REGIONAL PROBLEMS AND ISSUES

There are a number of critical problems and issues in the 11 Western States that, while not Westwide in scope, do involve two or more States or a major river basin. These have been classified as regional problems, of which nine have been identified. Four of these are centered in the Colorado River Basin and involve Colorado River salinity, Colorado River water supply, lower Colorado River management, and oil shale development in the Upper Colorado River Basin. Four occur in the Columbia River Basin and involve total water management of the Columbia River system, the Columbia River estuary, the Middle Snake River Canyon controversy, and erosion in the Palouse area. The ninth regional problem pertains to anadromous fisheries in the Pacific Northwest.

Colorado River Salinity.—As the waters of the Colorado River are put to consumptive use, the remaining waters are becoming progressively more saline, particularly in the lower reaches of the river. The concentrations of dissolved solids in the lower mainstream are already approaching the threshold limits for some uses. The primary agricultural impacts of increasing salinity will be in the Imperial, Coachella, Gila, and Yuma Valleys where a wide diversity of crops is produced. Adverse effects will also be experienced in Mexico. The primary impacts on municipal and industrial water supply will affect the Metropolitan Water District of southern California, the Las Vegas service area, and upon completion of the Central Arizona project the Phoenix and Tucson metropolitan areas.

The adverse effects of increasing salinity are primarily economic in character and confined to the consumptive uses of water. Instream uses of water for hydroelectric power production, for recreation, for fish and wildlife, and for overall environmental purposes will not be significantly affected. Recent studies by the Bureau of Reclamation estimated total annual direct and indirect economic losses of about $230,000 for each part per million of future increase in salinity of the Colorado River at Imperial Dam. Taking as a base the acceptable salinity levels of 500 p/m for municipal and industrial supplies and 750 p/m for agricultural use, the total damages attributable to salinity in the Colorado River system for 1973 were about $53 million. By the year 2000 these damages to the total regional economy are expected to reach $124 million per year if no control measures are applied.

The 1972 Joint Federal-State Enforcement Conference on the matter of pollution of the interstate water of the Colorado River and its tributaries initiated new efforts to establish an overall salinity control policy for the river. The seven basin State conferees and Federal representatives concluded that such a policy should have as its objective the maintenance of salinity concentration at or below levels found in the lower main stem while the upper basin continues to develop its compact apportioned water. The 1972 Federal Water Pollution Control Act Amendments have been interpreted by the Environmental Protection Agency to require the establishment of numerical salinity standards on the Colorado River. Another related matter that highlights the need for basinwide salinity controls is a recently executed agreement with Mexico to resolve the international salinity problem with Mexico. Under that agreement, water delivered to Mexico shall have an average annual salinity of no more than 115 p/m (plus or minus 30 p/m) over the average annual salinity of waters arriving at Imperial Dam.

Adequate studies have not been completed to identify accurately the quantitative contribution of salinity concentrations from various sources in the basin, but the order of magnitude is (1) natural sources, (2) irrigation sources, (3) reservoir evaporation, (4) out-of-basin export, and (5) municipal and industrial sources.

Solutions to the salinity problems on the Colorado River will result from the cooperative efforts of all involved Federal, State, and local agencies and organizations. The primary study effort under way at this

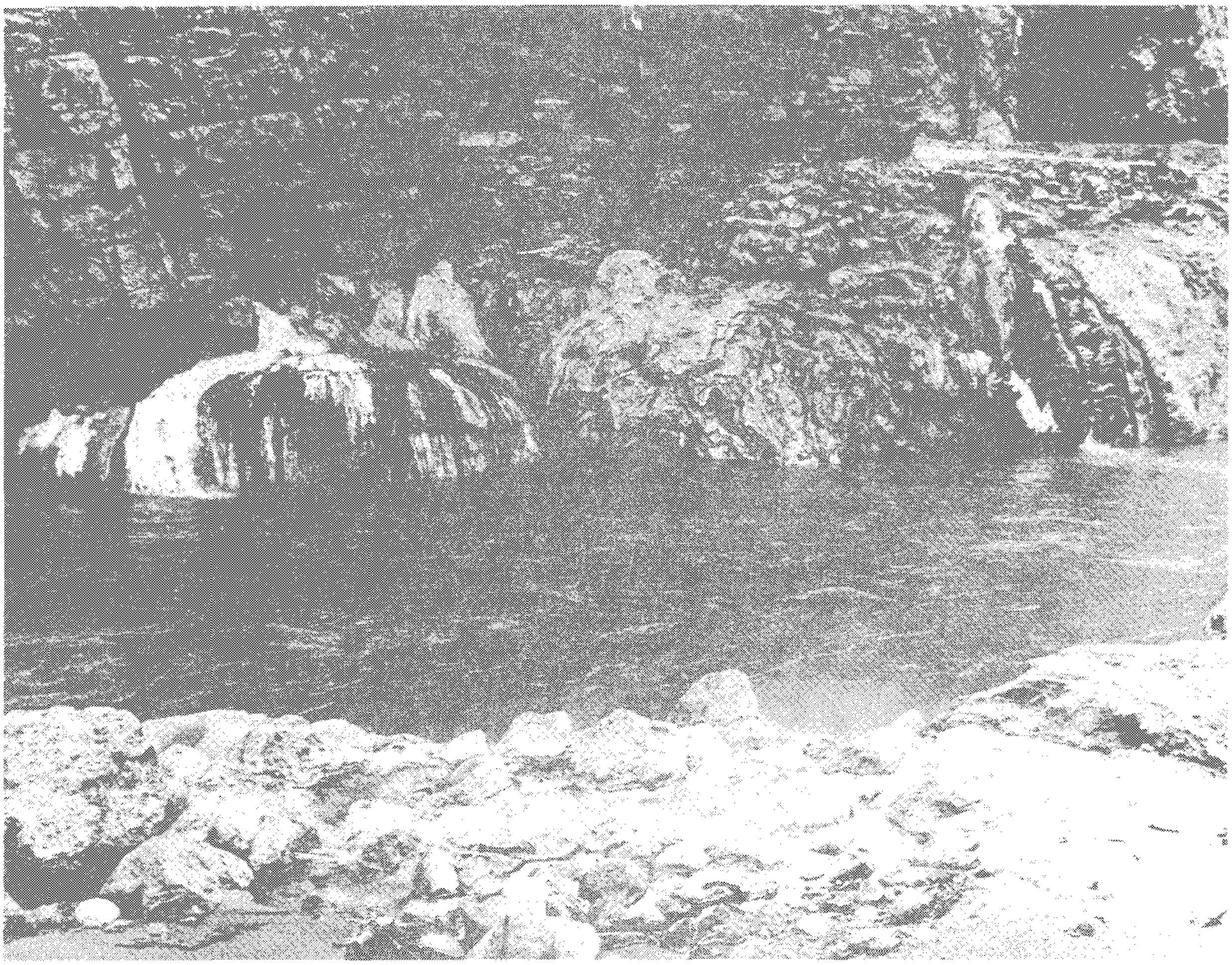

Figure 17. LaVerkin Springs discharging highly saline water into Virgin River, Utah.

time is the Bureau of Reclamation's Colorado River Water Quality Improvement Program (CRWQIP).

Working with several of the States involved, a comprehensive investigation program was structured and launched by the Bureau of Reclamation in FY 1972. Emphasis is placed on controlling salinity from irrigation, diffuse and point sources. Nonstructural measures, such as improving irrigation efficiency, river system management, water system management and utilizing return flows, are being given prime consideration. Other techniques such as structural control of point sources, weather modification, desalting of seawater and geothermal brines, land and vegetation management, erosion control, and waste-water utilization, are undergoing additional research and development to identify their prospects for water quality improvement.

An impressive start towards solving the Colorado River salinity problem is provided by Public Law 93-320, the Colorado River Basin Salinity Control Act of June 24, 1974. Title I of the act authorizes a series of undertakings, including the construction of a desalting plant to treat approximately 129 million gallons per day of drain water from the Wellton-Mohawk division of the Gila project, Arizona, to carry out the commitments of the United States in its recent agreement with Mexico, Minute 242 of the International Boundary and Water Commission, United States and Mexico.

Title II of the act authorizes four salinity control units upstream from Imperial Dam as the initial stage of the Colorado River Basin salinity control program — the Paradox Valley and Grand Valley units in Colorado, the Crystal Geyser unit in Utah, and the Las

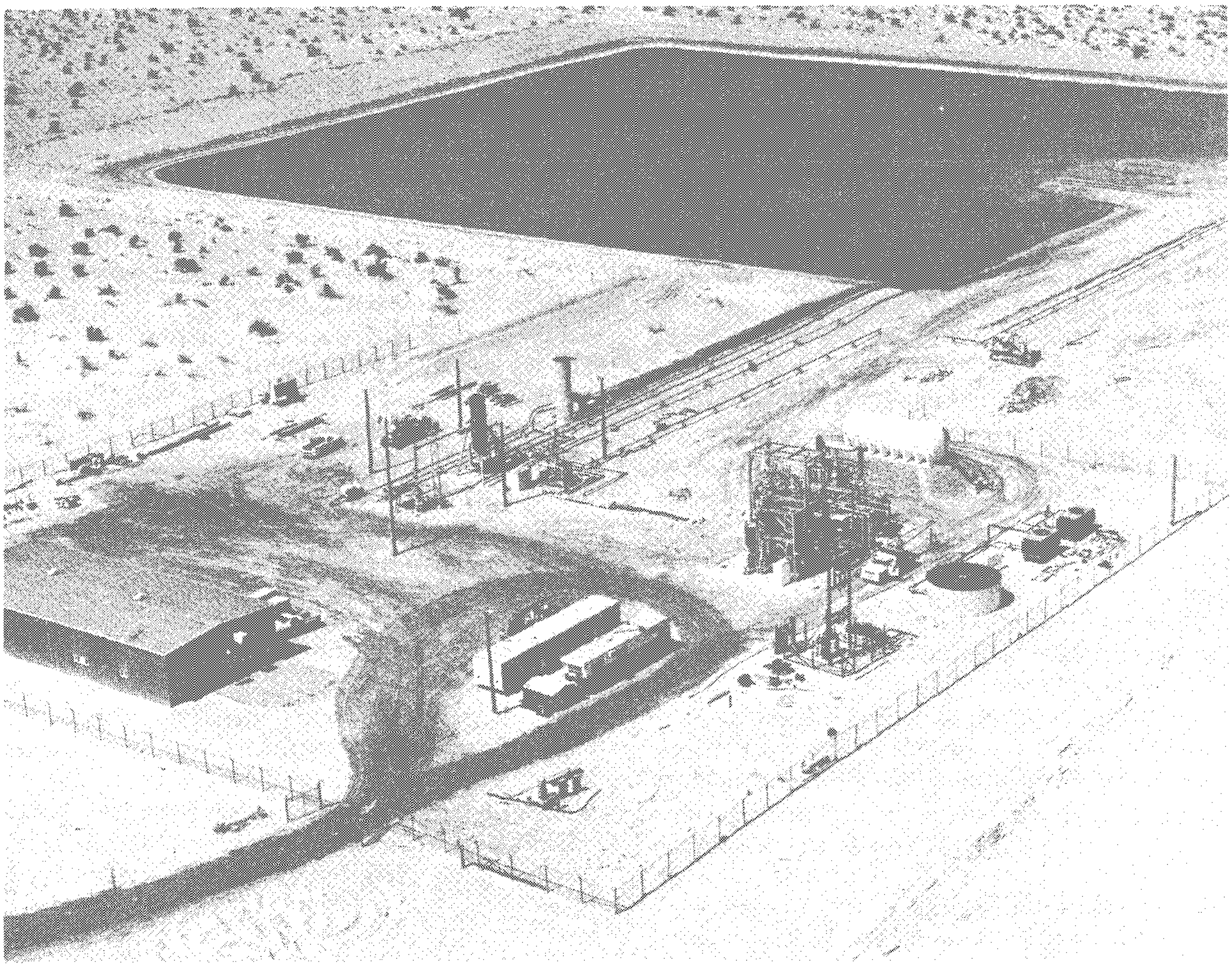

Figure 18. Geothermal test facility, Imperial Valley, California.

Vegas Wash unit in Nevada. Further, Title II prescribes that the costs of the initial units shall be allocated as follows: 75 percent to be nonreimbursable and 25 percent between the Upper Colorado River Basin Fund and the Lower Colorado River Basin Development Fund. The costs allocated to the Upper and Lower Basin funds are to be repaid without interest within 50 years from the date when each unit is in operation.

There is no one complete solution to the complex problem of salinity control in the Colorado River. A salinity control program should be regarded as but one element in a matrix of solutions which ultimately will form a comprehensive plan of management for the total water resources of the Colorado River Basin. Other elements include the planning and operation of interrelated structures, augmentation of the river, possible legal and institutional changes, new management techniques, increased efficiency in present use, and future development of basin water resources.

The Colorado River Water Quality Improvement Program should be continued on an accelerated basis to implement those investigations or programs that are considered cost effective and demonstrate immediate program benefits. Related programs of the Environmental Protection Agency, Department of Agriculture and Land Management agencies should be accelerated as needed to meet salinity control objectives.

Colorado River Water Supply.—The Colorado River is one of the most highly controlled rivers in the world. It is approaching that point, the initial operation of the Central Arizona project, when little usable water, if any, will ever escape from the basin to the Gulf of California. It is approaching that point also when the natural water supply of the river will be inadequate to meet all of the demands placed upon it.

The water supply of the river is adequate to meet the quantitative water demands of today and in the years immediately ahead. If the upper basin States, however, are to develop their resources at a rate commensurate with their expressed aspirations, it is a certainty that shortages will develop within a time frame that directly affects decisions which need to be made today. Studies indicate that, with a fairly intensive growth in the upper basin and without augmentation of the river, water shortages in the lower basin could emerge by 1995, and grow continually more severe thereafter. Shortages will occur periodically on upper basin tributaries. The overriding question then is on what water supply basis should the future of the Colorado River Basin service area be planned.

The Colorado River, supplying water to such metropolitan complexes as those along the coast of southern California, the Eastern Slope of the Rocky Mountains in Colorado, the Upper Rio Grande of New Mexico, and along the Wasatch Front in Utah, has a service area extending far beyond its physical drainage basin. In spite of its very meager water supply more water is exported from this system than from any other in the United States. More than half of the West's population is directly dependent on the Colorado River as a source of water.

The Colorado River is not only one of the most physically developed and controlled rivers in the Nation, it is also one of the most institutionally encompassed rivers in the country. There is no other river in the Western Hemisphere that has been the subject of so many disputes of such wide scope during the last half century as the Colorado River. These controversies have permeated the political, social, economic, and legal facets of the seven Colorado Basin States. The many lawsuits and interregional and interstate compacts have resulted from a water supply which is inadequate to meet the existing and potential water demands within the seven Colorado River Basin States.

Two primary factors have led to the present water supply problems of the Colorado Basin. The first is that the Colorado River Basin simply does not yield sufficient water on a natural basis to permit full development of land and mineral resources; to provide for fish and wildlife and recreation; and to service other needs. The second is that the negotiators of the Colorado River Compact apportioned a water resource that, at the time of negotiations, appeared much larger than the river has subsequently yielded.

The waters of the Colorado River System are divided among the Upper Colorado Basin, the Lower Colorado Basin, the Republic of Mexico, and among the States of the upper and lower basins by interstate compacts, an international treaty, a Supreme Court decision, and by State and Federal legislation. Additional Congressional legislation, agreements with Mexico, and other documents affect and, in some instances, dictate how the river shall be managed and operated. Collectively, these various agreements, guides and directives are known as the "Law of the River."

Major benchmarks in the "Law of the River" are:

1. The Colorado River Compact of 1922 which divided the waters of the Colorado River System between the upper and lower basins.

2. The Boulder Canyon Act of 1928 which authorized the construction of Hoover Dam and Powerplant and the All-American Canal. The act also sets the stage for division of lower mainstream waters among the lower basin States.

3. The Upper Colorado River Compact of 1948 that apportioned among the upper basin States the waters of the Colorado River allocated to the upper basin by the Colorado River Compact.

4. The Mexican Water Treaty of 1944 that obligated the United States to deliver 1.5 million

acre-feet to Mexico annually from the Colorado River.

5. The Colorado River Storage Project Act of 1965 which authorized several long-termed carry-over reservoir storage units in the upper basin which permit the upper basin to maximize the consumptive use of water within its Colorado River Compact apportionment.

6. The Supreme Court Decree in Arizona vs. California of March 9, 1964, which apportioned the lower basin supply of Colorado River water among the States of Arizona, California, and Nevada.

7. Colorado River Basin Project Act of 1968 which directed that diversions to the Central Arizona project in times of shortage shall be so limited as to, in effect, guarantee California the use of 4.4 million acre-feet of Colorado River water annually. It also declared that the satisfaction of the Mexican Water Treaty from the Colorado River constitutes a national obligation which shall be the first obligation of any water augmentation project planned pursuant to the act.

8. The Federal Water Pollution Control Amendments Act of 1972 which gives the Environmental Protection Agency certain responsibilities and authorities for controlling water quality on the Nation's rivers.

9. Minute 242 (1973) of the International Boundary and Water Commission, United States and Mexico, which requires the initiation of several actions which will reduce the salinity of Colorado River water deliveries to Mexico under the Mexican Water Treaty.

10. Colorado River Basin Salinity Control Act of 1974, which authorized construction of a desalting complex and salinity control units to control salinity and improve the quality of Colorado River water.

In negotiations leading to a number of the above documents, a water supply yield of the Colorado River was assumed that records of the past several decades have proven to be overly optimistic. For instance, at the time the Colorado River Compact was negotiated, existing records indicated that the average virgin runoff of the Colorado River at Lee Ferry was in excess of 18 million acre-feet. As of today, the long-term record (1906-1970) indicates a virgin yield at Lee Ferry of 14.9 million acre-feet, while for the period 1931-1964 the yield was only 12.9 million acre-feet.

With the above background in mind, attention can be focused on the current water supply problems of the Colorado River Basin. Today and for some years to come, the Colorado River should be able to meet all quantitative physical water demands. The upper basin States are meeting their Compact requirements and demands being placed on the river are being met. Lake Powell and Lake Mead are filling and, assuming average annual runoff conditions for the next few years, Lake Powell and Lake Mead will "spill" in the sense that they will be required to release water, other than Mexican Treaty waters, for which there will be no consumptive use in the United States. However, assuming a long-term average annual supply of 14.9 million acre-feet, sometime after the Central Arizona project is fully operational, the Colorado River will not yield enough water under normal circumstances to meet upper and lower basin demands, the Mexican Treaty obligations, and system losses. Thus, the Colorado River Basin faces future water shortages unless its natural flows are augmented or water-dependent basin development is curtailed. The extent and timing of these shortages will depend on the rate of future consumptive use development and the volumes of annual runoff.

There are several categories of potential shortages:

1. When California is first cut back from its present 5.1 million acre-feet annual consumptive use to 4.4 million acre-feet consumptive use a legitimate current demand on the river will not be

met in full because of limitations on basin water supply. Although California would still be receiving its basic Colorado River supply and even though it has available more expensive alternative supplies to offset the cutback, it could be said that a shortage exists;

2. At that time when the total annual water demands of the basin, including reservoir evaporation and other water losses, exceed the long-term average annual water supply, the basin will be in a water shortage status even though water demands could be met for a limited period by drawing on reservoir storage;

3. When Arizona must reduce its Colorado River consumptive uses below 2.8 million acre-feet per year a new shortage will occur;

4. When the upper basin reaches its assured annual consumptive use of 5.8 million acre-feet annually, a still different type of shortage will be reached. (The 5.8 million acre-feet annually is that assured amount remaining for use in the upper basin under adverse runoff conditions after it has met its obligation to deliver 75 million acre-feet to the lower basin each 10 years and if it is required to contribute 750,000 acre-feet annually toward meeting the Mexican Water Treaty obligation. The assured supply thus estimated is not to be construed as the limit of the upper basin apportionment, as it is recognized that there is not agreement among the States of the Colorado River Basin on how the Mexican Treaty obligation is to be shared prior to the time augmentation of the Colorado River is accomplished under the terms of the Colorado River Basin Act of 1968). Because of the long-term carry-over storage of Lake Mead and the upper basin storage project reservoirs, whenever shortages occur in the above categories such shortages likely will span several years;

5. Another category of shortage common to the river systems can occur in the upper basin tributaries above main storage units where the water supplies are not sufficiently regulated by long-term carry-over storage. In these circumstances, shortages can vary from as little as a month at a time to a year or more; and

6. Still another category of shortage is represented by the Gila River basin where the present consumptive uses far exceed the combined surface and ground-water recharge of the basin. A shortage has existed here for years.

To help predict future situations relating to both water supply shortages and water quality under varying assumptions, a mathematical model of the Colorado River referred to as the Colorado River Simulation Model (CRSM) was developed. The model receives projected hydrologic sequences and projected water demands, processes them through a comprehensive systems operation, and evaluates the results in terms of water supply versus water demand.

To explore various possible future Colorado River runoff conditions, hydrologic traces, or theoretical 30-year sequences of Colorado River flow, are generated for selected stations over the entire Colorado River Basin based on statistical parameters derived from historical data and modified as necessary to reflect the runoff period of 1914-65. This period of record was selected because the modified flow analysis for benchmark gaging stations was available. These data were prepared for the Upper Colorado Region Comprehensive Framework Study.

An almost infinite number of hydrologic traces can be generated. For the purpose of illustrating a range of possible future runoff sequences three hydrologic traces were structured. Trace A reflects a reasonably low runoff cycle with a 30-year mean estimated virgin flow at Lee Ferry of 13.2 million acre-feet. Trace C reflects a reasonably high runoff cycle of 15.5 million acre-feet. Trace B (14.1 million acre-feet) reflects a reasonable intermediate situation.

Alternative Future Water Demand Schedules.—The element of uncertainty in projecting the rate at which future water demands in the

Colorado River Basin will occur is limited almost exclusively to the upper basin. In the lower basin the major important factor is the date that the Central Arizona project will start to divert water. Thereafter, Arizona and California will be diverting water to the limits of their entitlements. Projects for Nevada involve relatively small quantities. Thus, the future pattern of deliveries to the states in the lower basin is firmly established.

By contrast current upper basin uses are well below the assured upper basin water supply. This situation permits significant expansion of consumptive use before the upper basin reaches the ceiling attainable within the Compact. The rate of which upper basin water demands will grow depends upon several factors — the rate at which authorized Federal projects in the upper basin will be constructed and put into operation; the rate at which oil shale, coal and other energy resources are exploited; the rate at which municipal and industrial uses will expand; the level of conversion of water now used for irrigation to other purposes; and the future availability of water.

To illustrate a range of possible future water demands, three alternative water demand schedules through the year 2000 were structured.

Alternative 1 projects a reasonably slow rate of future water demand buildup in the basin. It provides for a low level of Federal project construction and for limited future water demands to service energy resource development in the upper basin. The Central Arizona project is estimated to divert water initially in 1987. Specifically alternative 1 provides that, in addition to the Federal projects currently under construction (Navajo Indian Irrigation Project; Bonneville Unit, Central Utah project; and the Fryingpan-Arkansas project), the five upper basin projects authorized in the Colorado River Basin Project Act would be constructed and in operation by 1987. It provides for a total of 22,630 MW of thermal power, 1,797 million cubic feet per day of coal gasification capacity, and the production of 680,000 barrels of oil per day from oil shale. All other functions and non-Federal development were projected to increase at a restricted rate.

Alternative 2 is a middle-ground projection. It anticipates a moderate level of Federal project construction and a moderate increase in water demands to serve energy resource development in the upper basin. It projects initial Central Arizona project diversions in 1987. Specifically, it provides that, in addition to the Federal projects included in alternative 1, the Lyman project would be constructed by 1980 and some Ute Indian deferral lands and the Jensen unit of the Central Utah project would be constructed by 1995. Thermal power development increased to 28,060 MW, coal gasification capacity to 2,373 million cubic feet per day and oil production from oil shale to 1,315,000 barrels per day.

Alternative 3 projects a high level of future construction of Federal projects in the upper basin together with sharply increasing water demands to service development of energy resources in the upper basin. It projects initial diversions from the Central Arizona project by 1985. Thus, alternative 3 represents a reasonably high projection of future basin water demands. Specifically it provides for the construction of all Federal projects now authorized except those authorized in the Colorado River Basin Salinity Control Act of 1974 which have little effect on water quantities. Thermal power development increases to 32,560 MW. Coal gasification capacity is at 2,911 million cubic feet per day and oil production from oil shale is at 1,515,000 barrels per day. Other demands are also increased substantially.

In developing these alternative water demand schedules, extensive use was made of information in the Upper Colorado Region Comprehensive Framework Study. The projections of water demands for the energy function of thermal coal power generation, coal gasification and oil production from oil shale were based largely on information in the Report on Water for Energy in the Upper Colorado River Basin, prepared by the U.S. Department of the Interior.

It should be noted that for alternative 1 only those plants reasonably sure of development were included and none subsequent to 1985 were included. For alternative 2 no plants subsequent to 1988 were projected but for alternative 3 potential plants through the year 2000 were included.

The three alternatives reflect three different rates of increase in future upper basin water use and are intended only for illustrative purposes to demonstrate the adequacy or inadequacy of Colorado River water supply under varying assumptions as to basin runoff and basin water demand. Consideration was not given as to whether projected water demands in the upper basin would exceed the upper basin's assured supply or whether such demands in any given state would exceed the state's allocation of upper basin water. It is realized that should such an event occur compensating steps would be necessary or water-based development restricted.

Water demand levels in the Lower Colorado River Basin reflect two future situations: prior to initial operation of the Central Arizona project and subsequent to initial operation. In the former situation, full demand levels can be met within compact and other limitations, whereas in the latter case, full demand levels by Arizona and California cannot always be met because of water supply limitations.

Results of Model Runs. — The Colorado River Simulation Model is in its trial stages. With the change from a single historical runoff sequence to several theoretically possible sequences, more testing will be required before there can be complete confidence in its operation and the answers it provides. The results given hereafter, thus, should be considered preliminary and subject to further analysis. There are, however, considered adequate for the purpose intended — that of demonstrating the adequacy or inadequacy of Colorado River water supply under varying future conditions.

The model operation assumed upper basin deliveries at Lee Ferry of at least 8.25 million acre-feet annually. It took into account all inflow and reservoir and river losses below Lee Ferry. It followed the operating criteria promulgated under provisions of Section 602(a) of the Colorado River Basin Project Act and accommodated the flood control operating criteria established by the Corps of Engineers. It recognized surplus and shortage levels at Lake Mead which governed the amount of releases for lower basin consumptive uses.

With three different projected runoff sequences and three different projected levels of basin water demand buildup, nine different patterns of future water supply-water demand situations were delineated through the model runs.

The combination of Trace A (low runoff) and Alternative 3 (high-water demands) presents an extremely poor picture of future water supply adequacy. While the situation portrayed by this combination should occur the chances of it materializing are quite small.

By combining Trace C (high runoff after CAP) with Alternative 1 (low-water demands) a highly favorable picture of future water supply adequacy is presented. The chances of this combination occurring likewise are quite small but probably not as remote as the Trace A — Alternative 1 combination.

The combination of Trace B — Alternative 2 presents a reasonable middle-ground picture.

The following table summarizes the results of the model runs for the three alternative demand schedules matched against the three hydrologic traces.

Results of model runs—Colorado River

Alternative demands and hydrologic traces	Estimated 30-year average annual virgin water supply at Lees-Ferry (million acre-feet)	Year CAP on line	Shortage conditions: (1) California consumptive use cut back to 4.4 million acre-feet per year	(2) Year total basin water demands exceed long-term average virgin flow of 14.9 million acre feet	(3) Arizona consumptive use reduced to less than 2.8 million acre-feet per year	(4) Year upper basin demands equal to 5.8 million acre-feet	End of month contents December 2000: Lake Powell (million acre-feet	Lake Mead (million acre-feet)
ALT-1		1987						
A	13.2		1994	—	—	—	17.2	20.1
B	14.1		1988	—	1999	—	16.3	20.1
C	15.5		—	1987	—	—	25.7	26.4
ALT-2		1987						
A	13.2		1989	1987	—	—	15.8	18.7
B	14.1		1987	1988	1999	—	16.4	18.2
C	15.5		—	1987	—	—	25.6	26.5
ALT-3		1975						
A	13.2		1985	1987	2000	1993	12.9	16.0
B	14.1		1985	1988	1995	1995	14.0	14.7
C	15.5		—[1]	1985	—	1989	24.1	25.6

[1]In 1998 California was cut back to 4.4 million acre-feet, however, deliveries were greater than 4.4 million acre-feet the following two years.

The results of the model runs support the following observations:

1. Total basin water demands in all likelihood will exceed the long-term virgin flow of the Colorado River in the 1985-1988 time frame, coincidental with study projection dates for completion of the Central Arizona project.

2. Upper Basin water demands under the high-level growth projection could equal or exceed 5.8 million acre-feet in the 1990-1995 time period. However, in most cases, because of favorable runoff or storage conditions, the projected demands were met until after the year 2000.

3. Except under a runoff cycle higher than the long-term average, California's current water use will be cut back to 4.4 million acre-feet some time between 1985 and 1995, depending upon basin water demand growth and hydrologic conditions.

4. Except upon a runoff cycle higher than the long-term average, Arizona's consumptive use could be reduced below 2.8 million acre-feet some time within the 1995-2000 time period, depending upon basin water demand growth and hydrologic conditions.

5. Should the virgin runoff at Lee Ferry for the next 25 years average 15.5 million acre feet, all reasonably foreseeable basin water demands could be met through 2000, and both Lake Powell and Lake Mead would be full at that time.

6. Under any future runoff cycle other than an extremely adverse one, it is reasonably certain that the main Colorado River storage reservoirs will be

full or nearly so when the Central Arizona project initially diverts water. By drawing on reservoir storage, the basic water demands of the basin under most circumstances could be met at least through the year 1995. However, by the year 2000 reservoir storage could be sorely depleted or exhausted, depending upon actual hydrologic conditions and the growth of upper basin water demands. After that date, serious water shortages could be common except in periods of high runoff conditions. The basic keys to the extent and timing of future Colorado River water shortages are the runoff patterns and rates of growth of upper basin water demands after the Central Arizona project is completed.

In coping with the problem of potential future shortages, attention first should be directed to maximizing the yield and optimizing the use of the natural water supply of the Colorado River Basin consistent with environmental considerations. This can best be accomplished through a total water management program that includes such activities as coordinated operation of all major basin structures, conjunctive use of surface and ground-water supplies, increased irrigation efficiency, water salvage, and wastewater reclamation and reuse. Potential savings by these means could increase present supplies of the Colorado River by as much as 300,000 acre-feet annually.

It is evident that a total water management program can only delay and not prevent water shortages from occurring eventually. When such shortages do occur, there appear to be two alternative courses open.

The first would be to accept the limitation in water supply and pattern the economic and social future of the basin to that limitation. Such a situation could arise either from the desire of basin residents to restrict water-dependent developments or through the impracticality of augmentation for physical, economic, environmental, national policy, or other reasons. Under this option, there would still be choices of controlling the future economy of the basin through the transfer of irrigation water to other uses such as energy resource development, municipal and industrial, and recreation.

The second option would be to augment the flows of the Colorado River thus increasing its water supply and permitting continued growth of water-dependent development. Study has been given as part of the Westwide endeavor to means by which the river could be augmented including weather modification, desalting of seawater, and desalting of geothermal brines. Importation of water from resource regions outside the seven basin States was not considered in the Westwide Study because of restrictions on import studies contained in the Colorado River Basin Project Act. Although physically possible, importation of water to the Colorado River from other basins in the seven basin States does not appear practical.

Weather modification, from both a technical and economic viewpoint, appears to be a viable means of augmenting Colorado River runoff by from 0.9 to 1.3 million acre-feet annually. Social, legal, and environmental problems, however, remain to be resolved. Desalting of geothermal brines, although costly, may have augmentation potential. A decision point has not yet been reached on either its technical or economic feasibility. Desalting of seawater at this time appears to be too expensive to merit serious consideration as a source of large-scale augmentation.

To assist in resolving the water supply problems of the Colorado River Basin:

1. The total water management concept for the entire Colorado River Basin should continue to be broadened and perfected.

2. There should be an acceleration of programs of assistance to water users which would bring about the adoption of water management methods and practices to improve the efficiency of water use.

3. In conjunction with the States and other interested parties, a wide range of future water demand

schedules for both options should be projected to be matched on the Colorado River Simulation Model with varied projected hydrologic sequences and operating criteria to provide information on the extent and timing of potential future water shortages.

4. Investigations and activities to delineate the most appropriate means of augmenting the Colorado River as envisioned in the Colorado River Basin Project Act of 1968, should be given the highest priority.

a. The weather modification program of the Bureau of Reclamation should be continued aggressively with emphasis on resolving remaining sociological, legal, and environmental problems. A demonstration program of several years' duration, as presently proposed under the weather modification program, should be initiated in the Upper Colorado River Basin as soon as practicable to verify the findings to date, particularly as to the magnitude of increases and results of the weather modification program in runoff.

b. The ongoing geothermal desalting program of the Bureau of Reclamation on the East Mesa of Imperial Valley should be continued aggressively.

c. Other means of augmentation such as the importation of surface water, directly or by exchange, should be investigated as early as such studies would be appropriate and justified.

Lower Colorado River Main Stem Management. — The Colorado River from Lake Mead to its mouth has undergone more change in its physical characteristics and patterns of land and water use since completion of Hoover Dam in 1936 then any other major river in the Nation. These changes have created an urgent need for a comprehensive coordinated lower river water and related land management plan and operation.

Prior to Hoover Dam, the lower river was uncontrolled, alternating between massive floods in the spring and early summer and meager flows in the late summer and fall, a traditional feast or famine situation. The area was sparsely populated and the river was little used except for limited irrigation diversion when water was available and diversion structures hadn't been destroyed by spring floods. It was an area more suited for wildlife than for human occupancy.

Following construction of Hoover Dam and other major lower river regulatory and control structures, the character of the river and its uses changed radically. Today, the river is almost completely controlled. While still supporting important fish and wildlife populations, it has also become a center of intense human occupancy and activity. Recreation use of the river has burgeoned. More than 12 million people live within 4 hours driving time of the lower Colorado River and, during 1973, 8 million visitor-days of recreational use were recorded there. Urban and recreational home development along the main stem continues at an increasing pace. Much of the rapidly growing population growth in the area occurs along the river valley downstream from Davis Dam where the communities of Bullhead City, Havasu City, Parker, and Yuma in Arizona, and Blythe and Needles in California are located. Waste disposal associated with spreading population presents a water quality hazard.

Several reaches of the river below Davis Dam still remain relatively undeveloped. These areas have some of the best fish habitat along the river and provide many thousands of man-days of fishing each year. Water and heavy vegetative growth throughout the bottomlands provide a favorable wildlife habitat, with animal life concentrated in and adjacent to thickets. Marshlands provide a habitat which is rare in the arid Southwest and support many species of resident and migratory wildlife. In addition to the numerous game and species, several endangered species depend upon these areas. The preservation of this favorable habitat and its abundant wildlife is

Figure 19. Undeveloped river reach, Topock Gorge Area, Lower Colorado River main stem.

essential to the environmental quality of the valley. The important Imperial and Havasu National Wildlife Refuges are located here. Channelization of the river and phreatophyte control to conserve and salvage water have, in the past, conflicted with fish and wildlife management objectives. Reaches of the river have been identified as having potential for designation under the National Wild and Scenic River Act.

Irrigation is important with over 300,000 acres being irrigated along the river in Arizona and California. Water is diverted here also in irrigated lands in the Imperial and Coachella Valleys of California. The Colorado River, Yuma, Chemehuevi, and Mojave Indian Reservations are developing facilities to utilize their remaining shares of Colorado River water through expansion of irrigation, recreation, and urban development. Illegal land occupancy and diversion of flows for irrigation also are a problem.

The river is an important source of hydroelectric power for the Southwest with major power installations at Hoover, Parker, and Davis Dams. Numerous excellent sites exist for potential pumped-storage hydroelectrical installations. The siting of several nuclear powerplants in the area is under active consideration.

Downstream from Davis Dam more than three-fourths of the area bordering the river is in Federal ownership or Indian trust. As most of the remaining lands suitable for potential resort and community use are federally administered, there are increasing demands, supported by the States, that public lands be released for development.

The long list of the lower river's attributes, uses, and problems — several of which are competing or conflicting — calls strongly for a total water and related land-management plan. These uses, attributes, and problems include: natural scenic values; heavy and growing water-based recreational use; urban and community growth including attendant waste disposal problems; major existing and potential hydroelectric developments; potential nuclear plant siting; important fish and wildlife habitat and resources; endangered species; extensive irrigation development; illegal trespass and occupancy; important Indian reservations; water salvage potentials through channelization and vegetation control; extensive Federal land ownership; and water quality improvement.

There is a long history of Federal actions dealing with water and related land management problems along the lower Colorado River which have not always been consistent or had common objectives. Several Federal agencies have been involved, including the Bureau of Reclamation, Bureau of Land Management, Fish and Wildlife Service, Bureau of Indian Affairs, National Park Service, and, more recently, the Environmental Protection Agency.

Land use and management plans and proposals have been made by the Bureau of Land Management and by the Bureau of Reclamation within the past decade and the Bureau of Land Management is presently preparing a Management Framework Plan for lands which it administers. Even though a multiplicity of research, investigation, management, and implementation programs are underway by various Federal agencies, there is an urgent need to organize a multiagency, multidisciplinary group with sufficient authority to formulate a comprehensive long-range plan for the lower river and to establish the means for coordinating the various Federal, State, and local programs and activities in the area. Such a group should be basically a Federal-State group with opportunity for active public involvement and should include representatives of all State and Federal agencies having designated responsibilities in the area as well as representatives of other public interests.

Oil Shale Development in the Upper Colorado Region. — The recent energy crisis, with its widespread shortages of gasoline and fuel oil, has focused national attention on the extensive reserves of oil locked in the oil shales of Colorado, Utah, and Wyoming. The higher grade deposits cover about 16,000 to 17,000 square miles and contain about 600 billion barrels of extractable oil, enough to meet oil requirements of the United States for 100 years at present rates of consumption. These reserves are approximately 17 times the present U.S. (including Alaska) proved crude petroleum reserves. By States, 80 percent of the high-grade reserves are in Colorado, 15 percent in Utah, and 5 percent in Wyoming. Most of the reserves are on public lands, but there are also significant reserves on private lands.

To adequately assess the water problems associated with oil shale development, it is necessary to determine when development will start and the rate and ultimate level of development. Several projections have been made by various authorities and they range in production capacity by 1985 of from 450,000 bpd to 1,200,000 bpd.

Water requirements for oil shale production and processing vary with the production rate, mining techniques, and methods adopted for spent shale disposal. Municipal water for the increased population to support the oil shale activity would also be needed but would be relatively minor compared with other requirements. Total estimated water requirements vary between 5,000 and 20,000 acre-feet per year per 100,000 bpd production. On the basis of a projected industry output of 1 million bpd by 1985, the new water demands could vary between 50,000 and 200,000 acre-feet per year.

The Department of Interior's Final Environmental Impact Statement (EIS) for the Prototype Oil Shale Leasing Program assumes that oil shale development will take place in two phases: Phase I would be experimental, testing different mining techniques, land and water disposal, reclamation schemes, and environmental programs. In this phase, the three States are expected to produce, by 1983, about 500,000 bpd. Of this, 250,000 bpd would come from private lands in Colorado. Phase II is envisioned to evolve from Phase I research and development and thus could start between 1982 and 1986. Development would be continuous and dependent on Phase I technical results, the alternative cost of energy, extent of private development, environmental assessments, and other factors. About 500,000 bpd of capacity reasonably could be expected to be added in the early stages of Phase II for a total oil shale industry production of 1 million bpd by 1987.

For Phase I development, no severe problems are anticipated in meeting water demands. As development expands, however, problems will arise. Sources of water that may be used are ground water, diversions from uncontrolled streams, existing Federal reservoirs, newly constructed storage facilities both Federal and non-Federal, and conversion of agricultural water use to industrial use. As development proceeds, other problems may involve Colorado River Compact limitations on total consumptive use within the upper basin States.

The July 1974 report of the Department of the Interior on "Water for Energy in the Upper Colorado River Basin" projects an oil shale industrial output of 1,515,000 barrels of crude oil per day by the year 2000 with accompanying water requirements of 259,000 acre-feet per year.

Oil shale production and processing will be accompanied by a number of significant impacts. Socioeconomic impacts related to population growth could place heavy burdens on the existing housing, school, and public service facilities of the area. Environmental impacts could affect winter range for deer, high-quality trout streams, wild and scenic rivers, endangered species, and general scenic values. Land impacts will be those directly involved with the amount and kinds of disturbances resulting from exploration, mining, processing, and spent shale disposal activities. There also will be a significant new demand for energy to serve production and processing activities.