CHANNEL

constructed across the riverbed just upstream from the drop structure. This dam would also be earthfill, with a height of 80 feet and a crest length of 850 feet. This structure would prevent the surfacing brine from leaving the valley and entering the river downstream from the bypass channel. Impounded behind the dam, the brine would form an evaporation pond in the natural flood plain of the river. The pond would be enclosed by the lower dam on the north, by the bank of the bypass channel on the west, and by natural terrain on the south and east. With a maximum volume of 58,200 acre-feet and surface area of 2,630 acres, it would be large enough for a 100-year operational life. At its maximum size, the pond would extend across the entire width of the valley.

The long-term effectiveness of this plan is highly questionable, since the formation of a large pond on top of the seeps and springs could alter the behavior of the ground water. As the pond grew larger, the increasing static head created by the water and the precipitated salts could gradually overcome the ground water pressure that now forces the brine to surface along the river. Consequently, part or all of the brine, or perhaps additional brine, could begin to surface at one or more locations outside the control area and again enter the river. Also, the chances of failure are much greater because of the subsiding nature of the ground as the underlying salts were removed and the instability of the river channel during floodflows. Another problem with this plan would be the availability of construction materials, since local sources in the valley are of questionable suitability.

The plan could be modified by increasing the size of the upper dam to provide temporary storage space for floodflows of the Dolores River. The stored flows would then be gradually released at a controlled rate into the bypass channel, thus allowing the capacity of the channel to be decreased. Such a modification does not offer any economic advantage, however, since the increased cost of the dam would outweigh the decreased cost of the channel. The estimated costs of the plan are shown in the tabulation on the following page.

Construction costs (January 1977 prices)	
Upper dam and cutoff wall	$6,000,000
Bypass channel	23,000,000
Lower dam and cutoff wall, evaporation pond	16,000,000
Drop structure	11,000,000
Total construction costs	56,000,000
Interest during construction	6,000,000
Total investment	62,000,000
Annual costs	
Amortized investment (100 years at 5 5/8 percent interest)	3,520,000
Operation, maintenance, and replacement costs	180,000
Total	3,700,000
Per mg/l of salinity reduction	203,300

Smaller Scales of Development

Modified Radium Evaporation Pond

If pumping brine from the well field at 2 cfs would reduce the salt inflow by about 180,000 tons annually, all of the proposed unit facilities would be reduced in operating capacity. None of them could be eliminated, however. The hydrogen sulfide stripping plant, brine pipeline, and pumping plants would all have the same locations as in the proposed plan. The most significant change would involve Radium Evaporation Pond, which would be reduced from 86,800 to 36,000 acre-feet in capacity and from 3,630 to 1,780 acres in surface area, located entirely in the drainage of the West Fork of Dry Creek. Radium Dam would be reduced in size to a height of 89 feet and a crest length of 6,000 feet but would have the same location. The dike, also considerably smaller with a height of 22 feet and a crest length of 5,500 feet, would be located on the saddle between the East and West Forks. Because of the smaller pond, the wildlife area would also be reduced. A cost summary for the plan is shown on the following page.

Construction costs (January 1977 prices)	
Brine well field	$1,600,000
H_2S stripping plant	1,500,000
Brine pipeline	3,700,000
Pumping plants	3,000,000
Evaporation pond	25,000,000
Total construction costs	34,800,000
Interest during construction	3,900,000
Total investment	38,700,000
Annual costs	
Amortized investment (100 years at 5 5/8 percent interest)	2,120,000
Operation, maintenance, and replacement costs	224,000
Power	35,000
Total	2,379,000
Per mg/l of salinity reduction	130,700

Modified Sinbad Valley Evaporation Pond

This plan would involve pumping the brine to Sinbad Valley for disposal, as discussed earlier, but the H_2S stripping plant, 29.7-mile brine pipeline, pumping plants, and evaporation pond would be reduced in capacity to handle only 2 cfs of brine. The evaporation pond would have a maximum capacity of 146,000 acre-feet and a corresponding surface area of 1,600 acres. The dam required to form the pond would be about 360 feet high and 1,400 feet long at the crest. Because of the steep topography of the valley, the water surface of the pond would not be large enough for annual evaporation to equal the average annual inflow of brine, precipitation, and surface runoff during the 100-year period of operations. Only after a long period of time would all of the water evaporate and expose a salt flat.

Like the larger evaporation pond in Sinbad Valley this pond would also have serious geologic problems and would probably not be feasible. The problems would include the lack of a known quantity of suitable material for construction and the high cost of lining to prevent potential large scale seepage through the valley floor and walls.

The estimated costs of the plan are summarized in the table on the following page.

Construction costs (January 1977 prices)	
Brine well field	$1,600,000
H_2S stripping plant	1,500,000
Brine pipeline	4,300,000
Pumping plant	1,100,000
Evaporation pond	100,000,000
Total construction costs	108,500,000
Interest during construction	11,500,000
Total investment	115,000,000
Annual costs	
Amortized investment (100 years at 5 5/8 percent interest)	6,500,000
Operation, maintenance, and replacement costs	224,000
Power	30,000
Total	6,754,000
Per mg/l of salinity reduction	371,100

East Paradox Valley Evaporation Pond

With a wellfield pumping rate of about 2 cfs, the brine could be evaporated at an alternative site about 11 miles southeast of the proposed hydrogen sulfide stripping plant. A buried pipeline with three pumping plants would convey the brine to the evaporation pond, which would be located on a low and relatively flat saddle separating Paradox Valley from the northern tip of the Dry Creek drainage. A dike and a dam would be constructed to form the pond. The dike, located on the west side, would have a height of 88 feet and a crest length of 7,970 feet and would extend across East Paradox Creek. The dam, on the east side, would have a height of 180 feet and a crest length of 2,140 feet and would be located on an intermittent tributary of Dry Creek. The pond would have a total capacity of 65,000 acre-feet and a maximum surface area of 1,030 acres. The large capacity would be required to produce an adequate area for evaporation of the brine, although evaporation would still occur more slowly than inflow, and few salts would be deposited during the 100-year period of operations. Eventually, however, an exposed salt flat would replace the brine.

The location of the dam in this plan presents geologic problems, since the foundation would be situated on a number of fault blocks. The site is an area of peripheral collapse dividing the main Paradox salt cell from a lesser salt cell which underlies this reach of the Dry Creek drainage. Consequently, an expensive lining would be required for the pond.

The costs for the plan are summarized on the following page.

Construction costs (January 1977 prices)	
Brine well field	$1,600,000
H_2S stripping plant	1,500,000
Brine pipeline	3,600,000
Pumping plants	2,000,000
Evaporation pond	50,000,000
Total construction costs	58,700,000
Interest during construction	6,300,000
Total investment	65,000,000
Annual costs	
Amortized investment (100 years at 5 5/8 percent interest)	3,670,000
Operation, maintenance, and replacement costs	210,000
Power	30,000
Total	3,910,000
Per mg/l of salinity reduction	214,800

West Paradox Valley Evaporation Ponds

At a pumping rate of 2 cfs or less, the brine could also be evaporated by a series of eight small ponds located adjacent to the well field and in an area extending to the northwest for about 2 miles. The hydrogen sulfide stripping plant would also be located on the northwestern side of the well field, and a buried pipeline would extend from the plant along the length of the ponds, with a separate turnout and valve for each pond. A pumping plant would be installed at the beginning of the pipeline. The ponds would be formed by excavating eight basins and using the excavated material to construct surrounding dikes that would range in height from 25 to 80 feet. The resulting ponds would vary in capacity from 1,670 to 8,900 acre-feet and in surface area from 130 to 500 acres. The combined capacities would be about 29,600 acre-feet. To prevent seepage, the ponds would be lined with impervious material, such as butyl rubber, vinyl, or treated clay derived from local shale formations such as the Mancos or Morrison. The ponds would be constructed one at a time as needed during the 100-year operational life of the unit, and the last one would not be completed until about the 70th year. As each one was filled with salt deposits, it would be covered with earth and seeded. Costs for this plan are shown on the following page.

Construction costs (January 1977 prices)	
Brine well field	$1,600,000
H_2S stripping plant	1,500,000
Pumping plant	400,000
Evaporation ponds	1/ 31,900,000
Total construction costs	35,400,000
Interest during construction	4,000,000
Total investment	39,422,000
Annual costs	
Amortized investment (100 years at 5 5/8 percent interest)	2,155,000
Operation, maintenance, and replacement costs	170,000
Power	5,000
Total	2,330,000
Per mg/l of salinity reduction	128,000

1/ This value is the present worth of the construction costs required for staged construction of the ponds.

Deep Well Injection

This plan would involve pumping the brine at a rate of 2 cfs or less from the existing well field and injecting it into one or more deep wells as a means of disposal. As stated in Chapter IV, the Bureau's design data collection program at the brine well field may show that pumping rates of as low as 2 cfs would effectively control the salt influx. In this event, the alternative of deep well injection as a means of disposal would warrant further investigation to determine its feasibility. The deep wells, located in Paradox Valley near the river, would eliminate the need for the brine pipeline and evaporation pond.

A study by a consulting geologist under contract with the Bureau has recommended that in order to evaluate deep well injection two abandoned oil exploration wells, located 1 mile west and 3 1/2 miles southwest of the brine well field, be rehabilitated and tested to determine the feasibility of brine injection.1/ The closer of the two wells extends over 14,000 feet deep into the Mississippian Formation underlying the salt core of Paradox Valley, and the other well extends to a depth of 3,742 feet into the Cutler Formation. Because of its extensive size, thickness, and noted porosity, the Mississipian Formation could possibly provide a suitable subsurface reservoir for the brine. The depth to the formation is also a favorable factor, since it is deep enough to be unaffected by faults and other structures that could cause

1/ Turner, Frank P., Feasibility Study of Brine Disposal by Deep Well Injection on the Paradox Valley Unit, Colorado River Salinity Control Project, 1975. The report is available at the Bureau of Reclamation in Durango, Colo.

leakage to the surface and is also well below any freshwater circulation and confined by the thick layer of salt immediately above it.

To dispose of brine, the oil well nearer the brine well field would be rehabilitated, tested, and drilled to a greater depth if the tests showed that this would open up more porous zones. A short, buried pipeline would convey the brine from the hydrogen sulfide stripping plant, and a pumping plant would be installed to compress the existing formation water and thus force the brine into the formation. If necessary, additional surface facilities would be constructed to pretreat the brine by filtration or by the addition of chemicals in order to prevent it from clogging the pore spaces of the formation. When necessary, the second oil well would also be rehabilitated for use.

Deep well injection would involve several problems. Even if the formation could receive brine without significant problems, which has not been established, a large number of new wells would probably be required to provide an operational life of 100 years for the unit, although the number cannot be estimated. Some wells would probably encounter impervious areas of the formation and would have to be abandoned, and the successful wells would probably exhibit a great deal of variation in the rate of brine they could receive and the storage area available for brine. Another disadvantage is that a considerable amount of electric power would be required for injection, since the formation already contains ground water and a storage space for the pumped brine must therefore be created. Most previous cases of successful deep well injection have involved the injection of fluids into an underground reservoir to replace oil that has been pumped out. This situation does not exist in Paradox Valley, and the long-term effectiveness of forcing brine into an aquifer without also removing the existing formation water or the feasibility of preventing the brine from recirculating has not been demonstrated.

The total construction cost of this plan would depend upon the number of wells ultimately required to inject brine for an operational period of 100 years. Turner estimates that the cost of rehabilitating the two wells and installing surface pretreatment facilities would be less than $1,000,000. The Bureau of Reclamation estimates that the cost of installing each new injection well would be about $3.5 million. Annual operation, maintenance, and replacement costs would be very high, primarily because of the large power requirements and the probability that a large number of wells would be required for long-term control of the brine inflow.

REPORTS OF COOPERATING AGENCIES

FISH AND WILDLIFE SERVICE

January 21, 1977

Memorandum

To: Regional Director
Upper Colorado Region
Bureau of Reclamation
Salt Lake City, Utah

From: Area Manager
Fish and Wildlife Service
Salt Lake City, Utah

Subject: Colorado River Basin Salinity Control Project, Paradox Valley Unit, CO (BR)

This advance planning aid memorandum on the subject project furnishes our analysis of project impacts on fish and wildlife resources and our recommendations to offset these impacts. It has been prepared under the authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U. S.C. 661 et. seq.), the National Environmental Policy Act of 1969 (P.L. 91-190; 83 Stat. 852-856), and with the cooperation of the Colorado Division of Wildlife.

The most important adverse impact of the Paradox Valley Unit will result from the construction of Radium Dam and Reservoir. Approximately 3,000 acres of wildlife habitat will be lost as a result of this project feature.

The area within the reservoir basin is mule deer winter range and antelope range. In addition to loss of big game range, the area contains a good sage grouse population. The reservoir would inundate sage grouse breeding grounds and feeding areas.

Radium Reservoir Basin offers a wide variety of vegetative and habitat types that are ideal hunting areas for raptors. Golden and bald eagles, kestrel, rough-legged hawk as well as other raptors are commonly seen within the project area.

As required by the Water Resources Council, Principles and Standards, the Fish and Wildlife Service has developed ecological planning and evaluation procedures. Briefly, the system provides for a quality and quantity evaluation of the various ecosystems within a planning area for several species of wildlife, both game and nongame. Randomly selected samples of each ecosystem are rated for their value to support wildlife. The results are expressed in habitat units per acre.

On June 28, 1976, an evaluation team consisting of Don Smith, Colorado Division of Wildlife, Glenn Bessinger, Bureau of Reclamation and John Boaze, Fish and Wildlife Service conducted a field evaluation of the existing wildlife habitat within the proposed project area. The field forms and computer printouts developed for this evaluation are on file in our Salt Lake City Area Office for your inspection. Table 1 presents a summary of the team evaluation.

To compensate for the habitat units loss caused by the project, the Colorado Division of Wildlife and our Service recommend that the adjoining lands within the takeline (shown on the attached map on page 74) be made available to the Colorado Division of Wildlife for wildlife management purposes.

In addition, we recommend that the project fund specific development features so the maximum habitat unit values can be realized for the compensation lands. The estimated costs of the development of the wildlife management area are shown in Table 2 on page 75.

A habitat evaluation of the aquatic environment (Dolores River and West Paradox Creek) was not carried out. However, based on studies conducted by the Colorado Division of Wildlife, the streams within the project area have a poor fishery. This is due largely to unstable banks, few spawning areas, little cover, few aquatic organisms, low flows and especially poor water quality. Probably the two most important water quality parameters are total dissolved solids and siltation.

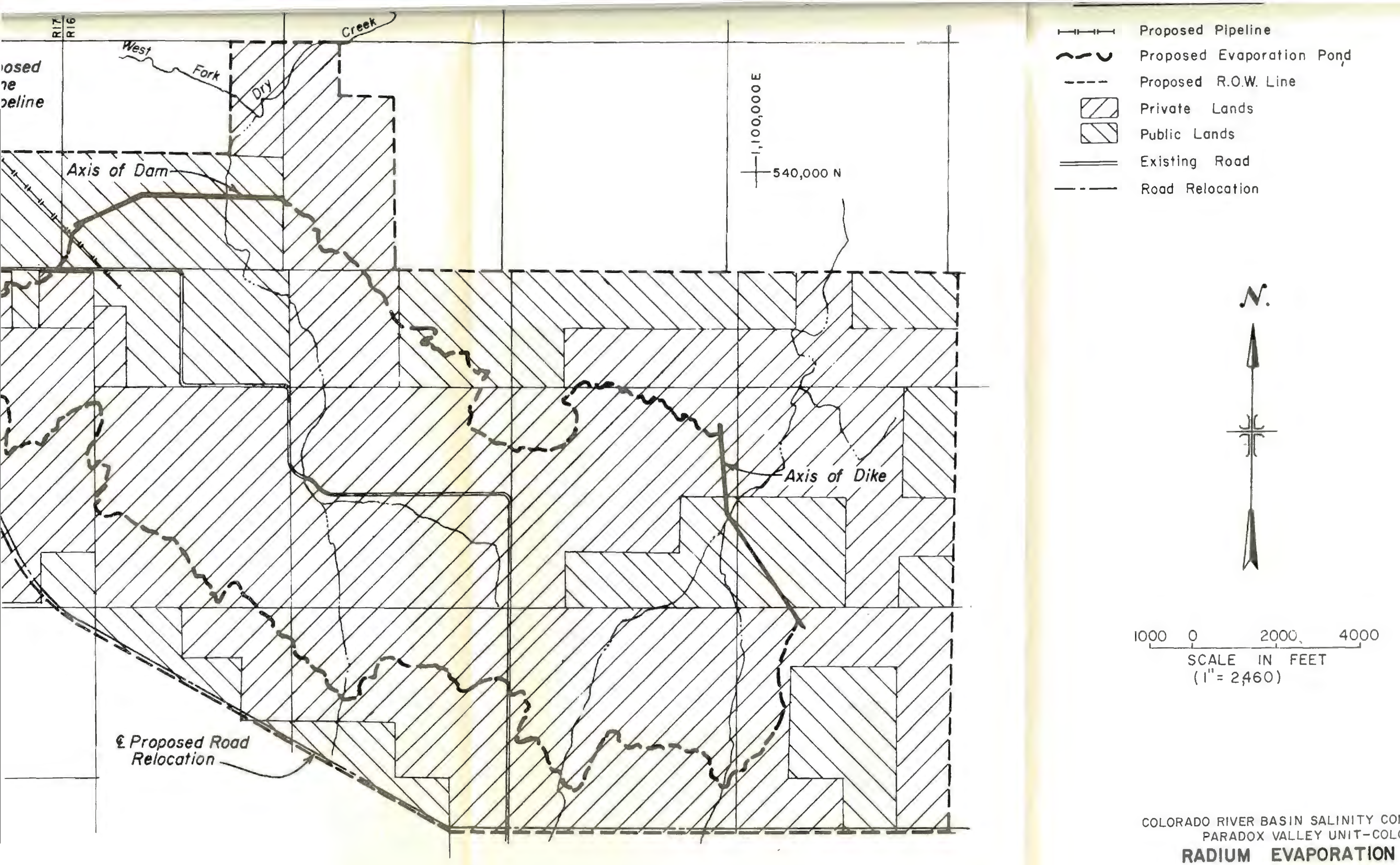
Based on the present project design, it appears that the only measurable adverse impact to the aquatic ecosystem would be increased turbidity. The increase in turbidity can be expected to occur when ground cover is removed for construction of the various facilities.

To reduce the increase in turbidity associated with the project we recommend that all disturbed areas be reseeded as soon as possible with a mixture conducive to wildlife use. This measure would not only reduce siltation, but accelerate the recovery rate for the vegetation and provide forage for wildlife.

The construction of the Paradox Valley Unit will improve the water quality in the Dolores River by reducing the TDS levels. However, the effect of this improvement on the aquatic ecosystem is not known. Other things such as heavy metals may be a limiting factor in the aquatic ecosystem.

Thank you for your cooperation in this study.

/s/ Robert H. Shields



COLORADO RIVER BASIN SALINITY CONTROL PROJECT
PARADOX VALLEY UNIT—COLORADO

RADIUM EVAPORATION POND
RIGHT—OF—WAY

Table 2
Estimated development cost of lands around Radium Reservoir, Paradox Valley Unit, Colorado

1. Fence the right-of-way to exclude unmanaged livestock	
15 miles @ $3,000/mile	$45,000.00
2. Construct small (± 2 acres) earthfill water retention structures	
5 @ $4,000 each	20,000.00
3. Range (habitat) improvement	
A. Fertilizing	
1st application (1982)	
3,700 acres--100 lbs/acre @ $125/ton	23,125.00
2nd application (1985)	
3,700 acres--75 lbs/acre @ $125/ton	17,344.00
B. Seeding	40,469.00
2,000 acres @ $10.00/acre	20,000.00
Total estimated cost	125,469.00

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Area Office Colorado-Utah
1426 Federal Building
125 South State Street
Salt Lake City, Utah 84138

December 6, 1977

MEMORANDUM

To: Regional Director
Bureau of Reclamation
Salt Lake City, Utah

From: Area Manager

Subject: Advance Copy of Draft Environmental Statement for the Paradox Valley Unit, CRBSCP, Colorado

We have reviewed the mitigation proposal presented in the subject document. The acreages and development procedures outlined are similar to our recommendations of January 21, 1977. Although not specified, we assume the newly acquired lands will be contiguous with existing state lands and that your agency will fund the wildlife facilities discussed on page A-13. It should also be clarified who is to assume responsibility for management of the wildlife lands. We believe responsibility for the public lands should be retained by the Bureau of Land Management in cooperation with the Colorado Division of Wildlife.

It should also be stipulated that funds will be provided by your agency to construct required mitigating features if the continuing studies determine significant losses of waterfowl will result with construction of Radium Reservoir.

Subsequent to our memorandum of January 21, 1977, our Regional Director provided formal consultation regarding the peregrine falcon and recommended that marshy areas be developed in the project area. This procedure would diversify the habitat, improve the prey-base, and therefore, aid the recovery of this endangered species. We therefore, continue to recommend that the project incorporate measures to develop marshy areas. Provided that the stipulations addressed in this memorandum are incorporated, we will concur with the mitigation plan.

We appreciate the opportunity for this early review.

/s/ Robert H. Shields

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

Mailing Address
Post Office Box 25486
Denver Federal Center
Denver, Colorado 80225

Street Location
10597 West Sixth Avenue
Lakewood, Colorado
Across from Federal Center

October 18, 1977

MEMORANDUM

To: Regional Director, Upper Colorado Region
Bureau of Reclamation, Salt Lake City, Utah

From: Regional Director, Region 6
Fish and Wildlife Service, Denver, Colorado

Subject: Endangered Species Consultation--Paradox Valley Unit
Colorado River Salinity Control Project

In response to your request for formal consultation we have conducted a threshold examination. We conclude the Paradox Valley Unit, as now proposed, will in no likelihood jeopardize the continued existence of the American peregrine falcon or destroy or adversely modify its critical habitat.

By lowering the soil salinity, construction of the Paradox Valley Unit, as now proposed, could improve riparian vegetation and, as a consequence, benefit the prey-base for falcons. However, this is not true of some of the other alternatives developed for the Environmental Impact Statement. If one of these other alternatives is selected to replace the proposal now being considered and the new proposal may result in some adverse impact on riparian vegetation, the prey-base, or directly affect the falcons, then the new proposal should be re-examined under the Section 7 formal consultation process.

As you are aware, the eyrie(s) located in the general area of the project is either new or has not been observed prior to this summer. It is certainly a significant find and offers an opportunity to improve the status of the peregrine in that area by various techniques carried out in conjunction with the Western Breeding Project of the Colorado Division of Wildlife and the Peregrine Fund at Fort Collins, Colorado.

The State Director of the Bureau of Land Management has indicated, since the nesting location is almost entirely on public lands, they will initiate a monitoring program for any adverse action and will take the necessary legal steps to close the area seasonally (March 1--August 1) to public use and development.

FISH AND WILDLIFE SERVICE

We recommend the four agencies (Bureau of Land Management, Colorado Division of Wildlife, Bureau of Reclamation, and Fish and Wildlife Service) cooperate to assure adequate protection, determination of the total feeding area and exact eyrie(s) location. In addition, we recommend including some project features to further improve the riparian vegetation by developing marshy areas in the project area. Finally, we wish to commend you on the conservation actions taken to protect these birds and their habitat. The awareness of this need by your people will add considerably to the recovery effect for American peregrine falcon.

/s/ Harvey Willoughby

MINERAL RESOURCES AT PARADOX VALLEY UNIT, DOLORES RIVER, MONTROSE AND SAN MIGUEL COUNTIES, COLO.

By Albert E. Ward, Intermountain Field Operations Center, Denver, Colo.

United States Department of the Interior

Bureau of Mines

MINERAL RESOURCES AT PARADOX VALLEY UNIT, DOLORES RIVER, MONTROSE AND SAN MIGUEL COUNTIES, COLO.

by

Albert E. Ward[1/]

SUMMARY

Major components of the proposed Paradox Valley Unit are a brine-well field, a brine pipeline, and the Radium reservoir site (an evaporation pond).

Development of the brine-well field and construction of the brine pipeline would not have any adverse impact upon mineral production or potential mineral production in the project area. Brine currently is produced at the proposed brine-well field site in the Paradox Valley and piped northward through the Dolores River canyon to Uravan, Colo., for use in processing uranium ore. No other minerals are produced at the brine-well field site or along the proposed 20.5-mile brine pipeline to Radium reservoir site in Dry Creek Basin, and no potential for the development of other minerals is apparent.

Impoundment of Radium reservoir, however, might result in a major conflict with the future development of uranium resources. Radium reservoir would be a 5.27-square-mile evaporation pond centrally located in Dry Creek Basin, about 19 miles southeast of the brine-well field. Substantial and extensive uranium mineralization apparently underlies the site and nearby areas. The reservoir site is blanketed by lode claims held by Union Carbide Corp., Metals Division, Grand Junction, Colo.

Because of the indicated uranium involvement at the Radium reservoir site, it is recommended that the Bureau of Reclamation seek an alternate site for the proposed evaporation pond.

INTRODUCTION

At the request of the Bureau of Reclamation's Upper Colorado Regional Office in Salt Lake City, the Bureau of Mines investigated mineral

1/ Mining engineer, Intermountain Field Operations Center, Bureau of Mines, U.S. Department of the Interior, Denver, Colo.

resources within and in the vicinity of project facility sites of the Paradox Valley Unit, Montrose and San Miguel Counties, Colo. The project would be a part of the Colorado River Basin Salinity Control Program. The objective of the project is to reduce sharply the flow of brine into the Dolores River. An estimated 180,000 tons of salt annually enters the Dolores in Paradox Valley. Major components of the proposed project are a brine-well field, a brine pipeline, and the Radium reservoir site (an evaporation pond).

The investigation consisted of a study of geologic literature, a review of Bureau of Mines file data pertinent to the area, and a field reconnaissance completed during October 1976. Results of the investigation are described in this report.

LOCATION AND PROJECT DESCRIPTION

Paradox Valley is located in the western part of Montrose County in southwestern Colorado. The brine-well field would be in the west-central part of Paradox Valley, about 2 miles northeast of Bedrock and 18 miles northwest of Naturita. The southeast-trending, 20.5-mile pipeline would deliver brine to Radium reservoir in the central part of Dry Creek Basin in San Miguel County (fig. 1).

Deteriorating water quality poses definite economic problems for water users in the lower reaches of the Colorado River Basin. Bureau of Reclamation studies indicate an average annual loss of about $230,000 for each increase of 1 milligram per liter (mg/l) of salt at Imperial Dam near Yuma, Ariz. Total damage attributable to salinity amounted to $53 million (from 850 mg/l of salt) in 1973 and could reach $124 million (from 1,160 mg/l to 1,340 mg/l of salt) by 2000 if corrective measures are not implemented. Salinity reduction is the objective of the proposed project; an estimated 180,000 tons of salt annually enters the Dolores River in the Paradox Valley (fig. 2). The confluence of the San Miguel River with the briny Dolores, about 4 miles northeast of the proposed brine-well field, presents a striking view of contrasts in river water quality (fig. 3). Removal of this salt inflow would lower the salinity of the Colorado River by approximately 16 mg/l at Imperial Dam.

Paradox Valley is 3 to 5 miles wide and 24 miles long (along its northwest axis) and is traversed just west of its midpoint by the Dolores River. A 14,000-foot-thick salt and gypsum anticline underlies the valley--at a very shallow depth where the Dolores enters the canyon south of Martin Mesa. Salt inflow could be reduced by drilling wells into the brine layer on both sides of the river and pumping brine from such wells to lower the interface between relatively fresh near-surface ground water and the underlying brine.

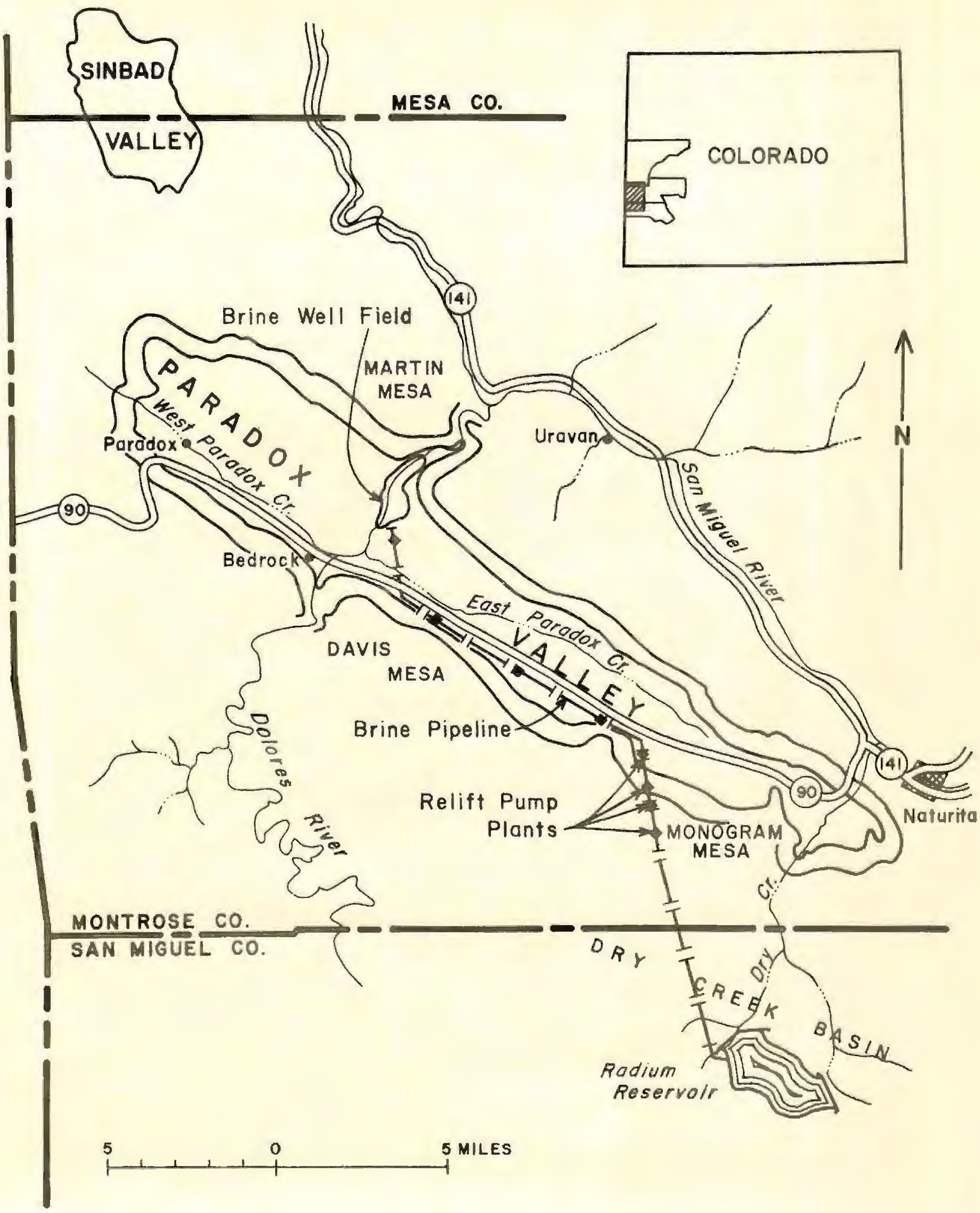


FIGURE 1. – Map showing proposed brine-well field, brine pipeline, and Radium reservoir site, Montrose and San Miguel Counties, Colo.

FIGURE 2. – Dolores River in the canyon northeast of the proposed brine-well field site. Froth and salt-film on boulders are indicators of the salinity problem,

FIGURE 3. – Confluence of the San Miguel River (right) with the Dolores River. The Dolores is pea-green in color, the San Miguel is blue.

Hydrogen sulfide would be removed from the brine in a scrubbing plant near the brine-well field. The brine then would be pumped through a 20.5-mile pipeline, paralleling State Highway 90 for about 10 miles, turning south for 4 miles to cross over Monogram Mesa, and finally continuing southward for 6 miles of gravity flow into Radium reservoir.

Eight pumping plants would be required to move the solution from the brine-well field to the evaporation pond. Pumping plants would consume approximately 18.8 million kilowatt-hours of electrical energy yearly and would have a power demand of about 2,230 kilowatts.

Radium reservoir would have a maximum surface area of approximately 5.27 square miles. With an annual inflow of 180,000 tons of salt, it would have a life expectancy of about one century.

GENERAL GEOLOGY[1/2/3/]

Paradox Valley is underlain by one of five major northwest-trending salt anticlines in the Colorado Plateau region. The anticlines, 25 to 70 miles long, have structurally complex central parts 2 to 6 miles wide, and cores about 4,000 to 14,000 feet thick. The cores of these anticlines consist of plastic salt and gypsum. Erosion has removed much of the axial crests of the anticlines, leaving exposed or near-surface large plastic intrusive masses of salt-bearing formations.

Rocks exposed in the project area range from Pennsylvanian to Quaternary in age. The general geologic sequence in the area is listed on the following page.

1/ Cater, F.W. Jr. Geology of the Davis Mesa Quadrangle, Colorado. U.S. Geol. Survey Geol. Quad. Map GQ 77, 1955.

2/ Elston, D.P., and E.R. Landis. PreCutler Unconformities and Early Growth of the Paradox Valley and Gypsum Valley Salt Anticlines, Colorado. U.S. Geol. Survey Prof. Paper 400-B, 1960, pp. B261-265.

3/ Intermountain Association of Petroleum Geologists. Guidebook to the Geology of the Paradox Basin. Ninth Annual Field Conference, 1958, 308 pp.

Period	Series	Unit
Quaternary	Pleistocene and Holocene	Alluvium
Quaternary	Pleistocene and Holocene	Terrace gravel, landslide deposits, and fanglomerate
Cretaceous	Upper Cretaceous	Mesaverde Formation
Cretaceous	Upper Cretaceous	Mancos Shale
Cretaceous	Lower and Upper Cretaceous	Dakota Sandstone
Cretaceous	Lower Cretaceous	Burro Canyon Formation
Jurassic	Upper Jurassic	Morrison Formation
Jurassic	Upper Jurassic	Summerville Formation
Jurassic	Middle and Upper Jurassic	Entrada Sandstone and Carmel Formation
Jurassic(?)	Lower and Middle Jurassic(?)	Navajo Sandstone
Triassic(?)	Upper Triassic(?)	Kayenta Formation
Triassic	Upper Triassic	Wingate Sandstone
Triassic	Upper Triassic	Chinle Formation
Permian(?)		Cutler and Rico Formations
Pennsylvanian		Hermosa Formation

The brine-well field would be developed on both sides of the Dolores River on the veneer of Quaternary alluvium that overlies the salt- and gypsum-bearing Hermosa Formation. In years past, salt was harvested from a solar evaporation pond at the proposed brine-well field site (fig. 4). Several isolated outcrops of Hermosa Formation appear along East Paradox Creek, southeast of the proposed well field.

The proposed pipeline would initiate in Quaternary alluvium along State Highway 90. Turning south from the highway, about 10 miles southeast of the brine-well field, the pipeline would traverse Morrison and Burro Canyon outcrops to a highpoint on Monogram Mesa (fig. 5). In the final 6-mile gravity-flow segment, the pipeline would be in Dakota Sandstone and Quaternary alluvium (mostly eroded Dakota and windblown material).

Most of the surface rock at Radium reservoir site is dark-gray, homogeneous, soft, fissile Mancos Shale. This shale would serve as an impervious bed for the evaporation pond. Some Quaternary windblown alluvium is found at the eastern end of the proposed pond. Dakota Sandstone crops out along the northern edge of the pond site and dips gently (about 2° to 5°) to the south-southwest. Immediately southwest of the site, the Dakota dips northeast 5° to 10°.

Dry Creek Basin, in which the Radium reservoir would be centrally located, is a northwest-trending, 4- to 8-mile-wide syncline parallel to and southwest of the Paradox Valley anticline (fig. 6). Four miles southwest and outside the project area, Big Gypsum Valley, the next anticline in the anticline-syncline sequence, parallels Dry Creek Basin.

FIGURE 4. – Brine-well field site along the Dolores River in the Paradox Valley. Old solar evaporation beds in the foreground and the La Sal Mountains, about 25 miles northwest in Utah, on the horizon.

FIGURE 5. – View into the Paradox Valley from near the top of Monogram Mesa. Brine pipeline would cross the mesa in this area.

FIGURE 6. – View northwest in Dry Creek Basin. La Sal Mountains on the horizon are about 50 miles distant.

FIGURE 7. – Weathered Dakota Sandstone outcrop in northeastern part of proposed Radium reservoir. Note mining claim cornerpost, right-center, and discovery pit, left-center.

Elevation at the brine-well field is approximately 4,940 feet. Maximum elevation of the proposed pipeline crossing of Monogram Mesa is about 7,000 feet. Low point in the pond site is approximately 6,275 feet, and maximum pond level would be about 6,330 feet.

MINERAL RESOURCES

Metals

Uranium

The proposed Paradox Valley Unit project would be developed in the heart of the Uravan Mineral Belt, the source of most of Colorado's uranium output and associated vanadium and radium. Montrose and San Miguel Counties have been two of the three leading uranium-producing counties in Colorado for decades. Available reserve data and ongoing exploration activity suggest this leading position in the State will be maintained in the foreseeable future.

Uranium mineralization in commercial quantities is limited largely to occurrences in upper layers of the Salt Wash (lower) Member of the Morrison Formation. The older Chinle and Hermosa Formations also have uranium potential in the Colorado Plateau region but apparently not in the immediate project area. Numerous mines and prospects dot the mesa tops and Salt Wash outcrops throughout much of the project area. Substantially increased regional uranium output in the next two decades or so will be required to help satisfy growing national nuclear fuel needs.

No indication of uranium mineralization occurs in the vicinity of the proposed brine-well field, which would be developed on alluvium. The Morrison is completely eroded away and the Chinle crops out high on the unnamed mesa to the east of the brine field site and on Martin Mesa, about 1 mile to the north. Uranium mineralization in the Hermosa usually is found in the upper fossiliferous limestone member, which would be north of the site because the lowermost shale, gypsum, and salt members appear in Hermosa outcrops along the anticlinal axis to the southeast. Therefore, there is neither a known nor probable uranium-related conflict at the brine-well field site.

The 20.5-mile brine pipeline would cross Morrison and Chinle outcrops between the brine-well field and Radium reservoir site. Moreover, in traversing Paradox Valley as well as crossing the anticlinal and synclinal structures between the brine-well field site and Dry Creek, the pipeline would overlie the Hermosa Formation, and at times would overlie the Chinle and the Morrison. However, considering the narrow dimension of the proposed pipeline right-of-way and the spotty nature of uranium mineralization in the region, it seems unlikely that the pipeline would have any significant adverse impact upon future uranium developments along the route. If in the future a conflict did materialize, relocation of short sections of the pipeline would not be a costly undertaking. Therefore, the potential conflict between the proposed pipeline and possible uranium developments appears to be negligible.

Radium reservoir would be centrally located in the lowest lying part of Dry Creek Basin. The site now receives intermittent stream runoff, mostly from the northwest and the southeast. The basin is breached immediately north of the site by Dry Creek, which meanders north about 8 miles to its confluence with the San Miguel River, 2 miles northwest of Naturita (fig. 1 on page 81).

A thin veneer of Mancos Shale blankets the surface of most of the reservoir site. Dakota Sandstone crops out along the northern edge of the site, and recent wind deposits of sand and silt, which appear to be mostly eroded Mancos and Dakota, are found at the northeastern edge (fig. 7 on page 86). Burro Canyon Formation underlies the Dakota, and the Morrison Formation is beneath the Burro Canyon. The Salt Wash Member of the Morrison reportedly is 900 to 1,500 feet beneath the surface at the reservoir site and is extensively mineralized with uranium.

Radium reservoir site is blanketed by lode claims held by Union Carbide Corp., Metals Division, Grand Junction, Colo. (fig. 8). The company also has extensive claims elsewhere in Dry Creek Basin. Reportedly, most of the areas claimed by Union Carbide are surrounded by claims of other interests.

Union Carbide Corp. tentatively plans to begin mining uranium ore at the Radium reservoir site in the early 1980's. Impoundment of the Radium evaporation pond at the site would be a severe impediment to mining operations and would terminate or substantially curtail access to the 5.27-square-mile reservoir site. The brine level in the evaporation pond would rise relatively rapidly during early years of operation; therefore, surface mining structures would have to be protected by continuing enlargement of dikes and roadways, or the mining and access structures initially would have to be developed on earthen platforms at substantial extra cost.

Development of Radium reservoir or any other similar evaporation pond in the central part of Dry Creek Basin would result in a major conflict with apparently significant, deep-seated, uranium ore deposits in the area and could result in a substantial loss of this valuable mineral resource. For this reason, it is recommended that the Bureau of Reclamation seek an alternative site for the proposed evaporation pond.

Other Metals

Vanadium and radium occur, together with uranium mineralization, in the project area. They are recovered during uranium mining and are

FIGURE 8. – Mining claim cornerposts and discovery pits in proposed Radium reservoir site. View is west toward the upthrust ridge that delineates the southwest edge of Dry Creek Basin, a structural syncline. (Telephoto, Hektor 135mm lens.)

FIGURE 9. – Brine well at the proposed brine-well field site. Brine is pumped through a surface pipeline along the Dolores River canyon, right-center, to a Uravan uranium mill.

separated in subsequent processing. No other metallic mineral resources are known in the Paradox Valley Unit project area. Moreover, regional geology does not suggest the presence of other subsurface metallic mineral deposits.

Nonmetallic Minerals

Salt

Brine (sodium chloride solution) is produced at the proposed brine-well field site by Union Carbide Corp. (fig. 9 on page 89). The brine is transported through a surface pipeline along the Dolores River to Union Carbide's uranium mill in Uravan, about 7 miles northeast of the brine well (fig. 1 on page 81). The brine is used, along with soda ash, to precipitate uranium as "yellow cake" from a pregnant solution of uranium-vanadium. Bureau of Reclamation plans for the development of the brine-well field would not have any severe adverse impact upon this established mineral operation.

Potash (potassium chloride) occurs with the sodium chloride in the Paradox Member of the Hermosa Formation. Minable deposits appear to be located northwest of the project area. However, extraction of any deep-seated potash would not be hindered by project structures.

Other Nonmetallic Minerals

Sand, gravel, and stone are produced in the region in small quantities, mostly for use in local road construction and maintenance. Gypsum in the Hermosa Formation is a commonplace mineral resource in the region. Because these nonmetallic mineral resources are abundant, a mineral-related conflict is not anticipated in the project area.

Mineral Fuels

Oil and Gas

The first discovery of oil in the Paradox Basin was at Mexican Hat, Utah, in 1908. The Paradox Basin is a region that includes small areas in northwestern New Mexico and northeastern Arizona, and large areas in southeastern Utah and southwestern Colorado. A few major oilfields, numerous minor oilfields, and a few small gasfields are scattered throughout the basin; most of the production is recovered within 30 miles of the Four Corners (the point where the four State borders meet). Most of the oil production in the basin has been recovered in Utah. The Paradox Basin contains many geologic structures favorable for oil and gas accumulation, including the Paradox Valley and Dry Creek Basin in the project area. However, Paradox Valley, a structural anticline, and Dry Creek Basin, a structural syncline, to date have shared only modestly in the basin's oil and gas potential.

Montrose Dome gasfield is located about 5 miles north of Radium reservoir site along Dry Creek, and Andys Mesa gasfield is approximately 3 miles south of the site. Apparently, these gas accumulations are located in fault zones along the northern edge of Dry Creek Basin. No producing gas wells are found along the proposed pipeline or in the vicinity of the brine-well field site. No producing oil wells exist in the project area.

Prospects for gas discoveries in the project area seem to be moderately attractive. Although finds to date have been small in size, the region contains favorable structures. The brine-well field and pipeline would not create any exploration-related conflict. Radium reservoir site is centrally located over the trough of the underlying narrow, elongate syncline, and therefore is not a very likely target area unless other structure exists at depth. The proposed evaporation pond would have a northeast-southwest dimension of only 1.5 miles, so directional drilling could probe most of the underlying formations from the edge of the reservoir.

Considering the nominal dimensions of the brine-well field and pipeline, and the 1.5-mile-wide reservoir site, the future search for and possible recovery of oil and gas would not be unduly hindered.

Coal

Although a number of the formations in the project area include coal measures elsewhere in western Colorado, there is no evidence that these formations carry coal seams in the project area.

CONCLUSIONS

Information gained from the study of geologic literature, the review of Bureau of Mines records pertinent to the area, and the reconnaissance field examination strongly suggest that, other than sand, gravel, and stone deposits, there are no surface or near-surface mineral resources of value present at the brine-well field and along the pipeline of the Paradox Valley Unit project area. Owing to the narrow, elongate configuration of the brine-well field and narrow pipeline right-of-way, the exploration for and recovery of possible deep-seated mineral deposits would not be unduly hindered.

Substantial and extensive uranium mineralization apparently underlies the proposed Radium reservoir and nearby areas in Dry Creek Basin. The Bureau of Reclamation should seek an alternate site for one proposed evaporation pond.