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STATE OF ARIZONA

WATER QUALITY CONTROL COUNCIL

Tentative

WATER QUALITY CONTROL POLICY

COLORADO RIVER IN ARIZONA

[1967?]

Arizona State Water Quality Control Council HEA 5.6: C55

FOREWORD

The purpose of this policy statement, in addition to the obvious purpose of endeavoring to preserve and enhance the quality of Colorado River water, is to formulate and adopt a water quality control policy document for Interstate Streams in Arizona as required under the following State and Federal Acts:

1. Federal Water Pollution Control Act, as amended.

2. Arizona Revised Statutes, Chapter 14.

While these statutes are essentially designed towards the same endeavor, terms and definitions used therein may differ somewhat. Specifically, the water quality criteria and implementation and enforcement plans called for in the Federal Act are presented in this policy document as Waters Controlled, Water Quality Objectives, Measures to Achieve Water Quality Objectives, and Implementation of Objectives. The supporting data required by the Federal Act is supplied in Description of Area and Findings, Beneficial Water Uses to be Protected, and Rationale for Water Quality Objectives.

Conferees from Arizona met with conferees from the other six Colorado River Basin States. They discussed common problems associated with the quality and quantity of water in the Colorado River in view of present and future use, and jointly prepared Guidelines for Formulating Water Quality Standards for the Interstate Waters of the Colorado River System. A copy of the latest draft of these guidelines appears in the Appendix as Exhibit 20.

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WATER QUALITY CONTROL POLICY
for
COLORADO RIVER IN ARIZONA

1-0 WATERS CONTROLLED

1-1 This Water Quality Control Policy applies to the Interstate waters in the main stem of the Colorado River in Arizona from the Utah-Arizona border to the Southerly International Boundary with the Republic of Mexico, and to all those streams contributing water to the main stem of the Colorado River from Arizona. The main stem and tributary features are shown on the map below. The Gila River System upstream from its confluence with the Colorado River will be covered by a separate policy.

This Water Quality Control Policy includes the Virgin River which passes through the northwest tip of Arizona on its way from Utah to Nevada to Lake Mead.

2-0 DESCRIPTION OF AREA AND FINDINGS

2-1 The Main Stem of the Colorado River: The gross watershed of the Colorado River encompasses portions of the states of Wyoming, Colorado, Utah, New Mexico, Arizona, Nevada, and California, as shown on Plate 1. The upper portions of the watershed are drained by the Green, Colorado, and San Juan Rivers. These main tributaries in turn drain into Lake Powell, which is located behind Glen Canyon Dam near the Utah-Arizona boundary. Flows of these major tributaries into Lake Powell provide approximately 90 percent of the total waters available to the lower main stem of the Colorado River. The average annual undepleted flow of the Colorado River is approximately 15 million acre-feet.

Enroute to Lake Powell, river waters in the Upper Basin (that portion upstream of Glen Canyon Dam) are diverted, used, and returned to the system. The major such diversions and returns are regulated by control structures which are operated under the United States Department of the Interior, Bureau of Reclamation. Many of the Bureau's authorized projects in the Upper Basin remain to be constructed, and many existing projects are not yet fully developed.

Waters released from Glen Canyon Dam flow in the main stem to Lake Mead which is located behind Hoover Dam. Lake Mead provides most of the storage and regulation in the Lower Colorado River Basin. Hydroelectric power is generated at both Glen Canyon and Hoover Dams. Lake Mead will serve as the supply reservoir for the Southern Nevada Project. Return flow from the Southern Nevada Project will reach Lake Mead through Las Vegas Wash.

Water released from Hoover Dam flows into Lake Mohave behind Davis Dam which is located just north of the Nevada-California boundary. Lake Mohave is used for re-regulation of releases from Hoover Dam. Hydroelectric power is generated at Davis Dam.

Water released from Davis Dam crosses the Nevada-Arizona-California boundary and flows through the broad Mohave Valley for 33 miles before reaching the upper end of Lake Havasu. Lake Havasu, which is a widened portion of the Colorado River located behind Parker Dam, is about 45 miles in length. The Metropolitan Water District of Southern California diverts water from Lake Havasu for transport to the coastal regions of Southern California. The Central Arizona Project plans to divert water from Lake Havasu for transport to Central Arizona. Hydroelectric power is generated at Parker Dam.

Proceeding downstream, Headgate Rock Dam, located near Parker, Arizona, is used to divert water for irrigating the lands of the Colorado River Indian Reservation in Arizona. There is essentially no storage behind this dam, and no hydroelectric power is generated. Some returns from drainage of the reservation lands reach the Colorado River north of Palo Verde Diversion Dam, but the principal drain empties into the river south of this dam.

Palo Verde Diversion Dam, which also has essentially no storage, is used to divert water just north of Blythe, California, for irrigation in the Palo Verde Valley of California. While there are some minor drainage returns to the Colorado River from Palo Verde Valley along the adjacent reach, the predominate farm drainage returns from Palo Verde Valley are via Palo Verde Lagoon-Outfall

Drain at the most southerly end of the Valley.

Cibola Valley, on the Arizona side, is located near the southern tip of Palo Verde Valley. River water is pumped into Cibola Valley for irrigation.

Imperial Reservoir is located behind Imperial Dam, approximately 15 miles north of Yuma, Arizona. Imperial Dam is the major diversion structure for irrigation projects in the Imperial and Coachella Valleys and Yuma areas. Releases made to the mainstream below Imperial Dam are essentially for the purpose of satisfying treaty obligations with the Republic of Mexico. There is only minor river water storage behind Imperial Dam. No hydroelectric power is generated.

Senator Wash Dam and Reservoir are located on the California side of the Colorado River immediately upstream from Imperial Dam. The reservoir provides offstream regulatory storage and has a maximum capacity of 13,400 acre-feet. To provide regulation, water is either pumped from the Colorado River into the reservoir or released back to the river. Water released from the reservoir generates hydroelectric power. The Bureau of Reclamation estimates that approximately 170,000 acre-feet of water can be saved annually by short-term storage of releases from upstream dams in excess of downstream requests for water deliveries.

Laguna Dam, which is located about six stream miles below Imperial Dam, serves as somewhat of a foundation support for Imperial Dam. There is only minor water storage behind Laguna Dam. The area between Imperial and Laguna Dam serves as a depository of silt removed by the desilting works at Imperial Dam. The importance of this desilting operation is covered in Section 3-5.

The routing of water diverted from Imperial Dam and measured surface return flows to the Colorado River between Imperial Dam and the Republic of Mexico Boundary is difficult to describe verbally, and is better explained schematically in Plate 2.

Waters reaching Morelos Dam, just south of the Northerly International Boundary with the Republic of Mexico, are diverted into the Mexicali Valley for domestic, irrigation and other beneficial uses.

AT PRESENT ESSENTIALLY NONE OF THE COLORADO RIVER WATER IS WASTED DIRECTLY INTO THE OCEAN and the management afforded by the present system of storage reservoirs permits delivery of the highest quality water now economically possible considering that the supply is fully utilized. Water will be wasted to the ocean only after all of the upstream reservoirs are filled to storage capacity and all beneficial uses have been satisfied. This condition is not anticipated in the foreseeable future.

2-2 Tributaries to the Colorado River from Arizona: There are numerous tributaries to the Colorado River from Arizona in the 700 river miles between Page (Glen Canyon Dam) and Yuma, Arizona. A brief description of the significant ones follows, and available specific data on quantity and quality of water contributed appears in Exhibit 1 in the Appendix where applicable. The Total Dissolved Solids (TDS) change given for each tributary is for present conditions. As the flow from the Upper Basin decreases, the effect is expected to increase by up to one-third from each tributary.

a. Paria River - The Paria River joins the Colorado River just downstream of the Lees Ferry USGS gaging station. The river flows through remote country from Southern Utah. The water has a high mineral content, but is relatively free of other contamination. The TDS load at the Colorado River is increased less than 2 mg/l by flow from this tributary. (See Appendix 1.)

b. Little Colorado River - The Little Colorado River joins the Colorado River about 55 miles below Lees Ferry. The river essentially starts in eastern Arizona near Greer, although there are some minor intermittent flows in creeks from New Mexico. The water has a medium to high salinity, depending on the flow rate. A major problem is the contribution of salts from Blue Springs, about 13 miles upstream from its mouth on the Navajo Indian Reservation. These springs contribute about 547,400 tons of salt per year to the Colorado River. The TDS load of the Colorado River is increased by about 28 mg/l by this tributary, with about 20 mg/l attributable to the Blue Springs. The problem is being investigated at the present time by the Bureau of Reclamation. (See Appendix 1.)

c. Bright Angel Creek - The Bright Angel Creek enters the Colorado River from the north in Grand Canyon National Park. The flow is mostly from springs near the North Rim of the Grand Canyon, and the quality of the water is good. The TDS load of the Colorado River is decreased about one (1) mg/l by the dilution effect of this tributary. (See Appendix 1.)

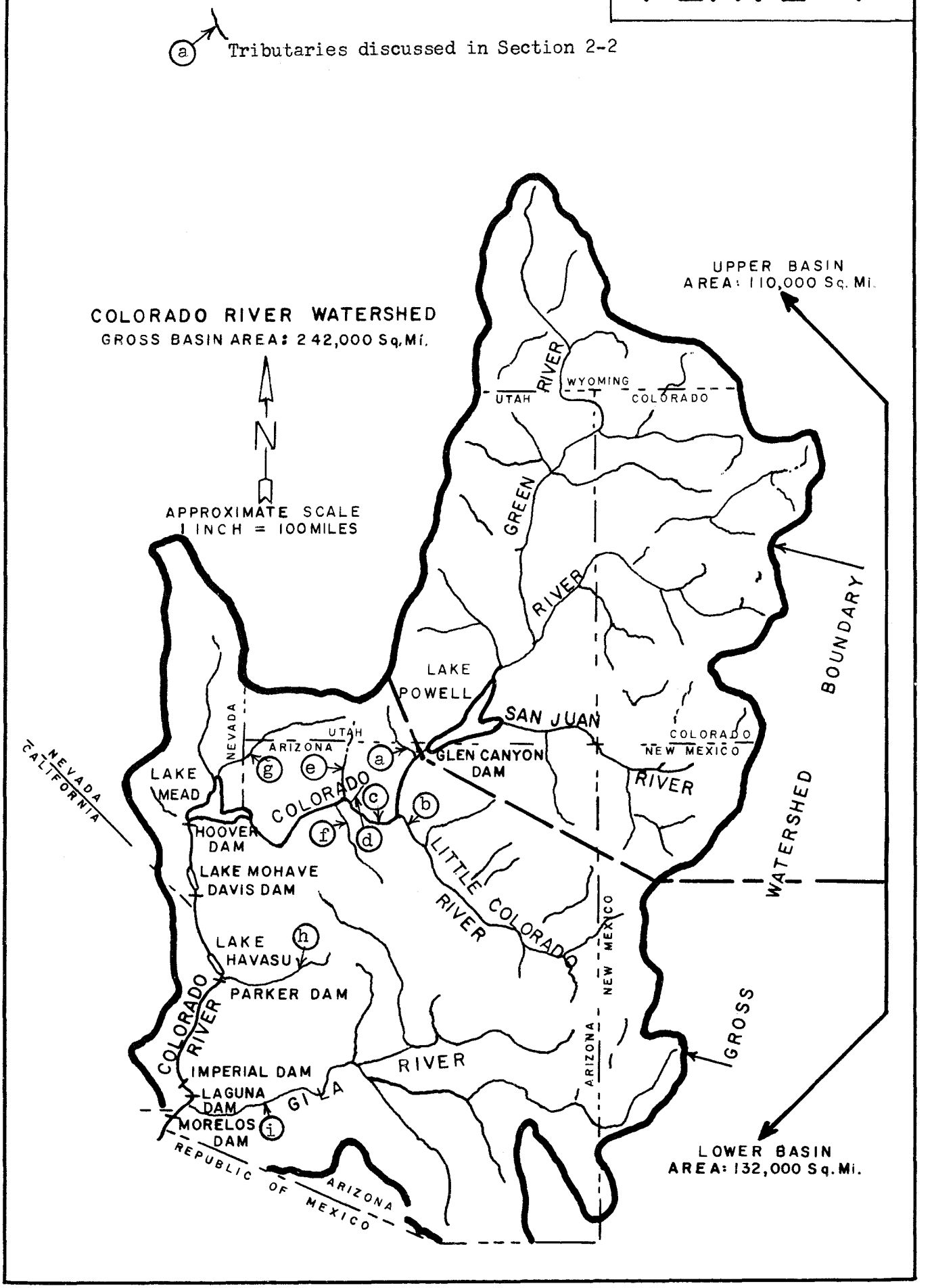
d. Tapeats Creek - Tapeats Creek is fed by springs on the north side of the Colorado River in the northwest portion of Grand Canyon National Park, a very remote and primitive area. The meager data indicate the discharge is of low mineralization, and the dilution would reduce the TDS load of the main stem flow of the Colorado River by about 2 mg/l. (See Appendix 1.)

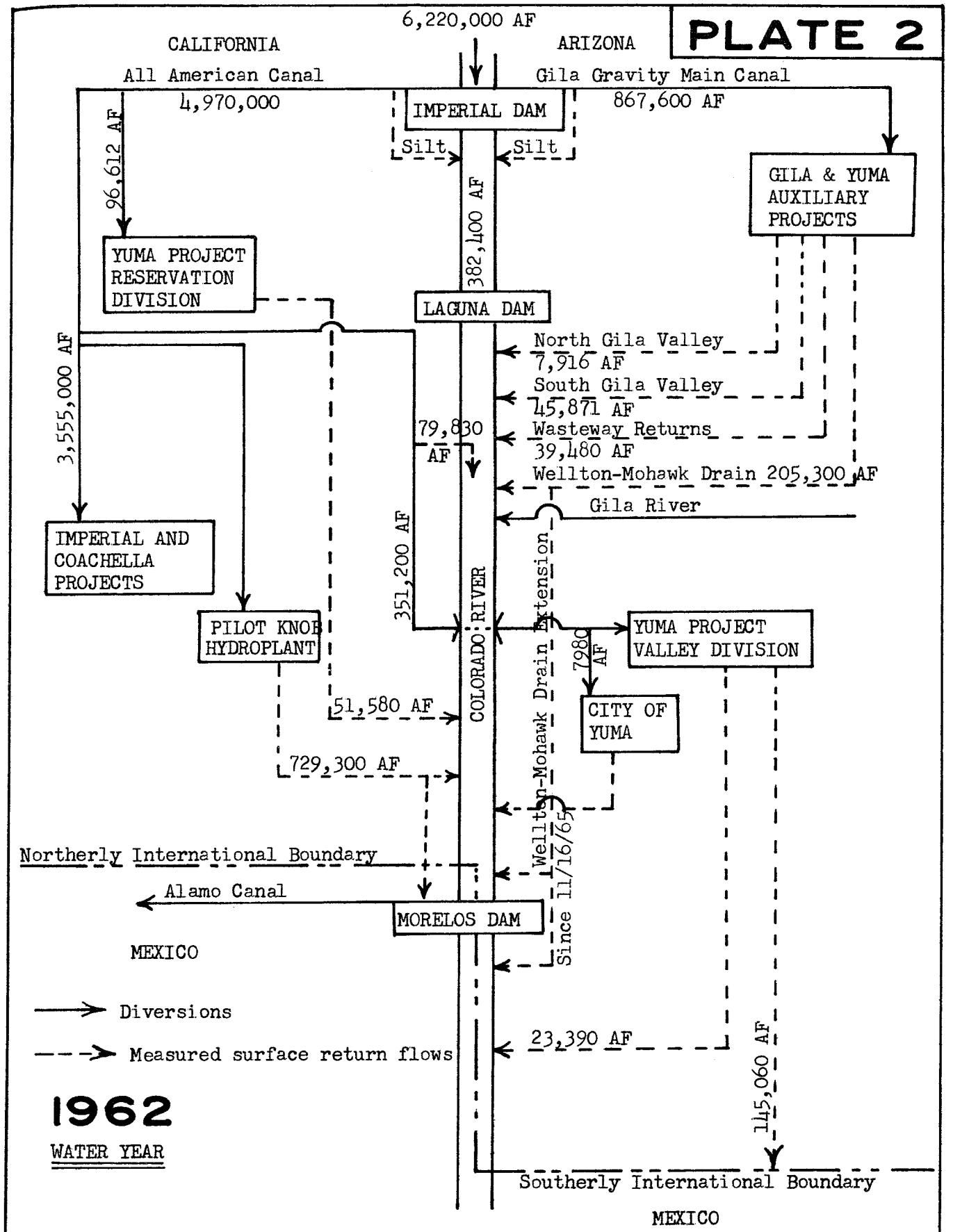
e. Kanab Creek - Kanab Creek has a drainage area of about 1,600 square miles, of which about 1,000 square miles is in southern Utah. The river crosses the border between Kanab, Utah and Fredonia, Arizona. The water is fairly high in mineralization, but the total flow is relatively small. The TDS load of the Colorado River is increased less than one (1) mg/l by this tributary. (See Appendix 1.)

f. Havasu Creek - Havasu Creek drains the Coconino Plateau south of the Colorado River and enters the river about 13 miles downstream from Kanab Creek. This is a remote area, and is inhabited by the Havasupai Indians. The very meager water flow and quality data indicates good quality water of low mineralization. The TDS load of the Colorado River is decreased by about 0.5 mg/l by dilution from this tributary. (See Appendix 1.)

g. Virgin River - The Virgin River begins in Utah, and flows into Arizona near Littlefield, then into Nevada near Mesquite, and then into Lake Mead. The Virgin River contributes about 350,000 tons of salts per year to the Colorado River System, and the quality of the water is

PLATE I


Tributaries discussed in Section 2-2
COLORADO RIVER WATERSHED
GROSS BASIN AREA: 242,000 Sq.Mi.
N
APPROXIMATE SCALE
1 INCH = 100 MILES
UPPER BASIN
AREA: 110,000 Sq. Mi.
UTAH
WYOMING
COLORADO
GREEN RIVER
LAKE POWELL
SAN JUAN RIVER
GLEN CANYON DAM
COLORADO
NEW MEXICO
NEVADA
ARIZONA
UTAH
NEVADA
CALIFORNIA
LAKE MEAD
HOOVER DAM
COLORADO
LAKE MOHAVE
DAVIS DAM
LITTLE COLORADO RIVER
LAKE HAVASU
PARKER DAM
COLORADO RIVER
IMPERIAL DAM
LAGUNA DAM
MORELOS DAM
GILA RIVER
REPUBLIC OF MEXICO
ARIZONA
NEW MEXICO
ARIZONA
GROSS WATERSHED BOUNDARY
LOWER BASIN
AREA: 132,000 Sq. Mi.



SCHEMATIC DIAGRAM OF DIVERSIONS AND RETURN FLOW IN THE LOWER COLORADO RIVER AREA BELOW IMPERIAL DAM. THE INFLOW-OUTFLOW FIGURES DO NOT BALANCE BECAUSE OF SIZEABLE UNMEASURED SURFACE AND SUB-SURFACE RETURN FLOWS TO THE RIVER.

extremely poor. The TDS load of the Colorado River is increased 14 mg/l as a result of this tributary. See Plate 1 and Appendix 1 for location and details. It appears that one major source (about one-fourth) of these salts is LaVerkin Springs (Dixie Hot Springs) in southern Utah upstream from St. George. Other specific sources are not known at this time.

h. Bill Williams River - The Bill Williams River discharges into Lake Havasu Lake just above Parker Dam. The River is erratic in flow since it drains a desert area with sparse rainfall. Flash floods are commonplace, and these are controlled by Parker Dam, and will be further controlled by the Alamo Dam now under construction about 35 miles from the mouth of the river. There is some irrigated acreage in this project. Data on water quality (WPSS) near the Alamo Dam site between October 1963 and October 1964 indicates that the TDS of the Bill Williams water is within the range of 535 to 698 mg/l, or less than that of the Colorado River arriving at Parker Dam. A source of pollution from the mining industry on this tributary is discussed in the Implementation Section.

i. Gila River - The Gila River joins the Colorado River just upstream of Yuma, and below Laguna Dam. The Gila River is now almost completely controlled by upstream dams, and the water is completely utilized, often many times. Floodwaters have never exceeded the present capacity of the Gila River storage system upstream of its confluence with the Salt River, and floodwaters have exceeded the capacity of the Salt-Verde System only twice in the last 25 years. Painted Rock Dam, northwest of Gila Bend, is the final flood control structure on the Gila River, and has only been used once since completion in 1959. During calendar year 1964, only 103 acre feet of water flowed past Dome, 12 miles upstream from the mouth of the Gila River near Yuma, and all of this flow originated downstream of Painted Rock Dam.

j. Other Tributaries - There are many small streams that flow for a short period of time after rainstorms, but the flow is so intermittent that very little data is available on total flow and water quality.

Many small springs and spring-fed tributaries, mostly in the reach between Glen Canyon Dam and Lake Mead, contribute small quantities of water and dissolved salts. Since most of these tributaries are in very remote uninhabited areas, very little data on them is available. The data that is available is shown in Exhibit 1.
There are some intermittent creeks flowing from Arizona into Utah above Glen Canyon Dam, and ultimately these may reach the San Juan or Colorado Rivers. Most of these streams are in remote areas of the Navajo Indian Reservation.

2-3 Tributaries to the Colorado River from Utah: In addition to tributaries to the Main Stem of the Colorado River upstream of the Utah-Arizona border, there are several streams that cross the Utah-Arizona border and flow through Arizona before reaching the Colorado River. The significant ones are as follows:

a. Paria River - This river is covered in Section 2-2a under Arizona tributaries.

b. Kanab Creek - This creek is covered in Section 2-2e under Arizona tributaries.

c. Virgin River - This river is covered in Section 2-2g under Arizona tributaries.

2-4 Tributaries to the Colorado River from Nevada: There are a few tributaries to the Colorado River along the common Nevada-Arizona border. The significant ones are as follows:

a. Virgin River - This river is covered in Section 2-2g under Arizona tributaries since it flows through the northwest tip of Arizona.

b. Las Vegas Wash - Las Vegas Wash drains the Las Vegas Valley and flows into Lake Mead just above Hoover Dam. Although the present flow is not great (about 15,000 to 20,000 acre feet per year), the salt burden is high, and the flow is expected to increase several-fold upon completion of the Southern Nevada Project. The TDS load of the Colorado River is increased about 4 mg/l by this tributary at the present time.

2-5 Tributaries to the Colorado River from California: The area within California which drains naturally to the Colorado River is a narrow strip of land varying in width from about 10 to 40 miles. This strip extends from the Nevada-California border to the California-Mexico boundary.

The area is essentially semi-desert, and stream flows are intermittent. Although rainfall is sparse in this area, the intensity of rainfall may be great when it occurs, and flash floods have occurred. Flow and quality data is almost non-existent.

2-6 History of the Colorado River Basin Development: The history of the development of the Colorado River Basin is important to the consideration of water quality.

a. General History - Irrigation development of the Colorado River Basin started with the beginning of settlement about 1860. The Upper Basin (above Lees Ferry) irrigated about 800,000 acres by 1905, and about 1,400,000 acres by 1920. Development slowed down after 1920 because of both physical and economic limitations in the availability of water. In the Lower Basin, irrigation began in the Palo Verde Valley in 1879, and development of the Yuma area and Imperial and Coachella Valleys followed. Irrigation on the Colorado River Indian Reservation was attempted in 1870, but inadequate flood control almost stopped this development until 1942.

Early development of river control centered around the agricultural economy of the area. The river flow was very erratic and undependable. Tremendous floods occurred in the lower basin around the Yuma area when both the Colorado and Gila River systems reached high flow stages. The Colorado River carried huge silt loads, and led to the statement that the Colorado River was "too thick to drink and too thin to plow". The salt burden was low at high flow, but very high when the flow was low.

The construction of dams on the Colorado River and its tributaries, especially the Gila, Salt and Verde Rivers, brought the River under control, reduced the silt load, evened out the salt burden, and made agricultural operations in the Lower Basin stable.

This development of the Colorado River has had considerable political problems, and further development, including quality control, will have some more political and legal problems.

b. Water compacts and Treaties - The development of the Colorado River has necessitated a number of compacts and treaties to protect the rights of individuals and states to the use of water. The following are certainly important when considering water quality criteria that could affect water use under existing rights.

(1) Colorado River Compact - The water of the Colorado River was divided between the Upper and Lower Basins by the Colorado River Compact of 1922, with the division point at Lees Ferry. The compact recognized the potential obligation of the United States to the Republic of Mexico.

(2) Mexican Treaty - The treaty with Mexico, signed in 1944, provides for annual delivery by the United States to Mexico of 1,5000,000 acre-feet of Colorado River water, with certain exceptions due to river flow conditions.

(3) Upper Colorado River Basin Compact - This Compact of 1948 apportioned the waters of the Upper Basin states (including 50,000 acre-feet to Arizona annually) to allow for orderly and proper development of the Upper Basin.

(4) Arizona vs. California Suit in the Supreme Court - The Lower Basin states never agreed to a division of the waters of the Lower Colorado River Basin, and the division was provided by Supreme Court decree in 1964. This decision cleared the way for further development of the Lower Basin.

(5) Water Quality - None of the agreements or compacts have specifically mentioned water quality. The Treaty with Mexico provides that Mexico will take from any and all sources...whatever their origin, the waters to which she is entitled. Water quality is recognized as a factor to be considered in recent legislation authorizing the construction of projects in the Basin.

2-7 Diversions of Water Along the Arizona Reach: Major United States projects divert and use water from the Colorado River along the Arizona reach. A description of these diversions, by states, follows, and data is summarized in Exhibit 2 in the Appendix.

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a. Arizona Projects:

(1) City of Page - Page receives its municipal water supply from Lake Powell. Sewage is disposed in sewage lagoons with minor effluent return to the Colorado River.

(2) Colorado River Indian Reservation - This project has 99,375 acres in Arizona with assigned water rights as set forth in the Arizona vs. California Supreme Court Decree, and about one-third is presently being irrigated by diversions at Headgate Rock Dam. About 60% of the water diverted is returned to the river as measured surface return flows. In addition, there are unmeasured surface and sub-surface returns to the river.

(3) Yuma Project, Valley Division - About 52,000 acres in this project are served by diversion at Imperial Dam via the All American Canal to the Yuma Main Canal by a siphon under the Colorado River. A portion of the water diverted passes through measured surface drains and wasteways back to the Colorado River south of the Northerly International Boundary or to Mexico over the Southerly International Boundary near San Luis, Sonora. Additional drainage facilities are needed in portions of the valley, particularly in the area adjacent to the mesa.

(4) Gila Project - Water is diverted at Imperial Dam via the Gila Gravity Main Canal to service an authorized project area of 115,000 acres. This project consists of the following units:

(a) North Gila Valley Irrigation District
(b) Yuma Mesa Irrigation and Drainage District
(c) Yuma Irrigation District (South Gila Valley)
(d) Wellton-Mohawk Irrigation and Drainage District

Surface drainage from the Gila Projects is returned to the Colorado River above the Northerly International Boundary except that the Wellton-Mohawk drainage facilities include a bypass channel which extends past Morelos Dam. This bypass channel was put into operation on November 16, 1965, and the Mexican Government has the option of deciding whether the drainage waters shall be discharged above or below Morelos Dam. About 30% of the water diverted is returned to the river as measured surface drainage or control water.

(5) Yuma Auxiliary Project - Water is diverted at Imperial Dam via the Gila Gravity Main Canal to irrigate 3,406 acres in this project, which includes certain Warren Act Lands. There is no measured return flow.

(6) City of Yuma - The City of Yuma presently receives most of its water through the Yuma Main Canal. The city's contract with the Secretary of the Interior provides for delivery of the water from the river. Sewage from Yuma is now discharged untreated to the river north of the Northerly International Boundary, but plans are progressing for a sewage treatment plant.

(7) Cibola Valley - Water is pumped from the Colorado River for irrigation of the Cibola Valley.

(8) Central Arizona Project - When authorized and built, this project will divert water from Lake Havasu to provide much needed supplemental water for domestic, industrial and agricultural purposes in Central Arizona. There will be no return flows from this project. The economic impact and importance of this project is discussed in Section 2-8.

(9) Fort Mohave Indian Reservation - This project has 14,916 acres in Arizona with assigned water rights as set forth in the Arizona vs. California Supreme Court Decree.

(10) Miscellaneous Diversions - These include domestic, agricultural and industrial waters, and consist of direct diversions or by groundwater pumping in the vicinity of the Colorado River. Water is used by cities, recreational centers, small farms, power plants, etc.

b. Nevada Projects: The Southern Nevada Project is authorized to divert from Lake Mead, 300,000 acre-feet of water for use in the Las Vegas area. The water will be used for domestic, agricultural and industrial purposes. The Bureau of Reclamation anticipates a return flow of approximately 50,000 acre-feet of water to Lake Mead annually.

c. California Projects:

(1) Metropolitan Water District of Southern California - The Metropolitan Water District aqueduct provides capacity for the annual diversion of 1,212,000 acre-feet of water for domestic, industrial and agricultural use on the coastal plain of southern California. There is essentially no return flow.

(2) Palo Verde Irrigation District - About 900,000 acre-feet of water is diverted annually at Palo Verde Diversion Dam near Blythe for agricultural purposes. Approximately 60% is returned to the Colorado River either as measured surface drainage or excess diverted water, mostly in a main drain at the lower end of the project.

(3) Imperial Irrigation District and Coachella Valley County Water District - Approximately 3,500,000 acre-feet of water is diverted annually at Imperial Dam via the All

American Canal for various uses within the Districts. There is no return flow (other than seepage from the All American Canal and flow regulation water) to the Colorado River. Agricultural drainage water, canal seepage, and any excess water diverted flows to the Salton Sea in California.

(4) Yuma Project, Reservation Division - About 96,000 acre-feet of water is diverted annually at Imperial Dam via the All American Canal for agricultural use in the Bard Valley. A portion is returned as drainage and flow regulation water to the Colorado River between Yuma and the Northerly International Boundary.

2-8 Economy and Natural Resources of Arizona: The economy of the entire State of Arizona is intimately associated with the development of the Colorado River. Arizona is semi-arid in character with a low average annual rainfall and limited natural water supplies. Since 1947, the population of the state has more than doubled, with more than 70% of the population residing in Maricopa and Pima Counties. These two counties along with Pinal County comprise the core area of the Central Arizona Project. This area is now supplied with water by surface water systems on the Salt, Verde and Gila Rivers and by pumping from the groundwater basins. The agricultural, domestic and industrial users of this area are using up all of the surface water available and are pumping approximately 3,000,000 acre-feet of water per year more than the natural groundwater replenishment. This annual overdraft is clearly evidenced by the accelerated decline of groundwater levels and by land subsidence in some areas.

The central Arizona area desperately needs the additional water to be delivered by the Central Arizona Project Aqueduct from Lake Havasu, but the supply available is still far short of the present overdraft, and the needs of the area are still growing. The quality of the presently available water is not always good with respect to its salt content and this quality is further degraded by multiple reuse since almost all beneficial uses of water add salts of some variety to the water.

The remaining areas of the state face similar problems of short supply and/or quality of water, and it is impossible to separate these factors completely in any proposed program of supply or regulations on quality. The total problem can only be solved by a major water augmentation program for the Lower Colorado River Basin.

The people of Arizona have been striving to improve the quality of their water and extend the supply for many years, long before a federal program for pollution control was initiated. The quantity of water available has been extended and the quality of the water has been enhanced by the following practices and programs:

a. Farming practices have been steadily improved so that less water is applied to the land per unit of crop yield. A report on this phase of water conservation and quality enhancement is appended as Exhibit 11.

b. Delivery systems for both surface and groundwater have been improved through re-design, lining and conversion to pipelines to reduce seepage, evaporation, salt pick-up, consumptive use by non-crop plants, and delivery waste. Statistics on past and future programs are presented in Exhibit 12.

c. Extensive watershed planning and control programs have been initiated to increase the yield and improve the quality of water delivered by the surface water systems. The Arizona Water Resources Committee, representing wildlands, banking, ranching, water authorities, timber, irrigation, power, mining, game and recreation and municipalities, has an annual symposium (10th in 1966) to present and discuss experimental results and plan larger scale experiments. A summary of watershed improvement accomplishments and future programs is appended as Exhibit 13.

d. Means of evaporation control or reduction of evaporation on reservoirs and streams have been investigated since evaporation of water from the surface of reservoirs and streams not only reduces the supply but also increases the salt content of the water remaining. A summary of activities in this field is presented in Exhibit 14.

e. Extensive phreatophyte investigation and control programs have been carried on to eliminate or reduce waste by certain types of vegetation growing in or near streams. Evapotranspiration by these plants concentrate salts in the soils and contribute to the salinity problems of the basin, so reduction of such growth would enhance water quality. A summary of the phreatophyte control program is presented in Exhibit 15.

f. Programs to supply water of the best available quality for domestic needs in exchange for treated sewage effluents for needs with lesser quality requirements are being worked out and tested. Other water exchanges have been worked out between areas of need and surplus, and more are needed. Examples are presented in Exhibit 16.

g. One Arizona city, Buckeye, has been a pioneer in providing desalinized water for domestic use. An expensive electrodialysis process was put in operation in 1962 to remove excessive salts from the only water available to the city, making Buckeye the first town in the U.S.A. to have its entire water supply treated by a demineralization plant. This was a local community program, and no Federal or State funds were involved in this project. A report on this project is presented in the Appendix as Exhibit 17.

It should be pointed out that all of the currently available methods of desalinization separates the influent water into two streams, one relatively pure, and one very salty. Disposal of the salty brine is a very great problem for an area isolated from the oceans where most of the desalinization programs are promoted and tested.

h. The Arizona Water and Pollution Control Association meets annually (the 39th annual meeting was held in 1966) to hear and discuss

papers presented by both local and out-of-state people involved in water supply and disposal problems. Educational programs are sponsored by the Association along with other programs designed to upgrade the quality of Arizona water. The Association is affiliated with the Water Pollution Control Federation and the American Water Works Association. A report of the Association is included in the Appendix as Exhibit 18.

i. The Soil Conservation Districts of Arizona, both individually and through their Association, have been actively engaged in projects aimed at soil and water conservation and water quality improvement. A summary report of the Association is presented as Exhibit 19 in the Appendix.

j. River channelization projects in the lower Colorado River below Hoover Dam have been in progress for several years by the Bureau of Reclamation to reduce consumptive losses, erosion and quality degradation. This work is generally opposed by fish and wildlife interests alleging it destroys natural habitat areas. Stabilized river flow and storage impoundments made possible by dam construction have, however, enhanced some fish and wildlife areas.

The following natural resources of Arizona, although presently utilized effectively through good management practices, shall be protected by Arizona's water quality control policy, and the tabulation is not intended to designate the order of importance:

a. Agriculture - Arizona's principal crops (alfalfa, citrus, cotton, grains, and vegetables) are grown on 1,160,000 acres scattered around the state, with some additional acreage for minor crops. Almost all of this acreage is dependent on irrigation, and over 300,000 acres in addition to that stated above are out of production due to water shortage. Growing conditions, and particularly climatic conditions, are well adapted to crop production under irrigation on a year-round basis, and many high value crops such as cotton, winter vegetables and citrus fruits are produced in addition to staple crops and feeds. The gross value of Arizona crops was $344,400,000 in 1965. The continued production of these crops is dependent upon our total water resources in Arizona, considering both quantity and quality. The quantity of flow must not be unnecessarily reduced by unrealistic quality considerations. Statistics on various phases of agriculture are shown in Exhibit 3 in the Appendix.

b. Urban Development - Urban development of Arizona has been growing rapidly, and this growth has demanded increased recognition of the need for a dependable supply of good quality water. Although the growth has been highest in the Phoenix and Tucson areas, there has also been considerable growth in cities adjacent to the Colorado River. An inventory of cities along the Colorado River with pertinent water supply and disposal data is shown on Exhibit 4 in the Appendix. The growth of Urban area has accompanied increased activity in tourism (due to climate, recreational facilities and

natural attractions), manufacturing and service industries for all state activities including but not limited to agriculture, construction and mining. Manufacturing statistics are shown in Exhibit 5.

c. Grazing and Livestock Feeding - This industry is extensive in Arizona, including the area along the Colorado River. The gross value of livestock and products was $237,900,000 in 1965. Livestock production requires water and also produces waste which must be controlled. Statistics are included in the Agricultural Exhibit 3 in the Appendix.

d. Mining Industry - There are only limited mining operations along the Colorado River, but mining is a major factor in the economy of Arizona and this industry requires huge quantities of water. Reuse of water in all phases of mining has been practiced for many years, and pollution of streams has not been a major problem. The minor problems are being corrected, and data is given in the Implementation Section.

The gross value of mineral production was $580,170,000 in 1965. The principal metals were copper, gold, silver, lead and zinc, but substantial quantities of sand, gravel, molybdenum, stone, uranium, lime, pumice and other miscellaneous minerals were produced. Copper produced about 86% of the total value. Statistics are shown in Exhibit 6 in the Appendix.

e. Fish and Wildlife - Although much of Arizona is arid or semi-arid, the State is blessed with fish and wildlife resources. Protection of this important natural resource is vital in the development of the Basin's water resources. Over 3,400,000 man-days of fishing and hunting were enjoyed by Arizona sportsmen during 1965. Additional man-days of hunting and fishing were enjoyed on the Colorado River by license holders of adjacent states. The Colorado River provides excellent feeding and resting areas for migratory waterfowl, particularly in those portions of the river where oxbows and sandbars exist. Additional value is created by shoreline vegetation which provides habitat for numerous species of mammals and birds.

Both the State and Federal Government have responsibilities under existing law to preserve and develop the fish and wildlife resources of the Colorado River, and cooperation among the states is vital and necessary. The Federal Government by virtue of existing treaties with Great Britain and Mexico, is responsible for management of the nation's migratory bird resource. This responsibility is implemented along the Colorado River by the Bureau of Sports Fisheries and Wildlife of the U. S. Fish and Wildlife Service. Both National and State Wildlife Refuges have been established to preserve water fowl wintering habitats.

The natural habitat has been constantly changing since the area was settled by man. A significant portion of the habitat no longer exists due to river control and land development, and the wildlife has

decreased accordingly in species and numbers. Channelization and controlled flows have eliminated many of the productive backwaters, bypasses, and oxbows that serve as spawning and nursery areas for warm water fishes, and have reduced angling potential for these species.

In contrast, the vast reservoir storage system created by the construction work of the Bureau of Reclamation has virtually eliminated flood flows, reduced turbidity, and lowered summer water temperatures so that extensive reaches of the Colorado River are now more suitable for trout. Fish are supplied by a National Trout Hatchery at Willow Beach and by the three State Game and Fish Departments involved in the Arizona reach of the Colorado River.

f. Recreational Use: In addition to the natural recreational resources in Arizona, the controlled river flows resulting from the operation of dams and related water projects have created stable recreational resources in the Colorado River. For the most part, this recreational potential still remains to be developed. Stable water impoundments behind the dams attract fisherman, boaters, water skiers, campers and persons interested in being near the attractive water during the pleasant fall, winter, and spring seasons. Recreation is a year-round activity, however.

Public recreation is permitted on substantial portions of the accessible land along the Colorado River from the Utah-Arizona border to the Mexican border. There are numerous public forests, parks, marinas and other points of interest not only to residents of the adjacent areas, but also to national and international visitors. The major facilities are listed in Exhibit 7 in the Appendix.

It is difficult to determine the overall recreational use of the Colorado River because of the variety of developments spread out over the 745 mile reach of the river in Arizona. The recreationists who come on peak weekends for special events in some sections jam commercial and public facilities and overflow onto every available piece of land along the river. Somewhat uncontrolled use has occurred on other reaches of the river and adjacent lands. Individuals and commercial interests have moved onto the Federal lands, and have built structures varying from shacks to well-established motels, trailer parks, fishing camps, and resort developments.

Recreational use of the river has created some serious pollution problems because of the lack of adequate sanitation facilities. Adequate facilities will have to be provided, and the recreationists themselves are going to have to cooperate in making the river areas safe and esthetically enjoyable.

Recreational use of the Colorado River area will expand along with the population growth in the contributing metropolitan areas and as the physical features are developed. The major recreation objective will be reached if the quantity and quality of water are maintained,

and the esthetic values of the area are preserved. Control measures are discussed in Implementation Section.

g. Forest Products Industry: The four million acres of commercial forest land, out of the total of 21 million forested acres in the state, are largely situated in the northern, higher altitude areas. Managed for multiple use the commercial forest area provides not only timber, but has important values for water production, recreation, livestock, forage, and wildlife. Arizona's forest lands play a big role in providing water to the consumer. Much of the surface water consumed annually originates within the state as run-off from the relatively high water-yielding forest.

The forest industry in Arizona annually harvests about 66 million cubic feet of sawtimber and produces in excess of 300 million board feet of lumber. The pulp and paper segment annually uses 100,000 cords of pulpwood and chips from sawmill residual equivalent to an additional 150,000 cords. It produces about 150,000 tons of newsprint and kraft linerboard annually. The paper industry requires a significant quantity of good quality water.

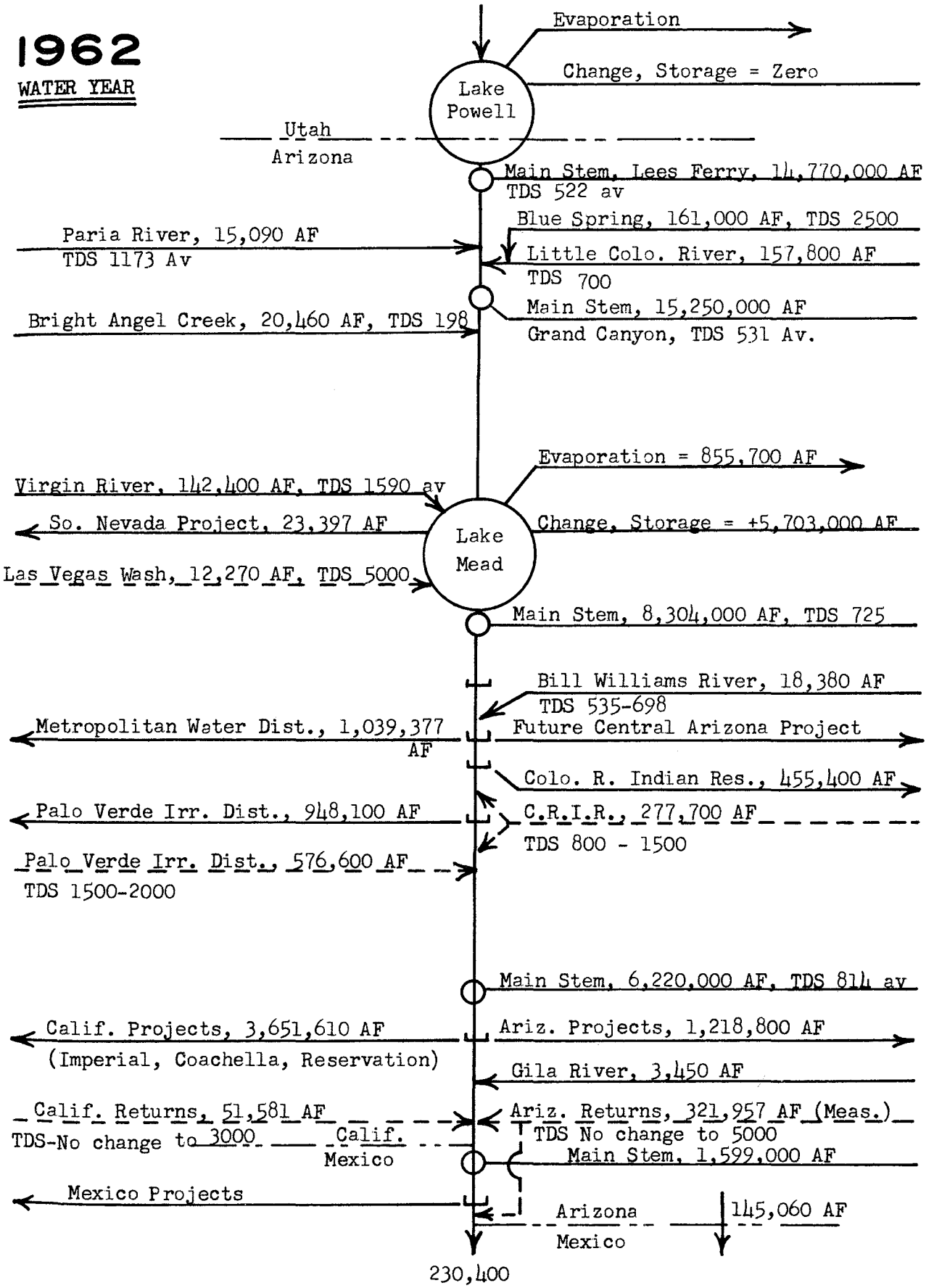
2-9 Water Quality Considerations: THE QUALITY AND QUANTITY FACTORS OF COLORADO RIVER WATER ARE SO INTER-RELATED THAT IT IS IMPOSSIBLE TO SEPARATE THESE PARAMETERS. Typical main stem flows, major diversions and return flows are shown along with pertinent salinity data on Plate 3 for reference. The Colorado Basin States Conferees, in drafting the Guidelines for Formulating Water Quality Standards for the Interstate Waters of the Colorado River System*, recognized that water quality standards could drastically restrict present and future uses of the Colorado River water under existing compacts. The following data on the quality of water in the Arizona Reach of the Colorado River is presented to provide the basis for stream standards listed in Section 4 of this Water Quality Control Policy for the Colorado River in Arizona:

a. Quality of Water Reaching Arizona: Historically, the water reaching Arizona in the Colorado River at Lees Ferry has been high in both salt and silt burden. Other pollutants have been negligible. The salinity has been steadily increasing due to both increased use in the Upper Basin and to depletions by trans-mountain diversion of the best quality water near the headwaters of the Colorado River. The quality of the water at Lees Ferry has been monitored diligently by the USGS, and excellent published records for the 1941-1964 period are available for comparison with other stations on the Colorado River. The Total Dissolved Solids (or TDS) in milligrams per liter (mg/l) is probably the best single parameter to judge the quality of the water.

Examination of the record indicates a wide variation in daily, weekly, monthly and yearly figures for TDS, and any water quality standards proposed will have to recognize this feature. In general, the TDS is low at high water flows and high at low water flows. This variation

*See Exhibit 20 in the Appendix

PLATE 3



Schematic diagram of the Colorado River main stem flow with major tributaries, diversions and return flows. The inflow-outflow figures do not balance because of sizeable unmeasured surface and sub-surface return flows to the river.

is discussed under sources of salinity. Variations in TDS at Lees Ferry are shown on Exhibit 8 in the Appendix.

Further development of the Upper Basin and increased use of the water upstream is expected to further degrade the water as far as TDS is concerned. In addition, further control of the flow of the river upstream will cause variation of the quality of the water. As an example, the effect of the closing of the gates at Glen Canyon Dam is seen in the TDS record for Lees Ferry in Exhibit 8. A partial explanation is shown in TDS variations in Lake Powell, Exhibit 9, Appendix.

Future storage in upstream reservoirs will ultimately decrease the flow in the Colorado River without appreciably changing the total salt burden, so this will increase the TDS. The present predictions are that the present TDS content will increase by 22 to 43% by 1990 (7)(15). Other authorities prognosticate a somewhat lesser increase in TDS accompanied by a deterioration in sodium and chloride content (16). These estimates are not keyed to the year 1990 and hence a direct comparison is difficult.

b. Quality of Water Released from Lake Mead: The water record for water released at Hoover Dam shows higher average TDS for water than that at Lees Ferry, but with much less fluctuation in quality because of the storage in Lake Mead. The TDS content appears to be gradually increasing.

The higher TDS can be attributed mainly to the increased TDS at Lees Ferry and natural sources of salinity between Lees Ferry and Lake Mead since there is negligible use of the Colorado River water in this reach. Some of these natural sources of salinity were discussed in Sections 2-2, 2-3 and 2-5, with further data in Exhibit 1 in the Appendix. Control of these natural sources of salinity should be investigated as a means of enhancing water quality, not only in this reach, but in the Upper Basin. Plans are discussed in Implementation Section.

Evaporation from the surface in the main stream and reservoirs is a contributing factor to the increased TDS. For example, the record shows that 907,200 acre-feet evaporated from Lake Mead in Water Year 1963, leaving behind approximately 800,000 tons of salt. Some of this salt is believed to have been precipitated out (7), but much of it undoubtedly contributes to downstream TDS. TDS comparisons at various points in the river are shown on Exhibit 10 in the Appendix.

Future river salinity like future streamflow can be predicted only from statistical records of past salinity and from knowledge of the changes in the river caused by impoundment and diminution of flow due to consumptive use. The most recent predictions on future salinity vary somewhat, but all indicate that progressive deterioration will occur. The Department of Interior study (7) and the Hill study (15) represent the most probable conditions. Hill predicts that the TDS

load by the year 1990 will increase to 735 mg/l at Lees Ferry and to 926 mg/l at Lake Havasu, compared to the Department of Interior figures of 663 mg/l and 865 mg/l at these same stations. These figures represent increases of 22 to 43% by 1990, and assume that current practices are not changed, a water augmentation program will not be implemented, future Upper Basin developments and trans-mountain diversions will be made, and that natural sources of salinity will not be controlled.

c. Quality of Water at Parker Dam: There is little TDS change in the quality of water between Hoover and Parker Dams. Increased population in this area, and increased recreational use could degrade the present quality, especially bacteriologically. Increased control of sanitary waste disposal from boats and recreational areas will be necessary.

d. Quality of Water at Imperial Dam: The TDS of the water reaching Imperial Dam shows a steady increase. A substantial part of this increase is due to agricultural drainage from the Colorado River Indian Reservation, the Palo Verde Valley, and probably some from the Cibola Valley. Reduced flow in the river due to consumptive use and diversions out of the basin has substantially reduced the assimilative and dilution capacity of the stream. A part of the increased TDS can be traced to evaporation from the water surface and phreatophyte growth along the river. The TDS record is shown on Exhibit 10 in the Appendix.

There is apparently little bacteriological deterioration in this section of the river, but new habitation along the river could become a source of pollution.

e. Quality of Water at Morelos Dam: The flow of the Colorado River has been reduced to a minimum at this point, and except for occasional storm flows, only enough flow is maintained to supply the Mexican Treaty requirements. The TDS fluctuates somewhat because of change of demand as compared with volumes of return flows. This problem is of International concern, and some relief has been afforded by the construction of the Wellton-Mohawk Drain Extension shown on Plate 2. The final solution of this problem is of total Basin concern, and the entire burden should not be placed on the local area or on one State of the Basin.

The City of Yuma is presently discharging untreated sewage to the river above Morelos Dam, and measures are being taken by the State Department of Health and the City of Yuma to eliminate this pollution at the earliest possible date.

3-0 BENEFICIAL WATER USES TO BE PROTECTED

3-1 General: All of the surface waters of Arizona are subject to either the appropriative rights doctrine or to water use contracts with the Secretary of the Interior. There are no Riparian water rights in Arizona. Some of Arizona's decreed entitlement to main stem waters of the Colorado River is not now diverted and is being used by other states until additional Arizona facilities are authorized and built. The following beneficial water uses are required of waters in the entire reach of the Colorado River in Arizona, and the tabulation is not intended to designate order of importance or rights to such use.

3-2 Agricultural:

(a) Waters diverted at Headgate Rock Dam are used on farmlands in the Colorado River Indian Reservation.
(b) Waters diverted at Imperial Dam are used on farmlands in the Yuma Valley, the Wellton-Mohawk Valley, the North and South Gila Valleys and on the Yuma Mesa.
(c) Waters pumped from the Colorado River are used on farmlands in the Cibola Valley.
(d) Waters of the Colorado River and its irrigation diversion systems are used for stockwatering.
(e) Isolated diversions for agricultural use are made along the entire Colorado River reach.
(f) Water to be diverted at Parker Dam through the proposed Central Arizona Project Aqueduct will be used on existing farmlands in Central Arizona.

3-3 Raw Domestic Water:

(a) Water diverted at Imperial Dam is utilized for domestic purposes by Yuma area communities and rural inhabitants as their only source.
(b) Water diverted at Glen Canyon Dam is utilized for domestic purposes by the City of Page.
(c) Various cities, communities and Indian Reservations along the entire reach of the Colorado River obtain their domestic water supply directly from the river or from wells, some of which may be influenced by Colorado River water.
(d) Water to be diverted at Parker Dam through the proposed Central Arizona Project Aqueduct will be used for domestic purposes in many cities and communities of Central Arizona.
(e) Isolated establishments along the river, ranging in size from major trailer courts to individual cabins, obtain water from wells adjacent to the Colorado River, and from the river itself.

3-4 Industrial:

(a) Water diverted at Imperial Dam is used by various industries in the Yuma area.
(b) Colorado River water is used for hydroelectric power generation.
(c) Colorado River water is used or will be used for steam-power generation.

(d) Water to be diverted at Parker Dam through the proposed Central Arizona Project Aqueduct will be used for various industrial purposes in Central Arizona.

3-5 Propagation of Aquatic and Wildlife Resources:

(a) The entire Colorado River contains aquatic and wildlife resources. Such resources include production of organisms, both plant and animal, that contribute to the food chain supporting a fish population, and populations of other animal life including water fowl and shore birds.

The reach between Imperial and Laguna Dams is used primarily as a silt depository for the desilting works at Imperial Dam and for operational control. Measures for the protection of aquatic and wildlife resources in this section will be practiced to the fullest extent possible consistent with the normal operation of the facility as a desilting works. Prior to the construction of the Imperial Dam and desilting works, most of the silt load of the Colorado River flowed through the canal system onto the irrigated fields, and silt control cost about one million dollars annually. Although the amount of silt decreased with the completion of Hoover Dam, channel degradation, bank erosion and storm runoff still contribute a heavy silt load at Imperial Dam (about 805,000 tons annually). The bulk of this silt is removed continuously in six classifier type basins on the California side and by a single basin with periodic sluicing of silt on the Arizona side of the river.

This operation results in a varying but heavy silt deposition in the area between the dams, and a rapidly varying water depth. The operation is absolutely essential in maintaining a low silt content water delivery into the canal systems of both Arizona and California.

(b) Water is used in the operation of the National Wildlife Service refuges, the Havasu Lake and Imperial Wildlife Refuges. This water use is covered by the Arizona vs. California Supreme Court Decree. Consideration is being given to deducation of a portion of the Lower Palo Verde-Cibola Valley region to waterfowl management purposes, to provide enough buffer lands to protect the waterfowl and to provide for future related recreational needs.

(c) Water is used at Mittry Lake, an Arizona State waterfowl area in the downstream area from Imperial Dam. A State Wildlife Area is being farmed for waterfowl habitat preservation and feed in the Cibola Valley.

3-6 Recreational:

(a) This includes fishing, boating, swimming, water skiing, hunting, and esthetic enjoyment. Applicable for the entire reach of the Colorado River in Arizona.

3-7 Future Uses of Surface Water: Future consumptive uses of surface water,

other than those specifically mentioned as allocated, are of necessity restricted until a major water augmentation program is realized. It is probable that some uses will have to be replaced by a higher priority use under due process of law with full recognition of legal water rights.

3-8 Classification of Waters According to Use: It is difficult to isolate certain sections of the Colorado River for a special purpose because of the extensive and varied use.

Water for domestic purposes is of prime importance throughout the Arizona Reach of the Colorado River. Although the application of conventional water treatment including flocculation, coagulation, filtration and disinfection to Colorado River water will generally not provide a water meeting the recommended drinking water standards of the U.S. Public Health Service, such treatment does provide a water meeting the mandatory requirements of the drinking water standards. Since a better alternate source of supply is usually not readily available, Colorado River water is used as a source of raw domestic water.

In view of the fact that much of the salinity of the Colorado River water is due to natural origin, and since it is difficult to control this source, it may be necessary in the future to seek alternate supplies of raw domestic water or provide desalinization facilities for the extreme southern portion of the Colorado River Basin. Raw domestic water requires a very minor fraction of the water reaching Imperial Dam, and expensive treatment of this small fraction of the flow might offer the most practical and economic solution to the salinity problem, even though entire basin subsidy might be required to protect the rights of domestic users in this area. Other beneficial users of water in the area are not affected by the salinity as are the domestic users.

Restrictions on use of portions of the Colorado River for any purpose should be made only after available alternates are proved impracticable.

3-9 Enhancement of Water Quality of the Colorado River Water: In view of the present quality of Colorado River water and the prospect of further degradation by upstream development, it is imperative that a major water augmentation program be instituted for the Colorado River System. Since this program would entail interstate cooperation and Federal sponsorship, the efforts of other appropriate State and Federal agencies are necessary to effectuate it.

4-0 WATER QUALITY OBJECTIVES

4-1 General Water Quality Objectives:

(a) To provide the highest quality water as practical for all beneficial uses.
(b) To protect the public health.
(c) To preclude pollution of the Colorado River and its tributaries.

4-2 Bacteriological:

(a) The Colorado River shall remain bacteriologically safe for all beneficial uses. Specifically, the arithmetic average of at least five consecutive samples in a 30 day period shall not exceed 5000 coliforms per 100 ml or 20 fecal streptococci per 100 ml.

4-3 Physical and Esthetic Objectives:

(a) The water shall be free from floating debris, oil, grease, scum, or other carried or floating materials from other than natural sources. Natural sources of these materials will be controlled to the most practical extent.
(b) The streams shall be free from bottom deposits or sludge attributable to domestic or industrial waste or other controllable sources.
(c) The water shall be free from tastes or odors attributable to domestic or industrial waste or other controllable sources.
(d) The water shall be free from materials attributable to domestic or industrial waste or other controllable sources that cause detectable off-flavor in the flesh of fish.
(e) The turbidity or color of the water will be maintained at the lowest practical value possible.
(f) Temperature changes in the water will be held to the lowest practical value commensurate with all beneficial uses of the stream.

4-4 Chemical Characteristics: The following chemical characteristics shall apply to Colorado River water:

(a) Constituents contributing to salinity and to increase in sodium percentage.

Degradation of water quality will result from increased intensity of beneficial usage of water within the Colorado River System. Minimization of this degradation without unreasonably restricting any beneficial use is mandatory. The setting of numerical standards on Total Dissolved Solids (TDS), chlorides, sulfates and sodium, which in effect would be allocating the dilution capacity of the stream, could be construed as re-allocating water rights and appropriations under existing compacts and treaties. Therefore, until this issue is resolved, no numerical values for these items will be established, but all identifiable sources of salinity increase in Colorado River water will be managed and controlled to the degree reasonably practicable with available technology. This subject is covered in the implementation section.

(b) Heavy metals and associated chemicals:

The general objective is the minimization of toxicants in the river. Wastes, from municipal, industrial, or other controllable sources, containing heavy metals or associated chemicals shall not be discharged into the Colorado River in amounts such that their cumulative effects may interfere with any beneficial use. In all cases, the concentration of these heavy metals and associated chemicals shall be the minimum concentrationswhich are physically and economically feasible to achieve, regardless of the dilution capacity of the stream at the point of discharge.

Specific limits for arsenic, barium, cadmium, chromium, cyanide, lead, selenium, silver, copper and zinc will be placed at various points on the Colorado River in keeping with the Colorado Basin Interstate Guidelines (Appendix 20) when the extent of the problem has been documented and interstate agreement on each state's equitable loading has been made. This task is expected to be complete in one to three years.

(c) Biocides:

Biocide concentrations in Colorado River water shall be kept below levels which are deleterious to human, animal, plant or aquatic life, or in amounts sufficient to interfere with any beneficial use of the water.

(d) Radioactivity:

Radioactive materials attributable to municipal, industrial or other controllable sources shall be minimum concentrations which are physically and economically feasible to achieve. The cumulative effects of these materials will be recognized in discharge requirements. In no case shall such materials exceed the limits established in the 1962 Public Health Service Drinking Water Standards or 1/10 of the 168-hr. values for other radioactive substances specified in National Bureau of Standards Handbook 69.

(e) Dissolved Oxygen:

The dissolved oxygen content in Colorado River water shall at all times be maintained above 6 mg/l*.

*In the reach between Imperial Dam and Laguna Dam achievement of the objective for dissolved oxygen shall remain subject to river control operations of the Bureau of Reclamation.

(f) pH

The pH of Colorado River water shall remain within the limits of 6.5 and 8.6 at all times.

(g) Other Chemical Characteristics:

The general objective is the minimization of miscellaneous chemicals that may interfere with any beneficial use of the water. These include but are not limited to methylene blue anionic surfactants, fluoride, boron, nitrate, phosphate, ammonia and phenols.

None of these substances now appear to be a major problem in Colorado River water, and specific limits will not be established for stream standards until interstate and possibly international agreement is achieved on apportioned loadings of these chemicals and the present condition is fully documented.

5-0 MEASURES TO ACHIEVE WATER QUALITY OBJECTIVES

5-1 General: Although the water quality indicators under consideration are numerous, they may effectively be grouped in the consideration of contributory sources and of achievement measures. In the selection of measures to achieve a particular quality objective, consideration must be given to the economic and social effects which may result therefrom. In the discussions below, the indicators are grouped into the categories contained under the Water Quality Objectives (Section 4-0).

5-2 Bacteriological: The objective is that Colorado River waters shall remain bacteriologically safe for all beneficial uses. This objective is oriented particularly towards protection of persons engaged in water-contact sports, since raw domestic water withdrawn from the Colorado River receives treatment before delivery to individual users. The contributory sources of pathogens are disposals of sanitary wastes from communities, from private establishments, and from boats.

Although the most effective measure against water carriage of pathogenic organisms is the complete elimination of sewage discharges to the river, the necessity for water conservation in the Southwest dictates that beneficial reuse of sewage effluents should be encouraged. In addition, the increased recreational use of the entire area could contribute human pathogens to offset the effect of the elimination of properly treated effluents. This objective will be met by establishment of effluent discharge requirements on sanitary wastes from private and community sewage systems, organic processing plants, and recreational facilities, including boats. Secondary treatment of sewage is mandatory before discharge to any river or dry wash, and tertiary treatment is required in certain cases. There are no known combined sanitary sewers and storm drains in Arizona, and such facilities will not be allowed. Specific problems, regulations, and time schedules for compliance are given in the Implementation Section.

Decaying vegetable matter can cause some esthetic problems, and every effort should be made to reduce the amount of nutrients causing excess vegetation in the river.

There are no known slaughter houses on the Colorado River that dispose of meat trimmings, etc. that could increase the BOD loadings on the river.

Livestock feeding operations are conducted at several locations along the Colorado River. In order to prevent pollution of Colorado River water by livestock, the following measures will be enforced:

a. Livestock, other than those which are grazing or pasturing, shall not enter or inhabit waters in the Colorado River drainage system.
b. Livestock which are corralled in the proximate area of the Colorado River and its tributaries shall be effectively excluded from entry into the waters.
c. Adequate permanent type measures shall be taken to assure that sewage from livestock other than from grazing or pasturing, shall not enter the Colorado and its tributaries without approved treatment.

5-3 Physical:

a. Temperature: Industrial wastes, cooling water for power plants and river control operations might reasonably be expected to cause temperature rise in Colorado River waters. River control is a necessary item to which temperature control must be subordinated. Since the number of industrial and power plants along the river are few, these should be considered on an individual basis for necessary control by discharge requirements.

b. Floating Debris, Oil, Grease, Scum, etc: These indicators are essentially absent in the Arizona reach of the Colorado River due to the scarcity of waste disposals to the river. Future problems will be prevented by discharge requirements.

c. Silt Load: The silt load of the Colorado River has always been a problem, but river control has been constantly reducing this parameter. Total control of silt will never be achieved due to esthetic desires with regard to the "wild river" concept and to general watershed conditions. Silt loadings due to man-made facilities will be subject to abatement.

5-4 Chemical Characteristics: Discharges from Upper Basin developments may in the future cause contributions of these chemicals in Colorado River waters entering the Arizona reach. In addition, further development in adjacent states could cause the same problem. Should such occur or threaten, corrective measures would be initially sought through cooperative efforts with the Basin States. Any tabulations or omissions of limiting concentrations contained in Section 4 are not to be construed as the Council's agreement to accept loading of these chemicals into the Colorado River from sources either inside or outside of Arizona.

(a) Salinity and Sodium Percentage: Measures to achieve the desired objective of minimizing degradation of Colorado River water through salinity increase are as follows:

1. Natural sources of salinity in the Arizona Reach of the Colorado River: Some of the natural sources of salinity have been enumerated in Sections 2-2, 2-3 and 2-4. The Bureau of Reclamation is currently studying the Blue Springs source in the Little Colorado River to determine the best possible means of control. A report and recommendations should be available within one year.

   Interstate cooperation will be necessary to evaluate and reduce the salinity of waters reaching the Colorado River from adjacent states as covered previously. The soils of the Colorado River Basin closely resemble the geological formations of their origin, namely igneous, sedimentary and metamorphic. The silts removed by constant erosion of the upper areas have been deposited in the Lower Basin to form the great delta of the Colorado River. These silts contain large quantities of salts such as sodium, calcium and magnesium combined with chlorides, carbonate, bicarbonate and sulfates. Thus the soils of the Colorado River Basin are the basic source of the salinity in the water. Only limited areas have been leached sufficiently to remove these soluble salts, and most lands of the Basin must be leached before they will become productive.

Efforts to control the natural sources of salinity between Lees Ferry and Lake Mead may meet with opposition from certain conservation groups who have been attacking further development of the Colorado River in this area. Every effort must be made to reconcile the many differences of opinion on river development.

Gypsum reefs are quite common in the Lake Mead area, and there is no feasible method of isolating these areas. Fortunately, they do not appear to contribute a large amount of total salt as evidenced by U.S.B.R. reports on Lake Mead and the Colorado River (7). The answer could be found in deposition of silts and/or precipitation of calcium carbonate as a crust over the gypsum beds.

2. Agricultural sources of salinity: An operational salt balance must be established in all agricultural operations. In general, all of the salt entering an agricultural project must be removed from the area if a sustained operation is to be possible. Failure to resolve this problem has apparently destroyed great civilizations in the past, including the Hohokam Indian civilization in the Salt River Valley of Arizona a few hundred years ago. Essentially, about two-thirds of the water applied to crops is removed by transpiration from the plants, use by the plants, and by evaporation from the soil itself, concentrating all the salts originally present in the remaining one-third of the water. This water must be drained away to prevent salt damage to future crops. Thus, agricultural drainage water will have about three times the concentration of dissolved salts or TDS present in the applied water. The higher the TDS content of available water, the greater the concentration effect will be. The high TDS initially present in Colorado River water makes the drainage water in the Lower Basin quite saline.

   The TDS concentration of drainage water resulting from the leaching of new lands can be higher than the concentration resulting from a salt balance operation. The effect, however, diminishes rapidly.

   The programs outlined in Section 2-8 (canal lining, pipe installation, land levelling, phreatophyte removal, watershed improvement etc.) are the currently acceptable methods of water conservation which contribute to water quality enhancement. These programs should be continued, and new, practical processes for reducing the salinity of irrigation return flows should be applied as they are developed.

   Specific projects where improvement is necessary and applicable are presented in the Implementation Section.

3. Industrial sources of salinity: There are a few minor sources of salinity in industrial operations along the Arizona reach

of the Colorado River. Most of these can be held to a minimum by proper discharge requirements. Current problems are discussed in the Implementation Section.

4. Municipal sources of salinity: Salts are added to water used for domestic purposes. Domestic sewage generally has a TDS increase of about 300 mg/l over the supply water. This increase can be attributed to a number of factors such as but not limited to human waste, water softener operation, washing clothes and dishes, garbage disposals, etc. The most significant increase is in sodium chloride.

   Return flows from lawn and garden watering follows the pattern set forth for agricultural drainage previously discussed.

   Light industrial and commercial operations in cities usually contribute salts to the municipal sewage or to the groundwater eventually returning to the river. Although the individual contribution may be small, the collective total can become appreciable, and all sources should be evaluated for effective control.

5. The total salinity problem: The salts added by the natural and beneficial use sources listed above combine with diminishing flows due to consumptive use and diversions out of the Colorado River Basin to create a serious salinity problem for all of the users of Colorado River water downstream of Lake Mead. The Bureau of Reclamation and Geological Survey are cooperating in an electric analog study of the diversions, use and returns for the area downstream of Imperial Dam, but this study is far too limited in scope and tends to convey the idea that the salinity problem is the responsibility of this one area alone, whereas it is a total Basin problem. This concept of a localized problem as set forth in Minute 218 (Exhibit 21) is totally unacceptable to Arizona, and the temporary alleviation procedure effective until November 16, 1970, must be replaced by a more acceptable procedure which recognizes total Basin responsibility. The Council will cooperate with the above agencies in working out a satisfactory policy on salinity control.

   A report on the study and suggestions on the problem solution by the Bureau of Reclamation and the Geological Survey is due on May 16, 1970.

(b) Heavy Metals and Associated Chemicals: The concentrations of these chemicals in Colorado River water are historically very low. Wastes containing these elements are widely scattered and can be controlled by discharge requirements on the individual waste stream. Each discharge requirement will be based on appropriate factors such as, but not limited to the dilution capacity of the stream and beneficial uses of the stream.

The setting of stream standards for any reach of the river at USPHS drinking water limits could be interpreted by a discharger as meaning that he could discharge these chemicals into the stream up to the limit. In effect, then, standards could be unjustly used to descriminate against downstream users because there is no dilution capacity left. This problem of apportionment of dilution capacity of the stream must be solved on an entire basin level before specific limits can be placed on the main stem of the Colorado. This task is expected to take one to three years.

Until specific limits are set, the policy of the Council through the State Department of Health is to minimize any discharge of these chemicals to the river. Generally, industry is the source of disposals containing these chemicals; and also generally, these wastes are contained in relatively small volumes of water which could be economically disposable elsewhere.

Known or potential sources of these chemicals on the Colorado River are listed in the Implementation Section with methods of control.

(c) Biocides: Biocides have been the subject of much discussion in the past, and probably will be discussed for many years. Prudent use of biocides has enabled our agricultural industry to provide ample food and fiber products for our high standard of living. Esthetically, we can have better gardens and a more healthful existence because of biocides. Uncontrolled use of biocides is not beneficial, and should not be allowed. Generally speaking, biocides are expensive, and over-applications are seldom made. Discharges of wastes containing biocides from manufacturing and tank cleaning operations must not be allowed.

More research and study of the cumulative effects of biocides on humans and wildlife must be made, and appropriate safeguards applied as standards for the Colorado River.

Types and effects of biocides are too numerous and varied for tabulation. Further, the intricacies and variations of technical analysis for biocides presently defies the prescription of anyone or a few tests for their detection or determination (4). Bio-assay tests can be used to establish allowable limits for biocides.

Unreasonable application of biocides in agricultural operations which could result in biocide levels in Colorado River water which are deleterious to human, animal, plant or aquatic life shall be subject to abatement. Mere detection of a biocide in the water is not cause for abatement.

(d) Radioactivity: Radioactivity in Colorado River water is contained within satisfactory limits. There are no wastes containing radioactivity being discharged into the Arizona reach. Future problems will be controlled by discharge requirements.

(e) Dissolved Oxygen: The dissolved oxygen content in Colorado River water is satisfactorily above the objective minimum of 6 mg/l. The maintenance of a satisfactory level of dissolved oxygen is obtained as a corollary of the institution of the above listed measures to achieve water quality objectives.

(f) Other Chemical Characteristics: The objectives listed in Section 4-4g will normally be achieved by the measures listed above or by discharge requirements. Boron reduction will be considered along with reduction of salinity in agricultural return flows.

Phenols and organic chemical concentrations are not now a problem, and there are no known discharges. Any proposed discharges will be subject to regulations commensurate with timely technology.

5-5 Problems Associated with Methods of Reducing Pollutants: The major problem associated with control of pollutants in the Colorado River is that the method chosen may reduce the quantity of water available to downstream users, or may adversely affect the user downstream by a chemical or physical change in the water. Factors such as the following should be considered in setting stream standards.

a. Hardness in domestic water is undesirable, and can be removed by several processes. Ion exchange or precipitation methods can alter the cation balance of the water to the extent that the change can adversely change penetration rates of water in agricultural operations.

b. Disposal of sewage effluents outside of the river area can reduce the total flow of the river and reduce the assimilative capacity of the river downstream, denying the downstream user of his legal entitlement to use of the water.

c. When waters containing considerable dissolved salts are being considered for discharge to the river, total resource effects should be determined, and the decision should not be made on the basis of the concentration of the discharge alone. This concept is vital in the conservation of total water supply in the stream. Unwarranted depletions could deprive downstream users of valuable rights to water use.

d. In view of the fact that water disposed of on land in a basin could return to the river underground in worse condition than when "disposed of", careful consideration of requirements for disposal on land must be made. In effect, such disposal could be similar to reclamation of new land for agricultural purposes as far as salinity build up is concerned.

5-6 Additional Measures to Enhance Water Quality:

a. Water augmentation: The need of a major water augmentation program for the Colorado River System is immediate. Institution of this important program requires cooperative actions and representations between local, state, interstate and federal agencies. The Council

and the State Department of Health will do all that it can to expedite the institution of such water augmentation program, to improve water quality in the Colorado River.

b. Investigations: In view of the changing topography and increasing intensity of multiple use of Colorado River waters, it is necessary that periodic investigations be conducted in the river or on the watershed to remain apprised of the most recent conditions which may degrade water quality, and which may effect any particular beneficial use of the river waters. The scope of such investigations will vary from cursory field inspections to technical studies of water quality conditions. Where possible, the investigations will be conducted under the direction of the Council by the State Department of Health staff either alone or in cooperation with other agencies. However, where specialty is required, the State Department of Health will either request or contract the necssary services.

Special emphasis will be placed on finding practical means of reducing the salinity of agricultural drainage water, since this beneficial use requires that large quantities of water be returned to the river in order to maintain a salt balance.

c. Coordination with Other Agencies: The Council and the State Department of Health, in the pursuance of their water quality control activities will at all times remain in advisement and consultation with the several interested agencies, and will work cooperatively with these agencies to produce the most effective water quality control program along Arizona's reach of the Colorado River.

6-0 IMPLEMENTATION OF OBJECTIVES

6-1 General: Preservation and enhancement of water quality in Arizona's reach of the Colorado River is a primary function of the State Water Quality Control Council. The Council's implementation plan is a comprehensive program of surveillance, control of discharges to the Colorado River, enforcement, and special activities relating to investigations, research, coordination with other agencies concerned with water quality control, and support of a water augmentation program for the Colorado River. These activities will be elaborated on in the remainder of this section.

None of the provisions of this Water Quality Control Policy, including specific criteria, measures or methods of implementation shall be construed as an exemption or a modification of the Rules and Regulations of the State Department of Health governing waste treatment and/or discharge requirements. The policy of the Department will require the maximum practicable degree of treatment for all waste sources under the jurisdiction of the Department and treatment methods shall comply with the applicable rules and regulations.

6-2 Surveillance: Surveillance is the continued observance of waters of the state, including measurement of water quality indicators and evaluation of water quality factors. It also includes the continuous review of monitoring data supplied by waste dischargers for compliance with requirements prescribed by the Council and the State Department of Health.

The surveillance program is designed to produce sufficient water quality data at key stations for continued, effective appraisement of water quality conditions in the Colorado River. Advantage is taken of existing monitoring programs of other agencies, with supplement as necessary. The Council will encourage the other agencies to incorporate the supplement into their programs.

Sampling and analyses in the surveillance program shall be conducted in accordance with the procedures contained in the latest edition of "Standard Methods for the Examination of Water and Wastewater", or by other acceptable procedures.

At the present time the Geological Survey (USGS) maintains water quality and stream flow gaging stations at various points on both the main stem of the Colorado River and major tributaries. The Federal Water Pollution Control Administration has also established several water quality surveillance stations at key locations under the Water Pollution Surveillance System (WPSS). The Colorado River Basin Project (CRBP) maintains a radium monitoring system, and plans additional sampling at exisiting quality stations. The WPSS and CRBP parameter coverage is more comprehensive than the USGS. Consolidation of these programs should be encouraged.

The existing or proposed surveillance network on the main stem and tributaries in the Arizona reach consists of the following:

Station	USGS	WPSS	CRBP
Page		X	
Lees Ferry	X		
Paria River	0		
Little Colorado River	0		P
Grand Canyon	X		
Virgin River	X		P
Las Vegas Wash	X		P
Hoover Dam	X	X	X
Davis Dam		X	
Parker Dam	X	X	P*
Imperial Dam	X*		
Northerly Int. Bound.		X*	P

X = Chemical Quality Station, 0 = Silt, temp and/or gaging station P = proposed

*Station is near this control point.

The proposed monitoring schedule for the Arizona Reach of the Colorado River is shown for the various indicators at the basic stations in Table I. This schedule is designed to take advantage of the data being compiled by the USGS, WPSS and other agencies, and new stations may or may not be necessary.

The State Department of Health will initiate a program of sampling for bacteriological quality and other special conditions not covered by existing monitoring programs. It is anticipated that the Department's monitoring schedule will not be rigid but rather will be aimed at identifying special conditions that may vary with the season of the year and therefore require intensive monitoring rather than weekly or monthly schedules. Other state agencies, including the Game and Fish Department, will assist in the sampling aspects of this monitoring program.

Other Monitoring:

a. Local Agencies - Data submitted by local agencies, in addition to that included in Table I, will be reviewed and acted upon as may be appropriate.

b. Disposals to the Colorado River - Monitoring data received on individual disposals to the Colorado River will be reviewed and recorded.

c. Land Use Investigations - Periodic land use investigations will be conducted along the entire Arizona Reach of the Colorado River to determine any features of Arizona operations which may adversely affect water quality.

d. Records - Records of surveillance are to be maintained in the office of the State Health Department, in a document titled "Surveillance Record - Colorado River".

6-3 Waste Discharge Requirements: The State Board of Health of Arizona has the authority to prescribe waste discharge requirements under ARS Section 36-1855.

TABLE I

SURVEILLANCE SCHEDULE AT BASIC STATIONS

Schedule will be worked
out for final document.

TABLE I (cont.)

SURVEILLANCE SCHEDULE AT BASIC STATIONS

Schedule will be worked
out for final document.

The discharge requirements will be set in keeping with the stream standards set by the Council.

The State Department of Health will propose additional rules and regulations for adoption by the State Board of Health. Such regulations have not been written at this time due to a shortage of staff. Such regulations should be adopted within twelve months after these standards become effective. The regulations may include, but not be limited to the following considerations:

1. Effluent standards as required to meet the stream standards and protect the public health.
2. Minimum sanitation facilities for recreational areas such as marinas, parks, and picnic areas.
3. Land use practices such as logging, highway construction, livestock operations, solid waste disposal, etc.
4. Degradation due to consumptive and non-consumptive usage of water for cooling, ore leaching, conveyance, etc.

The State Department of Health issues a permit for each discharge of waste to the Colorado River. Disposal requirements in each permit are directed mainly towards control of pollution and nuisance, and maintenance of the water quality objectives. However, where appropriate, consideration will be given to possible enhancement of water quality. Where considered necessary, the permit shall specify a monitoring schedule, requiring that the discharger periodically obtain and report various technical data concerning the disposals. A discharger may not modify an exisiting disposal system or increase the volume or strength of any wastes under an existing permit.

A record, titled "Waste Disposals-Colorado River", containing permit data for waste disposals that may affect the Colorado River is to be maintained in the office of the State Department of Health.

6-4 General Enforcement: Enforcement activities are directed mainly towards obtaining compliance with prescribed waste discharge requirements. Generally, enforcement is initiated on staff level. Here attempt is made to obtain correction by informal discussion of the problem. Where such informal procedures fail to produce adequate correction, the alleged violation will be considered by the State Department of Health to determine whether the discharge is taking place contrary to the prescribed requirements.

Upon finding affirmatively, the State Department of Health will cause a written complaint to be served upon the alleged violator, specifying the regulation violated, and shall order that corrective action be taken within a specified reasonable time, affording opportunity for a fair hearing as prescribed by law. Upon failure of the discharger to comply with the cease and desist order, the State Department of Health will certify the facts to the Attorney General, whose duty is to bring an action for an injunction against the alleged violator. Thereafter, the State Department of Health will provide evidence as requested by the Attorney General or the court.

6-5 Special Enforcement Actions: The following are specific areas that need explanation regarding enforcement action in the immediate and foreseeable future:

a. The City of Yuma is located near the Northerly International Boundary with Mexico. It has a population of approximately 30,000. Yuma does not have a waste treatment facility at the present time. The City has acquired title to the land on which a facility is to be built. A consulting firm has been retained to prepare a feasibility report, prepare construction drawings and inspect construction. The engineering report is to be submitted by August 1967. It is anticipated that a contract for construction of an adequate facility will be awarded before July 1, 1968.

b. The City of Parker is located approximately fifteen miles downstream from Parker Dam. Parker has a population of approximately 1600 people and is unsewered. The domestic wastes are currently disposed of by individual septic tanks and there is little or no contribution of wastes to the Colorado River. This community has retained a consulting engineer to prepare plans and specifications for a waste collection and treatment system. It is anticipated that this community will be contributing treated effluent to the Colorado River within two years.

c. The area adjacent to the Colorado River between Lake Havasu City and Davis Dam is currently undergoing extensive land development. Literally thousands of lots have been subdivided and sold, or leased, to the public in this area. The vast majority of these subdivisions are to be served by individual septic tank systems. There is a limited amount of building in the area at the present time since many buyers of these lots are speculating on an increase in value or expect to build a retirement home many years in the future. The number of summer and/or retirement homes is expected to increase at rather slow but steady rate in the next few years. The potentially large number of septic tank installations in this area are expected to present a pollution and public health problem in the future. A specific time schedule for enforcement in this area cannot be adopted at this time since the problem is a potential one rather than a real problem. Construction of community sewerage facilities will be dependent on population densities that will make such facilities economically feasible. There are currently two methods by which such areas may obtain community sewerage systems when the need arises. The owners in a given area may form an improvement district to finance the construction of needed facilities and turn over the facility to an existing authority such as a city or utility company upon its completion or they may form a sanitary district which provides for construction and continuation of operation.

d. There are several marinas and/or parks located on Lake Mead and the Colorado River. Sanitation facilities in these areas have received very little attention in the past. There have been reports that some of these areas are contributing wastes to the Colorado River system

due to lack of adequate facilities. This Department intends to make a comprehensive survey of these areas prior to July 1, 1968. The Department will then apply the provisions of the applicable regulations to eliminate the problem prior to 1969.

e. There are many areas in Arizona that have sources of pollution but do not fall under the direct jurisdiction of the Department. These include areas under the control of the Department of Defense, the Bureau of Reclamation, the Bureau of Land Management, the Forest Service, the National Park Service, the Bureau of Indian Affairs, U.S. Public Health Service, and the International Boundary and Water Commission. Some of these areas have not always provided adequate facilities in the past and a few such areas are still a problem. A particular areas of concern is the stretch of the Colorado River between Parker and Yuma. There are numerous "squatters" on government land that use the Colorado River as an illicit source of water and as a receiving body for their untreated or inadequately treated wastes. Arizona is confident that sources of pollution from areas under the control of the federal government will be rigidly controlled to ensure compliance with the requirements of the Department of Health.

6-6 Inventory of Pollutional Sources on the Colorado River in Arizona: Potential Pollution sources are listed and evaluated in Table II.

TABLE II

ARIZONA WASTE SOURCES IN THE COLORADO RIVER BASIN

The following is a general outline on pollutional sources by sub-basins in the State of Arizona as of April 10, 1967. (All locations noted are straightline distances and river mile data is for the respective rivers.)

A. San Juan Sub-basin

1. The City of Rock Point (BIA Board School) located in Apache County, has a base population of 350 during the school season. Wastes produced are treated in a stabilization lagoon and released to Chinle Creek at the rate of 30,000 gallons per day at a point approximately 20 miles south of the Utah-Arizona border. The facility is owned and operated by the Bureau of Indian Affairs. Deficiences at these facilities have not been reported to date. Information available does indicate that this facility is adequate.

2. The City of Lukachukai (BIA Boarding School) has a population of approximately 900 during the school year. Wastes produced at this school are treated in a stabilization lagoon. A daily flow of approximately 75,000 gallons per day is discharged to the Lukachukai Wash at a point approximately 45 miles south of the Arizona-Utah border. The facility is owned and operated by the Bureau of Indian Affairs. Deficiences at these facilities have not been reported to date. Information available does indicate that this facility is adequate.

3. The City of Many Farms (BIA Boarding School) has a population of approximately 1600 during the school year and produces approximately 130,000 gallons per day waste. The wastes are treated in a sewage stabilization lagoon and discharged to the Chinle Wash at a point approximately 48 miles south of Arizona-Utah border and 35 miles west of the Arizona-New Mexico border. The facility is owned and operated by the Bureau of Indian Affairs. Deficiences at these facilities have not been reported to date. Information available does indicate that this facility is adequate.

4. The City of Chinle. The population of this community is at this time unknown, however, records indicate that wastes are produced at the rate of 300,000 gallons per day. These wastes are treated by a stabilization lagoon and discharged into the Chinle Wash at a point approximately 55 miles south of the Arizona-Utah border and 30 miles west of the Arizona-New Mexico border. This facility is known to be adequate at this time.

5. The City of Dinnehotso has a population of approximately 200 with a daily waste volume of 20,000 gallons. These wastes are treated by a septic tank-oxidation lagoon system and discharged to Laguna Creek at a point approximately 10 miles south of the Arizona-Utah border and 50 miles west of the Arizona-New Mexico border. This facility is known to be adequate at this time.

The above communities contribute approximately 555,000 gallons per day of sewage effluent to the San Juan Sub-basin. It should be noted that during the warmer parts of the year very little of this effluent reaches the San Juan River. In summer months the receiving washes are essentially dry with the effluent being lost to subsurface flow and evaporation.

B. Little Colorado River Sub-basin

1. The City of Houck, situated in Apache County has a population of 200 and produces waste at the rate of 7,000 gallons per day. The wastes are treated in an extended aeration sewage treatment facility that is adequate at this time and discharged to a dry wash which flows into the Rio Puerto River (river mile 75) and then into the Little Colorado River at river mile 203.40.

2. The Cities of Springerville and Eager have a combined sewage disposal facility for a population of approximately 2,200 people. A stabilization lagoon system treats approximately 112,000 gallons per day. The effluent is partly used for irrigation and the remainder discharged to Nutrioso Wash which is tributary to the Little Colorado River at river mile 319.20. This facility may be inadequate due to increasing population during summer months.

3. The City of St. Johns, situated in Apache County has a population of 1350 people and treats its waste by a stabilization lagoon system whereby it is discharged to irrigation, of which any excess is put into the Little Colorado River at river mile location 282.20. There are no projected needs for this community.

4. The City of Holbrook is situated in Navajo County and has a population of 4,500 and treats its waste by stabilization lagoon system. The effluent is discharged to the Little Colorado River at river mile 201.30. The sewage disposal facility is inadequate at this time and plans are presently being formulated for modification of the lagoon system.

5. Joseph City. This community has a population of 500 and is located in Navajo County. Wastes are produced at the rate of 5,000 gallons per day and are treated by a stabilization lagoon. The effluent is discharged into the Little Colorado River at river mile location 186.30. This is a new facility and appears adequate at this time.

6. The City of Winslow has a population of 9,000 and is located in Navajo County. This community provides primary and secondary treatment of its sewage by the use of clarifiers, oxidation ponds, and sludge disposal by anaerobic digesters. The average flow of approximately 525,000 gallons per day is discharged to the Little Colorado River at river mile location 157.16. The community recently had a plant failure and of this writing is not using the full capacity of the clarifiers and digesters, thus imposing a larger load on the oxidation ponds.

7. The City of Moenkopi located in Coconino County has a population of around 500. Wastes are treated by stabilization lagoon system and are discharged at the rate of 50,000 gallons per day to the Moenkopi Wash at river mile 52.50 which is tributary to the Colorado River. These facilities are adequate at this time.

8. The City of Desert Butte located in Coconino County has a population of about 700. Wastes are treated in a stabilization lagoon system at the rate of 71,000 gallons per day and are discharged to a wash that carries the effluent to the Little Colorado River at a point 2 miles above the confluences of the Little Colorado River and the Colorado River at river mile 651.50. The sewage disposal facility is adequate at this time.

9. (a) The City of Flagstaff is located in Coconino County and has a population of approximately 30,000. The sewage disposal facilities are at this writing being modified to handle future demands. Presently the facility consists of clarifiers and a trickling filter which treats close to 2.8 mgd. The plant is seriously overloaded and every attempt is being made to hasten the completion of the present modifications. The effluent is discharged to the Rio de Flag Wash. This wash enters the San Francisco Wash which is tributary to the Little Colorado River at river mile 114.60, approximately 40 miles east of Flagstaff. Effluent from this facility will rarely, if ever, reach the Little Colorado River.

   (b) Ponderosa Paper Products Company located within the Flagstaff city limits discharges paper pulp wastes to Rio de Flag Wash and adds to the pollutional load already carried by this wash.

10. Southwest Forest Mills operates a paper products plant approximately 14 miles east of the community of Snowflake. Paper pulp wastes are discharged to a drainage ditch which carries it approximately 6 miles north to a shallow impoundment lake located on private property. There is no discharge from this facility. Possible effects on the ground water of this area are unknown at present.

C. Lower Colorado River Main Stem Basin

1. (a) Grand Canyon (North Rim) located in Coconino County has a population of approximately 800. Wastes are treated in a community septic tank system and then chlorinated whereby approximately 40,000 gallons per day are discharged to a dry wash which eventually reaches the Colorado River via Bright Angel Creek at river mile location 623.00. No recent inspections have been made of this facility, however, it is felt to be adequate.

   (b) Grand Canyon (South Rim). The National Park Service presently maintains a facility that treats approximately 40,000 gallons per day with the effluent used for flushing toilets, sprinkling lawns and irrigation.

(c) Grand Canyon Moqui Lodge (South Rim) is open only part of the year and operates two stabilization lagoons with design capacity of 85,000 gallons per day. Effluent is discharged to a wash draining away from the canyon.

2. Hoover Dam situated on the Colorado River has an equivalent population of approximately 2,300 people (tourist traffic, site seeing tours of dam facility). A daily waste load of approximately 70,000 gallons per day is treated by an activated sludge facility with digested sludge hauled away by tank truck. The effluent is then discharged into the Colorado River below the dam at river mile 356.00. The plant has been in operation since 1958 and is, reportedly, providing adequate treatment.

3. Davis Dam, located in Mohave County, treats sewage produced by the employees and tourist visits to the dam by a septic tank system. The effluent of this facility is inserted directly into the Colorado River below the dam at river mile 287.20. The effluent is unsuitable for discharge into the Colorado and the means of treatment inadequate. Plans are under study for abatement of this problem.

4. Davis Dam Community is located adjacent to the dam and provides residences for employees at the dam. Wastes are treated by a septic tank-lagoon disposal facility. It is estimated that approximately 10,000 gallons per day pass thru this facility into a wash which discharges into the Colorado River just below the dam at river mile 285.20 in the colder months of the year. This facility is inadequate.

5. Bullhead City is located in Mohave County on the Colorado River at river mile 283.50, just south of Davis Dam. The following are waste sources in this community:

   (a) Claude Bill's Broasted Chicken Restaurant wastes are treated in an extended aeration package plant at the rate of 2,500 gallons per day and discharged into the Colorado River.

   (b) Holiday Shores Subdivision is served by an extended aeration package plant that has a design capacity of 40,000 gallons per day. This facility is less than a year old and is currently receiving only a fraction of the design flow. The chlorinated effluent is discharged to the Colorado River.

   (c) River Queen Trailer Park produces 50,000 gallons of waste per day which are treated by extended aeration and chlorination and then discharged into the Colorado River.

   (d) River Bend Subdivision located in Mohave County approximately 6 miles south of Bullhead City. Waste produced in this subdivision is treated in an extended aeration plant of 40,000 gallons per day capacity and then discharged, after chlorination, to the Colorado River at river mile 280.70. This unit was recently installed and has sufficient capacity to provide adequate service for a number of years.

6. Lake Havasu City is located in Mohave County on the Colorado River at river mile 219.00. This community of approximately 1,200 people treats wastes by an extended aeration facility with the effluent being used entirely for irrigation.

7. The community of Kingman has a population of 6,000 and is currently served by two separate stabilization lagoon systems. The effluent of pond serving the west side of the city enters a dry wash that is tributary to Sacramento Wash 15 miles southwest of the city limits. The lagoon serving the eastern portion of the community has no effluent at this time as it is lost to percolation and evaporation. These facilities are inadequate and the city has retained a consulting engineer to prepare a report as a preliminary step in obtaining an adequate facility.

8. Duval's copper-molydenum mine and mill is located in the Cerbat Mountains 14 miles due north of Kingman. The mining operation at present is processing 5 million tons of ore annually with no measurable wastes leaving the mining region.

9. Catfish Paradise Trailer Park is located approximately 2 miles north of Topock, Arizona, in Mohave County. Approximately 15,000 gallons per day of wastes are treated in an extended aeration sewage disposal system. The effluent is discharged to the Colorado River after chlorination. The facility was functioning properly during the last inspection.

10. The City of Williams is located in Coconino County and has a population of approximately 5,000. The wastes are treated in a stabilization lagoon system. The effluent, estimated to be 40,000 gallons per day, is discharged to Cataract Creek which enters Cataract Lake some two miles downstream. The community is remote in the watershed in relation to the Colorado River. It is also doubtful that the effluent ever reaches the Colorado River. This facility is inadequate and the community has been urged to improve their waste disposal facility.

11. The community of Bagdad, located in Yavapai County, has a population of 1,500 with a substantial portion of the community being sewered. Domestic wastes are presently treated by an outmoded Imhoff Tank and trickling filter system. The effluent from the present facility enters Bridle Creek which is tributary to the Santa Maria River at river mile 25.80. This facility is inadequate and a consulting engineer has been retained to prepare a report as a preliminary step in obtaining an adequate facility.

12. The Bagdad Copper Corporation is located adjacent to the community of Bagdad. Acid leaching wastes from this operation have presented a pollution problem in the past. Construction of curtain wall dams in washes leading from the mining regions and elimination of the ponds receiving ferrous wastes has led to the abatement of the major portion of this problem.

13. Buckskin Mountain State Park located on the Colorado River at river mile 197.50 has recently installed a 15,000 gpd package aeration plant. The effluent is chlorinated and used for irrigation with any excess discharged to the river.

14. Arizona Ranch and Metals Corportaion is a new copper mining operation located near the Bill Williams River approximately five river miles from the confluence with the Colorado River. The new operation has presented a pollution problem from leaching wastes leaking through holding pond dykes into Mineral Wash. This drainage travels by subsurface flow and has been detected in the Bill Williams River. Proper sealing of these holding lagoons may solve the problem.

15. (a) The City of Yuma is located in Yuma County and has a population of 30,000. There is presently no form of sewage treatment for this community and the wastes are collected and discharged to the Colorado River at the rate of 2.24 million gallons per day at river mile 27.00. Preliminary plans are being formulated for the construction of a sewage treatment plant in the near future. (See Section 6-5a)

    (b) A cantaloupe produce company is located in the Yuma area adjacent to the Colorado River. This plant operates seasonally and discharges ground cantaloupe wastes into the Colorado River.

16. The community of Somerton, with a population of approximately 2,000, is located in the lower southwest corner of Yuma County. The city is partially sewered and treats collected wastes in a septic tank-oxidation lagoon system. The effluent is discharged to an irrigation canal.

7-0 RATIONALE FOR WATER QUALITY OBJECTIVES

7-1 General: Each beneficial water use requires certain indicators of water quality as desirable or essential. Pertinent indicators are investigated for adequate protection of each beneficial use. Water quality objectives are formulated in consideration of these indicators, and effects upon the economy of the area which may result from various levels of control. Where more than one level of an indicator is under consideration in the protection of various beneficial uses, preferential selection is given to that level which represents the superior water quality.

7-2 Agriculture: The most important water quality indicators for protection of irrigated agriculture are salinity, sodium relationships, boron and bicarbonate effects. These indicators are as follows:

a. Salinity: Excessive salinity in the root zone causes adverse effects upon plant life, ranging from leaf-burn to death of the plant. Salinity characteristics of water for agricultural applications are most effectively indicated by measuring the

(1) Total Dissolved Solids (TDS), in mg/l.
(2) Electrical Conductivity ($EC \times 10^6$), micromhos.

The records indicate some increase of salinity in Colorado River water released towards Arizona, as well as continuing increase in total quantities of salts returned to the main stem from farm drainage on both sides of the river along the Arizona reach.

The use of Colorado River water for irrigation requires special management for salinity control. Adequate drainage must be provided, and crop selection must be limited to those crops which will tolerate the existing salt content at the point of use.

TDS limits for stockwatering are far more liberal than are those for irrigation. Therefore, salinity control is oriented towards irrigation requirements.

b. Sodium Relationships: The predominance of sodium salts in soil is detrimental to maintenance of proper tilth and structure for agricultural purposes. High concentrations of sodium in agricultural supply waters (relative to calcium and magnesium) will cause cationic exchange whereby sodium will replace calcium and magnesium in the soil. The water quality indicator which expresses the level of sodium, relative to calcium and magnesium, is called "percent sodium", and is expressed mathematically as

$$\frac{Na \times 100}{Na+Ca+Mg+K}$$

where the basic constituents are expressed as milliequivalents per liter.

Percent sodium in Colorado River water ranges from approximately 28 at Lees Ferry to approximately 51 at Imperial Dam. The recommended safe

limit of this characteristic for continuous applications is 50. In view of the low soil permeability of many Lower Basin areas being irrigated with this water, every effort should be made to control sodium content in Colorado River waters, such that the present level of this indicator will not be increased at Imperial Dam.

c. Boron: The symptoms of boron injury, particularly in trees which are less tolerant to this constituent, are leaf yellowing and burning, premature leaf drop, and reduced yield. Citrus trees are among the crops most sensitive to boron. The critical concentration is accepted as 0.4 to 0.5 mg/l in irrigation waters. Citrus is one of the main crops in both the Yuma area of Arizona and the Coachella Valley of California. Both of these areas draw water from Imperial Dam. During 1964, the average boron content of Colorado River water at Imperial Dam was 0.2 mg/l and the maximum value was 0.4 mg/l.

To protect the extensive citrus industries cited, the quality of Colorado River Water at Imperial Dam, as represented by boron concentrations, must be at least maintained, and this quality should be enhanced if at all possible.

d. Bicarbonate Effects: Bicarbonate in irrigation water adds to the sodium hazard by precipitating out the calcium and magnesium salts, with the resultant proportional increase in sodium content. This effect is usually expressed in terms of the "residual sodium carbonate" (RSC), defined as

$$RSC = (CO_3 + HCO_3) - (Ca + Mg)$$

These ionic constituents are expressed as milliequivalents per liter. Waters containing 1.25 - 2.5 meq. per liter of RSC are of marginal quality for irrigation purposes. Waters containing over 2.5 meq. per liter of RSC are not suitable for irrigation purposes.

The RSC levels of Colorado River water in Arizona are as follows (1962 water year, the last data available before the filling of Lake Powell)

Station	RSC Level
Lees Ferry	- 3.7 meq/l
Hoover Dam	- 4.1 meq/l
Imperial Dam	- 3.8 meq/l

In view of the negative values, it appears that the bicarbonate level of Colorado River water is well within the safe range for agricultural purposes.

7-3 Raw Domestic Water: The State Department of Health is the unit of State Government with primary responsibility for formulating and enforcing quality of water delivered for domestic purposes. This responsibility also includes consideration of the quality of raw water being diverted for domestic use. The USPHS Drinking Water Standards are applicable, but liberal interpretation must be used because of the high natural salinity of Arizona waters.

It is recognized that USPHS Standards apply to treated drinking water supplies. However, since many of the indicators cannot be removed by conventional or reasonable treatment, the USPHS limits for most of the indicators are applicable to raw domestic water supplies. Bacteriological, physical, chemical and radioactivity indicators must be considered, as follows:

a. Bacteriological Quality: Published records show that existing coliform counts in certain reaches of the Colorado River are appreciable. Coliform counts at NWQN Stations in the Upper Colorado River Basin have been consistently higher than those at Page, Arizona. The reason for this can probably be found in the long stretches of the river in remote, inaccessible areas with no sewage discharges. There has not been sufficient time to determine the effects of storage and increased recreational use by the formation of Lake Powell.

   Although the most effective assurance against water-carriage of pathogenic organisms is the complete elimination of sewage discharges to the river, conservation of water policies dictate that beneficial reuse of sewage effluents should be encouraged after adequate treatment.

   All water from the Colorado River System should receive treatment, under State Department of Health Standards, before delivery to individual domestic users.

b. Physical Characteristics: Turbidity, color and suspended matter, if present at the point of diversion, will generally be carried to the municipal treatment plants where removal is difficult and expensive. Also, in place, the presence of these indicators detracts from esthetic and recreational appeal, and it reduces the transmission of sunlight needed for propagation of aquatic life.

   Further investigations are needed before turbidity, color, and suspended matter from natural conditions and from necessary river control operations may become objects of water quality control. However, turbidity and suspended matter that result from construction and dredging operations in the main stem of the river will be considered for control, except in the reach between Imperial Dam and Laguna Dam.

c. Chemical Characteristics: Sections 5.21 and 5.22 of the USPHS Drinking Water Standards read as follows:

   "5.21 The following chemical substances should not be present in a water supply in excess of the listed concentrations where, in the judgment of the Reporting Agency and the Certifying Authority, other more suitable supplies are or can be made available.

Substance	Concentration In mg/l
Alkyl Benzene Sulfonte (ABS)	0.5
Arsenic (AS)	0.01
Chloride (Cl)	250.
Copper (Cu)	1.
Carbon Chloroform Extract (CCE)	0.2
Cyanide (CN)	0.01
Fluoride (F)	(See 5.23)
Iron (Fe)	0.3
Manganese (Mn)	0.05
Nitrate (NO_3)	45.
Phenols	0.001
Sulfate (SO_4)	250.
Total Dissolved Solids	500.
Zinc (Zn)	5.

Section 5.23 of said USPHS Standards sets allowable fluoride concentrations in drinking water in accordance with the annual average of maximum daily air temperatures of the area. For the desert areas, the presence of fluorides in average concentrations greater than 1.4 mg/l shall constitute grounds for rejection of the supply. Some areas drawing raw domestic water from the Colorado River have upper limits of 0.8 mg/l of fluorides.

It is necessary to strive towards lowering of the concentrations of constituents which contribute towards increase of salinity; but it is realized that the only practical means at present by which the concentrations of these constituents in the river as a whole can be controlled within limits that approach drinking water standards is through the institution of a major water augmentation program for the Colorado River System.

In some areas, municipalities desiring better quality water than is naturally available must use special methods such as distillation, dialysis or other suitable means to reduce the salinity. This must be a local choice until a major water augmentation program is developed.

Concentrations of heavy metals and toxic substances are historically low in Colorado River water. Increases in concentrations of these substances are most often attributable to discharges from commercial and industrial operations. Controlled minor increases in concentrations of copper and zinc may be acceptable, as concentrations of these metals, up to 1 mg/l in drinking water, are beneficial to humans. Essentially no increase may be allowable in the remaining heavy metals or toxic sustances.

d. Radioactivity: Under said PHS Standards, approval of water supplies containing radioactive materials shall be based upon the judgment that the radioactivity intake from such water supplies, when added to that from all other sources, is not likely to result in an intake greater than the radiation protection guidance recommended in the Federal Radiation Council's Memorandum to the President, September 13, 1961, and approved by the President.

Water supplies are approved without further consideration of other sources of radioactivity intake of Radium-226 and Strontium-90 when the water contains these substances in amounts not exceeding 3 and 10 uuc/liter, respectively.

In the known absence of Strontium-90 and alpha emitters, a water supply is acceptable when the gross beta concentrations do not exceed 1000 uuc/liter. Gross beta concentrations in excess of 1000 uuc/liter are grounds for rejection of a supply.

The following data indicates existing levels of radioactivity in Colorado River waters during the most recent years.

Radioactivity Levels in Colorado River Waters

Station	Average values in uuc/l, and error of measurement Radium 226	Alpha	Gross Beta	Strontium-90
Lees Ferry				
Boulder City				
Davis Dam	No Data	7 ± 5	35 ± 29	1.70
Parker Dam	0.37	7 ± 5	36 ± 29	1.48
Yuma, Arizona	0.17	6 ± 13	87 ± 9	0.88

Concentration of radioactivity substances in Colorado River water is historically low. Disposals of wastes containing radioactive substances are controlled in the upper basin by the Colorado River Basin Water Quality Control Project.

7-4 Recreation: This includes fishing, boating, swimming, water skiing, hunting, and esthetic enjoyment. The recreational uses are varied in character, and in their corresponding water quality needs. The rationale for protecting certain of these uses overlap into other main categories of beneficial uses; and accordingly are discussed elsewhere in this chapter. For example: hunting and fishing are dependent entirely upon the main category "Propagation of Aquatic Wildlife Resources".

a. Swimming and Water Skiing: Waters used for these purposes must be:

1. Esthetically enjoyable - that is, free from obnoxious floating or suspended substances, objectionable color and foul odors.
2. Free from substances that are toxic upon injestion, or irritating to the skin.
3. Reasonably free from pathogenic organisms.

b. Fishing and Hunting: Levels of water quality indicators needed to adequately protect fishing and hunting are all included within the indicators and their levels as necessary for "Propagation of Aquatic and Wildlife Resources", and are explained below under that title.

c. Boating and Esthetic Enjoyment: Water quality requirements for boating and esthetic enjoyment as beneficial water uses are somewhat similar to those required for protection of water-contact sports, hunting, and fish-

ing. Explanations of rationale for protection of these latter uses are made elsewhere, and are not repeated here.

Other conditions of water quality that effect boating and esthetic enjoyment are visible floating, suspended, or settled solids arising from disposal of sewage or garbage; sludge banks; slime infestations; heavy growths of attached plants or animals; blooms or high concentrations of plankton; discoloration or excessive turbidity, evolution of odorous gases; visible oil or grease; excessive acidity or alkalinity that lead to corrosion or delignification of boats and docks; foaming; and excess water temperatures that cause high rates of evaporation and cloudiness over the water.

Biological growths and heavy plankton blooms are fertilized by excessive organic nutrients, such as nitrates, phosphates, carbonates and silicates. Surfactants are esthetically objectionable when they contribute to foam.

Boats themselves may be a source of esthetic degradation of recreational waters. Uncontrolled boating activities cause significant coliform concentrations in waters, along with visible quantities of refuse, fecal matter, and toilet paper of boat origin. In view of accelerated boating activities on the Colorado River, regulations should be considered for control of the activity, and for provision and use of dockside disposal facilities.

7-5 Propagation of Aquatic & Wildlife Resources: Requirements of water quality for protection of the propagation of aquatic and wildlife resources cover a broad range of environmental factors, which are variable dependent upon individual species needed to be protected. Consideration must be given to protection of entire food chains and factors of habitat that contribute towards the desired end product.

The following levels of water quality indicators and criteria will adequately support the general freshwater aquatic and wildlife environment. The listing is not complete, and cannot presently be made complete; but it is sufficiently comprehensive to serve the present purpose.

1. Dissolved oxygen content above 5 mg/l.
2. pH between 5.7 and 8.6.
3. Total dissolved solids at or near the present levels in Colorado River water.
4. Free carbon dioxide content below 3 cc per liter.
5. Ammonia not over 1.5 mg/l.
6. Suspended solids such that the millionth intensity of light penetration will not be less than 5 meters.
7. Essentially complete absence of toxic substances. These substances tend to accumulate in concentrations along the food chain.

Existing quality of Colorado River water is superior in comparison to the above-listed indicators, with the exception of total dissolved solids content.

Aquatic life is very sensitive to concentrations of copper and zinc. Also, these metals appear to exhibit mutual synergistic effect on toxicity towards aquatic

life. Therefore, the objective limits for concentrations of these metals in Colorado River water are governed by the need to preserve the aquatic life, and accordingly, the objective limits are set at values below those needed to preserve water quality for domestic use.

7-6 Industrial: Colorado River waters are used in such a variety of industrial processes that, it is impossible to organize the quality requirements for all of the processes into a single set of standards. Fortunately, this problem can be circumvented to a great extent, because industries are generally willing to accept for most processes, water that meets drinking water standards. Where particular industries require water of higher quality, industry recognizes that additional treatment is the responsiblity of the water user. However, it is of primary importance to all industries that the quality of the supply water remain relatively constant.

Therefore, the rationale which is explained above for formulating water quality objectives to protect raw domestic water will govern in protection of water for industrial purposes, with the added consideration that the quality of industrial supply water must remain relatively constant.

APPENDIX

References

The following references were utilized in preparation of this policy document.

1. Arizona Revised Statutes, Water Pollution Control Act, Chapter 14.

2. (Federal) Water Pollution Control Act, Public Law 660, as amended by PL 87-88, PL 89-234, and PL 89-753.

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7. Quality of Water, Colorado River Basin, Progress Report No. 3, January 1967. U. S. Dept. of Interior.

8. National Water Quality Network (Water Pollution Surveillance System) (1957 et. seq.), Published by U. S. Public Health Service.

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10. Standard Methods for the Examination of Water and Wastewater, American Public Health Association, 12th Edition.

11. Quality of Surface Waters of the United States, U.S.G.S. Water Supply Papers, (1941 et. seq.).

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13. Reclaimed Waste Water in Las Vegas Valley, Orcutt, R. G., Dept. of Conservation and Natural Resources, State of Nevada, 1965.

14. Arizona Statistical Review, 22nd Ed., 1966, Research Dept., Valley National Bank, Phoenix, Ariz.

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TRIBUTARIES TO COLORADO RIVER

BELOW LEES FERRY

Tributary	Ref. Period	Flow A.F./Yr.	TDS mg/l	Total Salt, Tons/Yr.	Remarks:
Main Stem @ Lees Ferry	1941-62	11,714,000	542	8,638,180	
Paria River	1941-64	18,800	1,173	30,000	
Little ColoradoR. Cameron	1948-64	(134,000)	(712)	(130,000)	The Blue Springs are on Indian Reservation land. U.S.B.R. is studying this problem.
Blue Springs	1952-66*	(161,000)	(2,499)	(547,400)	
Total		295,000	1,688 av	677,400	
Bright Angel Creek	(41 yrs.)	25,630	198	7,000	
Tapeats Creek	Correlated	58,000	147	12,000	
Kanab Creek	Estimated	3,000	1,103	4,500	
Havasu Creek	Estimated	47,000	365	24,000	
Virgin River	1941-64	153,000	1,668	348,000	LaVerkin Springs is in Utah. Utah should investigate problem.
LaVerkin Springs	(Test Flow)	(7,700)	(9,400)	(98,000)	
Las Vegas Wash	8 yr. av.	14,990	5,000**	75,000	Expected to increase with development of Southern Nevada Project.
Bill Williams R.	26 yr. av.	62,330			
Gila River (near Dome)	1964	103			Mostly waste and drainage from Wellton-Mohawk Div. of Gila Project.

(continued on next page)

*Determined by flow measurement of springs when river was dry at Cameron. Flow of springs is nearly constant at 222 c.f.s. Considered representative

** Approximate value derived from various published reports.

Minor Tributaries***

Tributary	Reference Period	Maximum Flow, A.F./Yr.	TDS, mg/l	Maximum Total Salt, Tons/Year
Vaseys Paradise	1960-65	3,000	198	800
Nankoweap Creek	1960-65	2,920	500	1,986
Lava Canyon Creek	1965	1,095	750	1,117
Red Canyon Spring	1965	150	44,835	9,150
Clear Creek	1960-65	1,460	309	613
Monument Creek	1960-65	150	1,470	300
Hermit Creek	1965	438	441	263
Boucher Creek	1960-65	183	786	195
Crystal Creek	1960-65	2,920	735	2,920
Shinumo Creek	1960-65	4,920	176	1,181
Elves Chasm	1960-65	183	588	146
Stone Creek	1960	197	367	98
Deer Creek	1960-65	8,760	184	2,190
Matkatamiba Creek	1960-65	44	1,139	68
Lava Falls	1960	4,380	845	5,037
Vulcan Springs	1965	3,650	684	3,395
Spring Canyon	1965	95	478	62
205 Mile Canyon	1960	-	728	-
3-Spring Canyon	1965	15	426	9
Diamond Creek	1960-65	2,555	470	1,635
Travertine Canyon	1965	365	742	369
Travertine Falls	1960	-	1,278	-
Separation Canyon	1965	4	441	2
Spencer Canyon	1960-65	1,095	426	635

***Data on minor tributaries between Lees Ferry and Lake Mead is very meager because of remoteness of area, and is therefore subject to question.

EXHIBIT 2

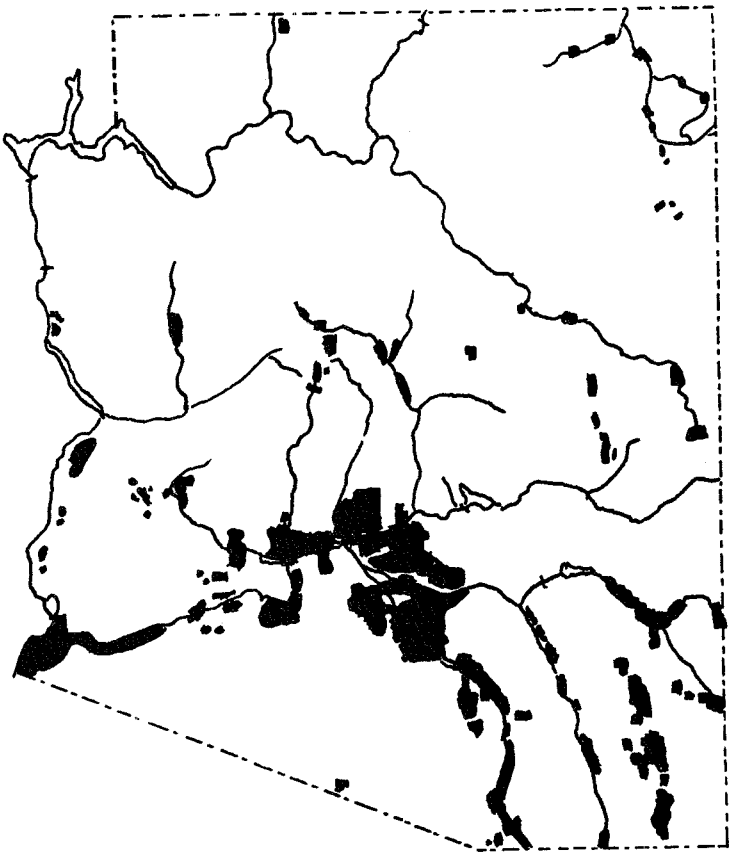
SUMMARY OF DIVERSIONS FROM THE COLORADO RIVER - CALENDAR YEAR 1964

Project (State)	Diverted At	Gross A.F. Diverted	Measured Return, A.F.	Net A.F. Diverted	Quality of Return Flow
City of Page	Lake Powell				
Southern Nevada Project Henderson-Las Vegas (Nev.) Boulder City (Nev.) Authorized future total	Lake Mead	 22,301 2,992 (300,000)	 16,028 none (50,000)	 6,273 2,992 (250,000)	High salinity, See Las Vegas Wash, Exhibit 1.
Metropolitan Water District (Calif.)	Parker Dam	1,136,698	neg.	1,136,698	
Central Arizona Project	Parker Dam	(1,200,000)	neg.	(1,200,000)	
Colorado River Indian Reservation (Ariz.)	Headgate Rock Dam	455,600	275,700	179,900	TDS 1500-2000 mg/l
Palo Verde Irrig. Dist. (Calif.)	Palo Verde Div. Dam	927,900	530,100	397,800	TDS 1500-2000 mg/l
Cibola Valley (Ariz.)	Pumps from River				
Imperial-Coachella Irrig. Dists. (Calif.)	Imperial Dam	3,380,000	none	3,380,000	
Res. Div., Yuma (Calif.)	Imperial Dam	96,340	46,980	49,360	TDS 1130 mg/l average
Valley Div., Yuma (Ariz.)	Imperial Dam	326,460	157,850	168,610	Same as intake-1700 mg/l
City of Yuma (Ariz.)	Imperial Dam	8,240	±4,000	±4,240	Raw sewage - Plans for treatment progressing.
Gila Projects (Ariz.) North Gila Valley South Gila Valley Wellton-Mohawk I.&D. Dist. Yuma Auxiliary Project	Imperial Dam	896,200	255,210	640,990	Varies from same as intake to TDS = 5000 mg/l

U.S.G.S. 1965 Water Resource Data for Arizona

ARIZONA AGRICULTURAL STATISTICS

Irrigated Areas in Arizona



DISTRIBUTION OF FARM ACREAGE BY COUNTIES - 1965

County	Alfalfa	Citrus	Cotton	Grains	Vegetables	Total
Apache . . .	2,000	-	-	5,440	40	8,400
Cochise. . .	12,000	-	13,486	53,400	4,900	87,866
Coconino . .	200	-	-	2,400	-	7,200
Gila	300	-	53	150	-	893
Graham . . .	6,100	-	17,850	27,510	140	53,800
Greenlee . .	1,000	-	1,700	2,350	100	5,850
Maricopa . .	95,000	15,940	128,000	161,600	51,000	481,120
Mohave . . .	1,800	-	270	530	100	4,900
Navajo . . .	4,600	-	-	13,000	200	18,900
Pima	1,000	50	23,385	22,700	500	49,715
Pinal . . .	20,500	85	123,100	79,840	4,900	247,000
Santa Cruz .	300	-	1,001	460	20	2,181
Yavapai. . .	3,200	-	10	3,600	100	8,660
Yuma	43,000	22,900	30,145	35,020	39,000	183,515

Note: Acreage double cropped is counted but once, and not all crops are shown.

Source: University of Arizona "Arizona Agriculture, 1965"

NUMBER OF ACRES DEVOTED TO ARIZONA'S PRINCIPAL CROPS

Year	Alfalfa	Citrus	Cotton	Grains	Vegetables	Total Acres
1960	231,000	29,078	426,095	378,000	99,500	1,263,673
1961	227,000	29,335	392,000	368,000	99,500	1,209,835
1962	210,000	31,025	405,000	301,000	96,650	1,172,675
1963	193,000	33,165	387,000	333,000	101,635	1,165,800
1964	201,000	34,785	375,000	365,000	104,540	1,154,000
1965	191,000	38,975	339,000	408,000	101,000	1,160,000

Note: Acreage double cropped is counted but once, and not all crops are shown.

Source: University of Arizona "Arizona Agriculture".

COMPARATIVE YIELDS PER ACRE - 1965

Crop	Arizona	U.S. Average	Crop	Arizona
Alfalfa seed, lbs. . .	180.00	202.00	Oats, bu.	42.00
Barley, bu.	73.00	43.50	Potatoes, cwt. . . .	210.00
Cotton, lbs. . . .	1,097.00	531.00	Sorghum, bu.	70.00
Hay, tons	4.77	1.82	Wheat, bu.	46.00

Source: U.S. Department of Agriculture, Arizona Crop & Livestock Reporting Service

GROSS VALUE OF ARIZONA CROPS AND LIVESTOCK

Livestock and Products	1963	1964	1965
Cattle and Calves	$174,800,000	$153,700,000	$190,100,000
Dairy Products	26,400,000	29,500,000	30,600,000
Sheep, Lamb & Wool	5,600,000	4,700,000	8,200,000
Poultry & Eggs	7,400,000	7,700,000	5,700,000
Miscellaneous	2,500,000	2,600,000	3,300,000
TOTAL	$216,700,000	$198,200,000	$237,900,000
Agricultural Crops			
Cotton Lint & Cottonseed	$154,800,000	$134,600,000	$133,100,000
Lettuce	50,000,000	47,300,000	54,800,000
Cantaloupe	17,400,000	15,800,000	14,400,000
Potatoes	5,500,000	7,600,000	9,700,000
Watermelons	1,600,000	1,400,000	1,100,000
Onions	2,800,000	1,100,000	3,900,000
Carrots	2,000,000	1,600,000	2,100,000
Celery	100,000	200,000	200,000
Broccoli	500,000	300,000	300,000
Cabbage	1,100,000	600,000	700,000
Cauliflower	400,000	400,000	500,000
Misc.Vegetables	6,300,000	5,500,000	5,700,000
Feed Grains	25,700,000	28,900,000	33,500,000
Hay	32,800,000	26,000,000	27,400,000
Citrus & Grapes	22,700,000	21,400,000	17,600,000
Seed Crops	5,800,000	6,100,000	5,400,000
Miscellaneous Crops	14,200,000	10,100,000	10,900,000
Forest Products	17,200,000	17,200,000	15,300,000
Federal Government Payments	4,400,000	5,800,000	7,800,000
TOTAL	$365,300,000	$331,900,000	$344,400,000
GRAND TOTAL	$582,000,000	$530,100,000	$582,300,000

Source: University of Arizona "Arizona Agriculture, 1966"

EXHIBIT 4

CITIES ALONG THE ARIZONA REACH OF THE COLORADO RIVER

YUMA, Arizona - The Yuma area population is about 30,000 people. Principal business activities are agriculture, tourism, transportation, military and recreation. Water is obtained from the irrigation canal system. Plans for a sewage treatment plant are in progress, but the sewage is now discharged directly to the river.

WINTERHAVEN, California - About 750 people live in this unincorporated community completely surrounded by Indian lands. Sewage disposal is by individual subsurface system.

BLYTHE, California - Total population of this area is about 10,000, with agriculture as the predominant industry, with minor tourist and recreation business. Sewage disposal is by sewage lagoons with no return to the river.

PARKER, Arizona - This city of about 1642 people is completely surrounded by the Colorado River Indian Reservation. Parker is the business center for the reservation, and serves tourist and recreational activities along the river. Sewage disposal is by individual subsurface system although a community system is planned.

LAKE HAVASU CITY, Arizona - This new city is primarily a recreational-residential city although there is some industry. Community waste waters are disposed of on land.

NEEDLES, California - Needles, with about 6,000 people, is a highway and transportation center, but activities include tourism, agriculture and recreation. The city's sewage effluent is treated effectively and discharged to the river.

TOPOCK, Arizona - This is a very small community adjacent to Needles. Sewage is by individual subsurface systems.

BULLHEAD CITY, Arizona - Bullhead City is a small town oriented to river recreation. Sewage disposal is by individual subsurface systems.

WILLOW BEACH, Arizona - This small town is the site of a National Fish Hatchery. Activities are centered around river recreation and fishing. Sewage disposal is by individual subsurface systems.

PAGE, Arizona - Page was created to serve the constructors of Glen Canyon Dam, and now serves the tourism and recreation activities of Lake Powell. The water supply is from Lake Powell, and wastes are disposed of in sewage lagoons with no return to the river.

1963 CENSUS OF MANUFACTURES — ARIZONA

Industry	Number of Establishments	Employees	Payroll	Value Added By Manufacture
All Industries TOTAL	1,512	57,339	$349,124,000	$617,413,000
Food and Kindred Products	228	6,527	34,198,000	76,196,000
Meat Products	27	804	4,814,000	8,184,000
Dairies	33	1,740	9,057,000	16,215,000
Canned & Frozen Foods	14	277	1,144,000	2,081,000
Grain Mill Products	16	481	2,640,000	8,487,000
Beverages	37	950	5,332,000	11,754,000
Miscellaneous	57	1,034	4,881,000	15,595,000
Apparel & Related Products	75	2,650	8,378,000	12,499,000
Women's Outerwear	17	463	1,331,000	1,790,000
Lumber and Wood Products	129	3,136	14,926,000	24,295,000
Logging Camps	41	316	1,080,000	1,845,000
Millwork Products	49	638	3,267,000	5,237,000
Furniture and Fixtures	77	945	4,177,000	6,953,000
Household Furniture	51	640	2,539,000	4,430,000
Printing and Publishing	252	4,122	21,295,000	44,412,000
Newspapers	59	2,631	13,109,000	30,823,000
Commercial Printing	125	943	5,424,000	8,961,000
Chemicals & Allied Products	61	898	5,652,000	14,915,000
Stone, Clay & Glass Products	148	3,232	18,149,000	44,392,000
Concrete & Plaster Products	103	2,503	13,965,000	31,010,000
Primary Metal Industries	29	4,484	29,462,000	94,026,000
Fabricated Metal Products	112	2,547	13,577,000	22,896,000
Structural Metal	64	2,047	11,170,000	18,778,000
Metal Services	20	269	1,443,000	2,065,000
Machinery Excl. Electrical	151	5,869	38,049,000	51,680,000
Metalworking Machinery	26	234	1,433,000	2,288,000
Service Industry Machinery	10	1,300	7,415,000	14,155,000
Miscellaneous Machinery	81	1,021	5,885,000	8,377,000
Electrical Machinery	52	9,123	55,877,000	86,533,000
Instruments & Related	18	1,540	12,233,000	27,430,000
Administrative & Auxiliary	—	593	5,082,000	—

NOTE: The All Industries total includes figures for industry groups which have been withheld in order to avoid disclosing figures for individual companies, or to permit further checking of figures for smaller industry groups.

MANUFACTURING EMPLOYMENT BY TYPE

Industry	June 1965	June 1966
Durable Goods	46,600	58,000
Ordnance, Aircraft & Parts	7,400	9,200
Lumber & Wood Products (except Furniture)	3,800	3,700
Stone, Clay & Glass Products	2,600	2,600
Primary Metal Industries	4,000	4,400
Fabricated Metal Products	3,600	3,500
Machinery (including Electrical)	21,300	29,500
All Other Durable Goods	3,900	5,100
Nondurable Goods	17,100	17,600
Food & Kindred Products	6,700	6,800
Apparel	3,600	3,700
Printing & Publishing	4,300	4,500
All Other Nondurable Goods	2,500	2,600
TOTAL	63,700	75,600

Source: Employment Security Commission, U. C. Division

GROWTH OF LABOR FORCE AND TOTAL EMPLOYMENT IN ARIZONA

As of June	Labor Force	Total Employment	Unemployment As % of Labor Force
1960	451,700	431,100	4.6%
1961	470,800	442,200	6.1
1962	488,400	462,700	5.3
1963	499,400	473,700	5.1
1964	514,600	488,400	5.1
1965	532,000	500,800	5.5
1966	546,900	524,900	4.0

EXHIBIT 6

MINERAL PRODUCTION IN ARIZONA

(Gross Value of Five Principal Metals, 000 Omitted)

Year	Copper	Gold	Silver	Lead	Zinc
1960. . .	$345,784	$5,007	$4,322	$1,988	$9,239
1961. . .	352,232	5,109	4,733	1,223	6,804
1962. . .	396,853	4,802	5,917	1,282	7,564
1963. . .	407,162	4,901	6,873	1,256	5,846
1964. . .	450,524	5,379	7,513	1,611	6,716
1965. . .	497,991	5,265	7,881	1,845	6,353

OTHER MINERALS PRODUCED IN ARIZONA

Mineral	1962	1963	1964	1965
Sand and Gravel.	$17,404,000	$14,466,000	$20,868,000	$16,621,000
Molybdenum . . .	5,864,000	7,584,000	9,532,000	15,880,000
Stone.	6,616,000	5,069,000	6,283,000	4,171,000
Uranium	3,047,000	4,844,000	3,253,000	3,918,000
Lime	2,914,000	3,048,000	2,920,000	3,543,000
Pumice	1,640,000	1,877,000	1,635,000	1,605,000
Miscellaneous. .	20,228,000	18,466,000	18,130,000	15,097,000

VALUE OF MINERAL PRODUCTION BY COUNTIES

County	1965	Minerals Produced in 1965 in Order of Value
Apache	4,296,106	Helium, uranium, sand and gravel, vanadium, natural gas, petroleum, pumice, clays, stone.
Cochise	(*)	Copper, gold, silver, stone, lime, sand and gravel, zinc, lead.
Coconino	(*)	Uranium, pumice, sand and gravel, copper, stone, silver.
Gila	70,389,453	Copper, lime, molybdenum, asbestos, silver, stone, sand and gravel.
Graham	(*)	Stone, pumice
Greenlee	93,809,251	Copper, lime, molybdenum, silver, stone, gold, sand and gravel.
Maricopa	6,004,733	Sand and gravel, mercury, mica, clays, stone, silver, copper, gold.
Mohave	19,586,739	Copper, molybdenum, sand and gravel, silver, stone, feldspar, zinc, gold, lead.
Navajo	1,468,466	Sand and gravel, uranium, stone, vanadium.
Pima	149,153,395	Copper, cement, molybdenum, silver, sand and gravel, gold, stone, zinc, clays, tungsten, lead.
Pinal.	141,730,125	Copper, molybdenum, sand and gravel, gold, silver, gypsum, lime, pyrites, perlite, stone, diatomite.
Santa Cruz . . .	377,323	Zinc, lead, copper, silver, gold, stone.
Yavapai.	33,054,812	Copper, zinc, cement, lead, silver, molybdenum, sand and gravel, gold, stone, lime, gypsum, clays, iron, pumice.
Yuma	1,290,738	Sand and gravel, stone, lead, gypsum, silver, zinc, gold, copper.
Undistributed (**)	59,008,629	
TOTAL	$580,170,000	

(*) Withheld to avoid disclosing individual company confidential data.
(**) Includes gem stones that cannot be assigned to specific counties

Source: U.S. Bureau of Mines

RECREATIONAL FEATURES ALONG ARIZONA REACH OF THE COLORADO RIVER

LAKE POWELL - Glen Canyon Dam backs up the Colorado River to form the 180 mile long Lake Powell, an area of spectacular beauty. Access to Lake Powell is at Wahweap Marina, om the northwest side of the dam. The City of Page is on the east side of the dam. Formation of the lake made Rainbow Bridge easier to visit by a larger number of people. The large number of boats could cause a bacteriological pollution problem in the area. Park is under National Park Service.

GLEN CANYON DAM - Glen Canyon Dam was completed in 1964, and along with Lake Powell is becoming a major tourist attraction.

LEES FERRY-RIVER AREA - Controlled water releases from Glen Canyon Dam have made the river into a good trout fishing area. Trips by boat through the Grand Canyon start in this area.

GRAND CANYON NATIONAL MONUMENT AND PARK - One of the world's greatest natural wonders. Tourist facilities are on both the North Rim and South Rim, but the South Rim, run by the National Park Service is the most popular. Trips into the Grand Canyon can be made by foot or by mule from the South Rim. Ironically, there is a water shortage in the Rim area, although a water supply from Bright Angel Creek is under construction. Sewage effluent is reclaimed for non-human consumption.

HAVASUPAI INDIAN RESERVATION - Limited camping facilities are available in the remote Havasu Creek area. Very primitive, available only by foot.

TEMPLE BAR - Temple Bar marina is located about 30 miles east of Hoover Dam. Tourist facilities (motel, restaurant) are available. Facility operated by the National Park Service. Sewage effluent disposed of on land, and boat disposal of wastes could become a problem.

HOOVER DAM - Millions of people have visited this Bureau of Reclamation project. Guided tours and exhibits available. Marinas, camping areas available on the Nevada shore northwest of the Dam. Lake Mead is a very popular sport area.

WILLOW BEACH - A National Fish Hatchery is maintained at Willow Beach. Fishing and recreational areas available.

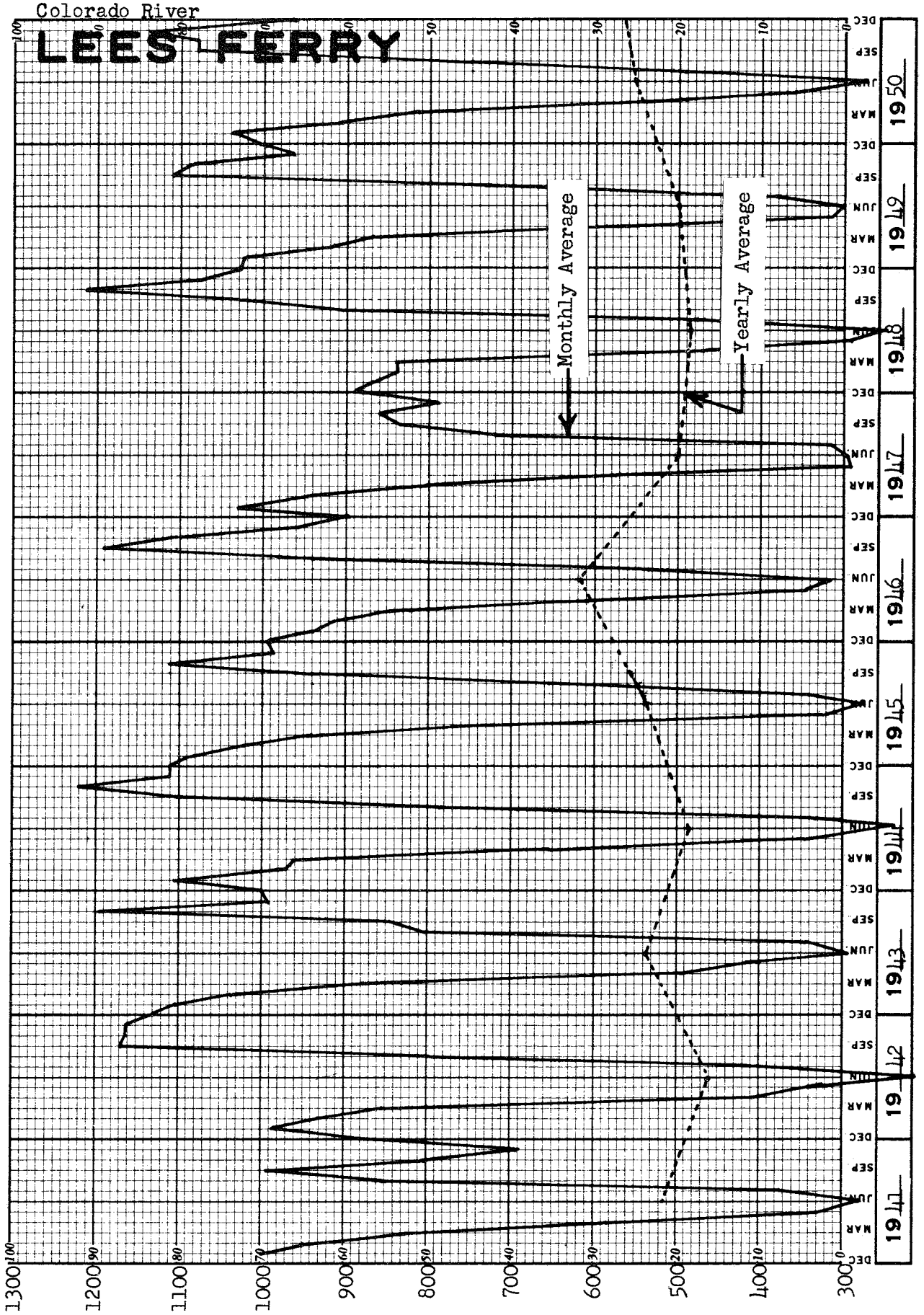
LAKE MOHAVE-DAVIS DAM - Lake Mohave, formed by Davis Dam 67 miles below Hoover Dam, is a popular water sport and fishing area of the Lake Mead National Recreation Area. Access from the Arizona side is at Katherine Landing at Davis Dam. Tourist facilities are available. Run by the National Park Service. Potential pollution problem from large number of boats.

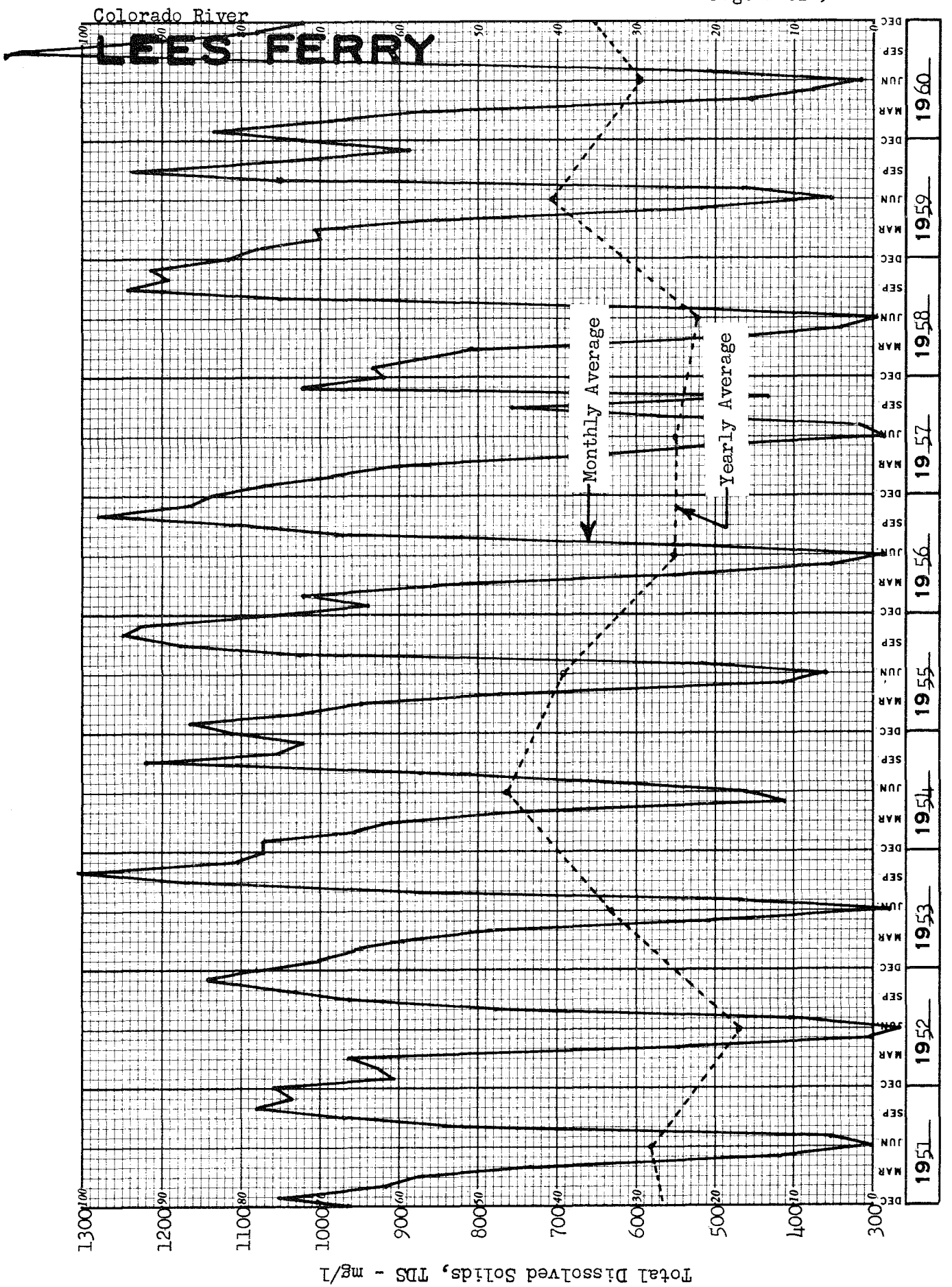
HAVASU LAKE - Havasu Lake, formed by Parker Dam 17 miles north of Parker, Arizona, is also a popular water sport and fishing area. The lake is 45 miles long. Major access on Arizona side of river is at Lake Havasu City, which was designed primarily as a recreational-residential community, although it contains some industry.

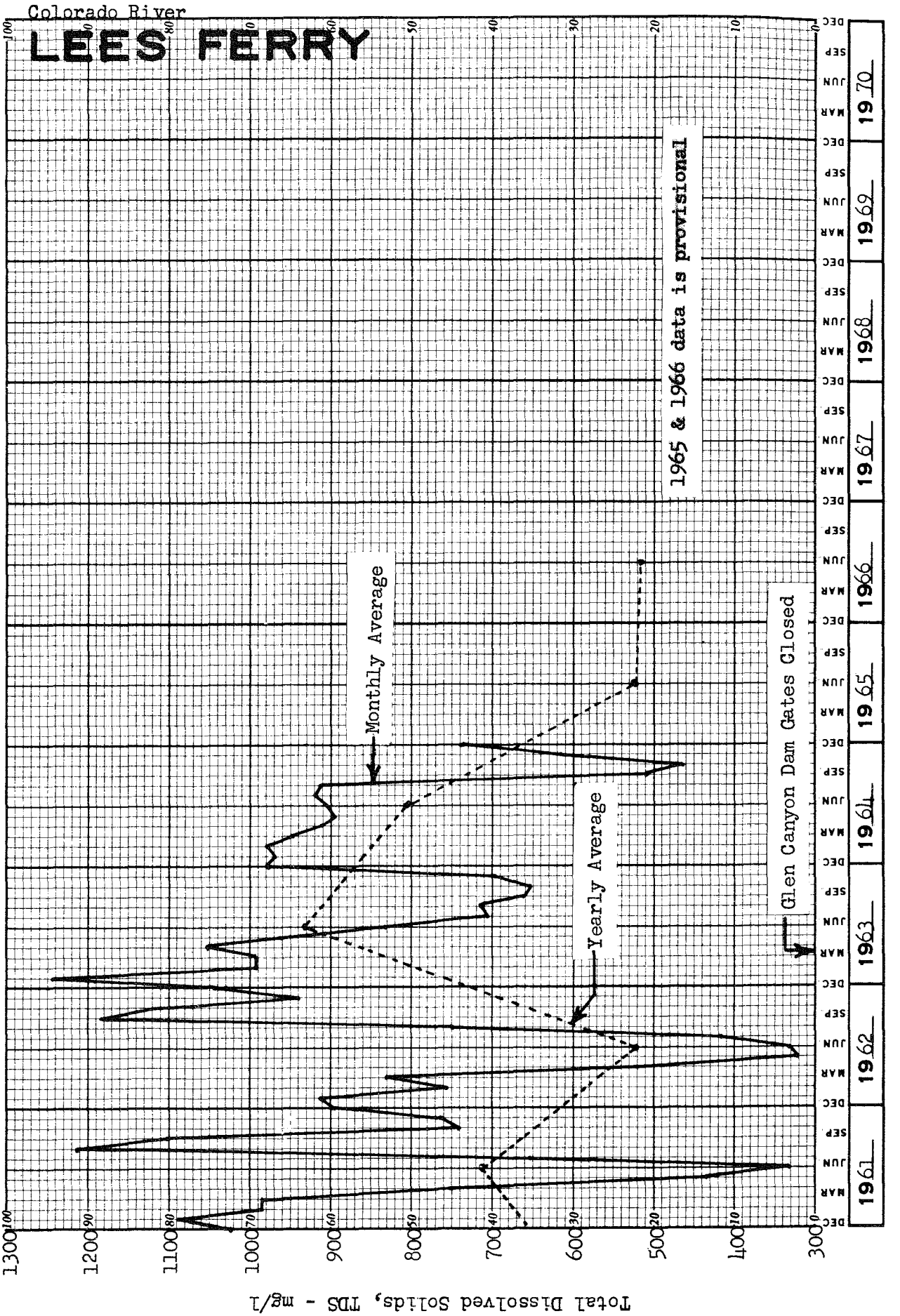
Again, the boats present a pollution problem. Community waste waters are disposed of on land with no return to the Colorado River.

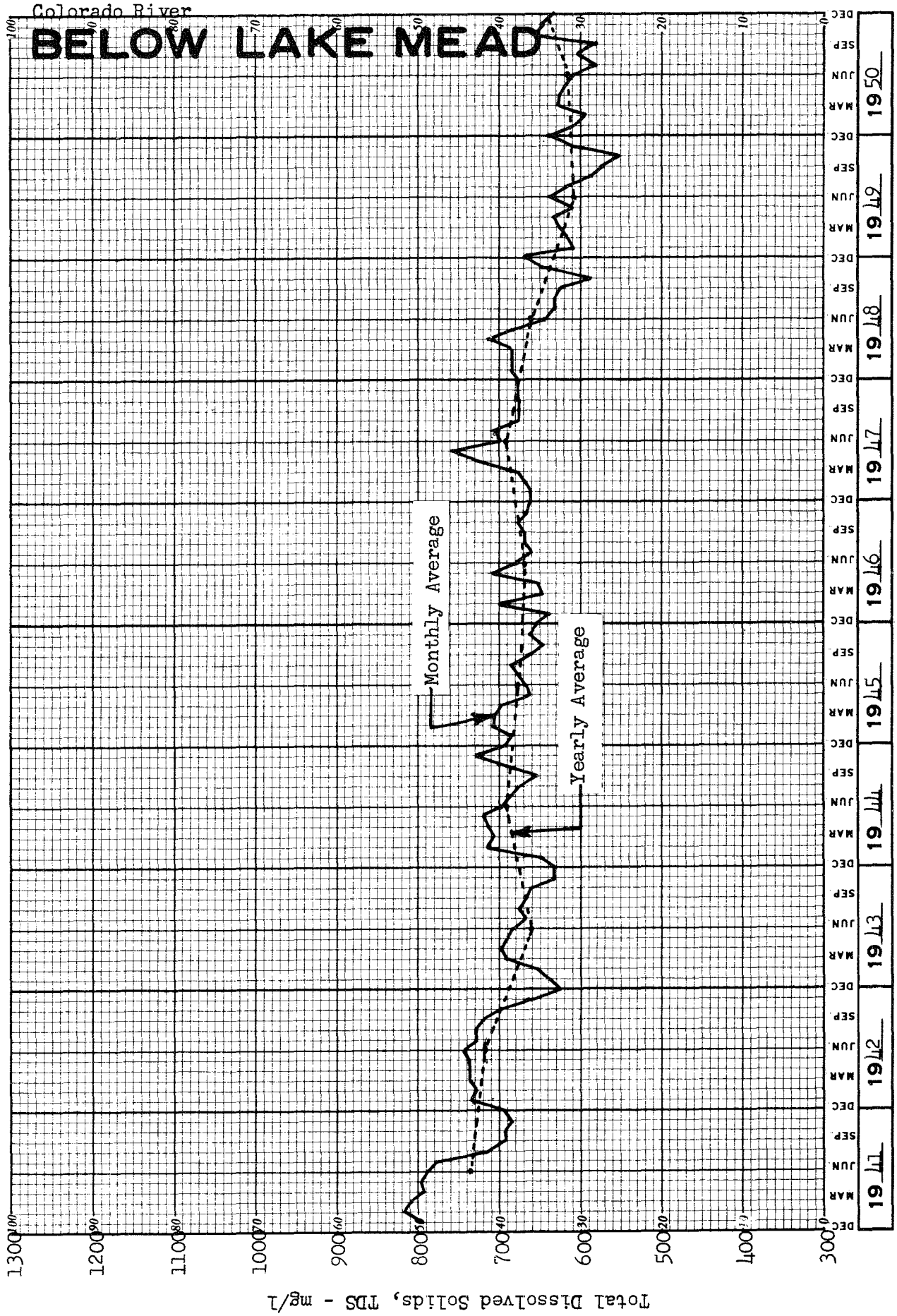
IMPERIAL RESERVOIR AND IMPERIAL NATIONAL WILDLIFE REFUGE - Public recreation is available in this area in the form of water sports and fishing. Access to MARTINEZ LAKE, 6 miles north of Imperial Dam, is at Fishers Landing and Castle Dome Landing. An Arizona waterfowl refuge is maintained at MITTRY LAKE just south of Imperial Dam.

Colorado River

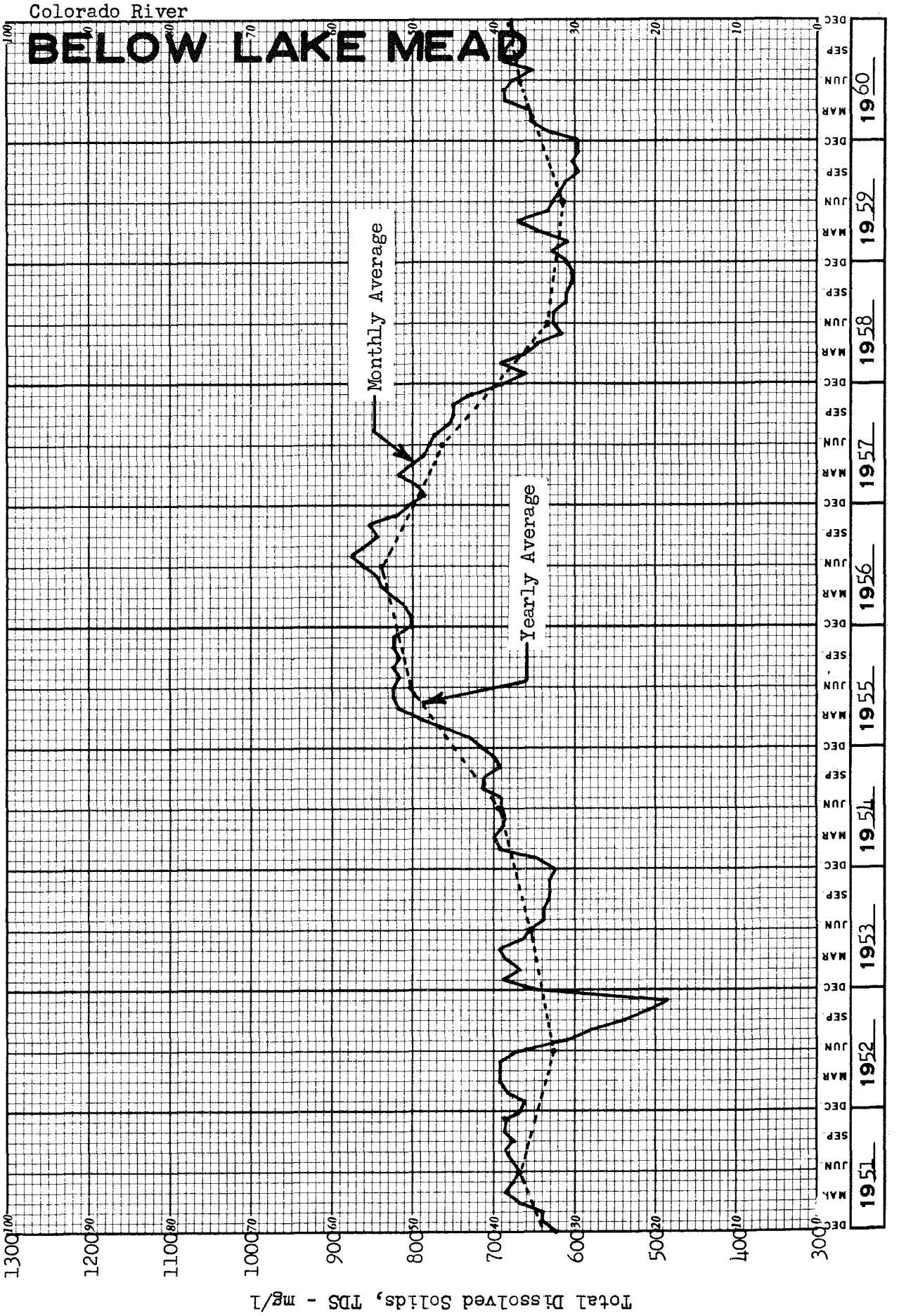


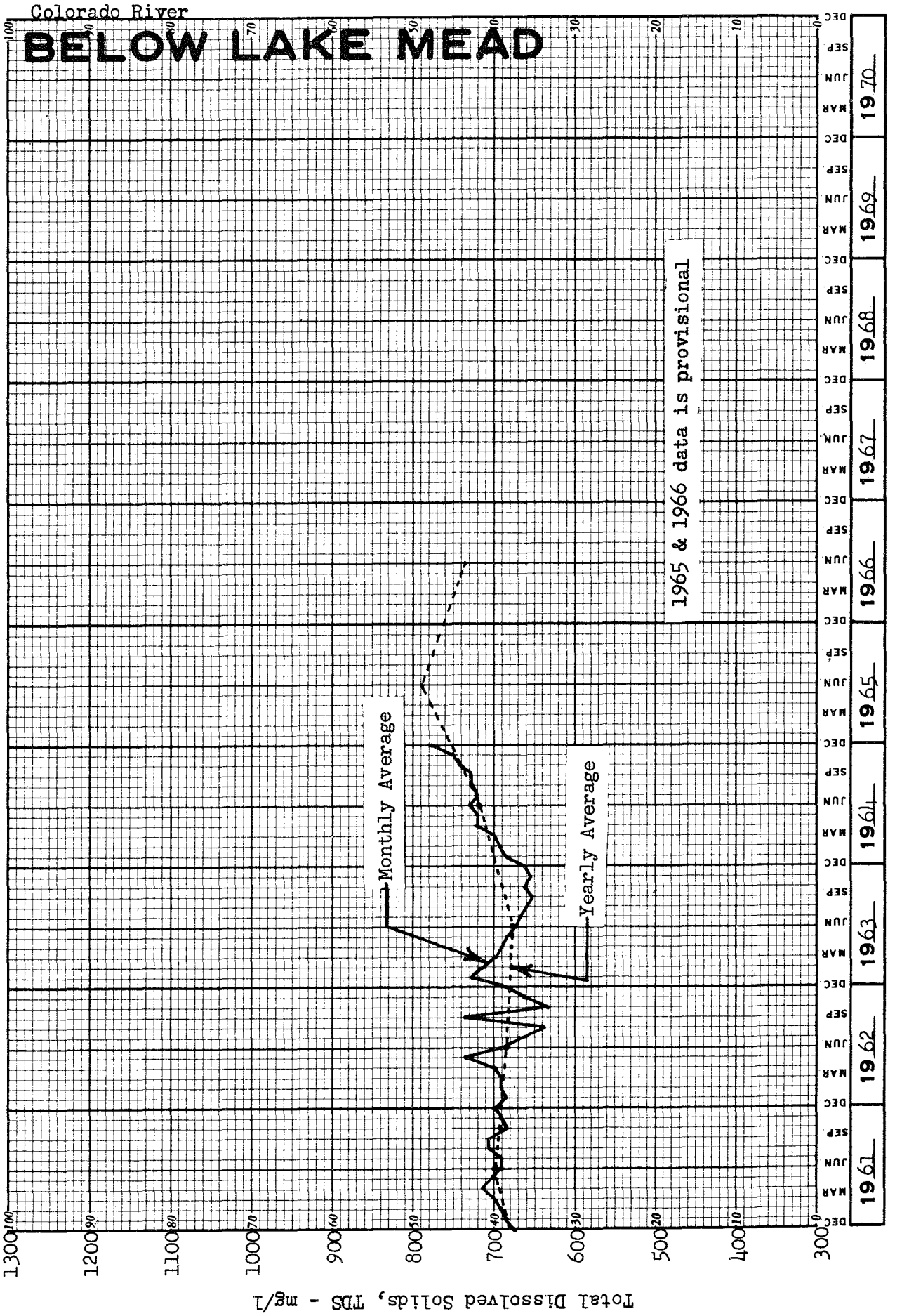

Colorado River
LEES FERRY
Monthly Average
Yearly Average
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
DEC
MAR
JUN
SEP
Total Dissolved Solids, TDS - mg/l
1300
1200
1100
1000
900
800
700
600
500
400
300

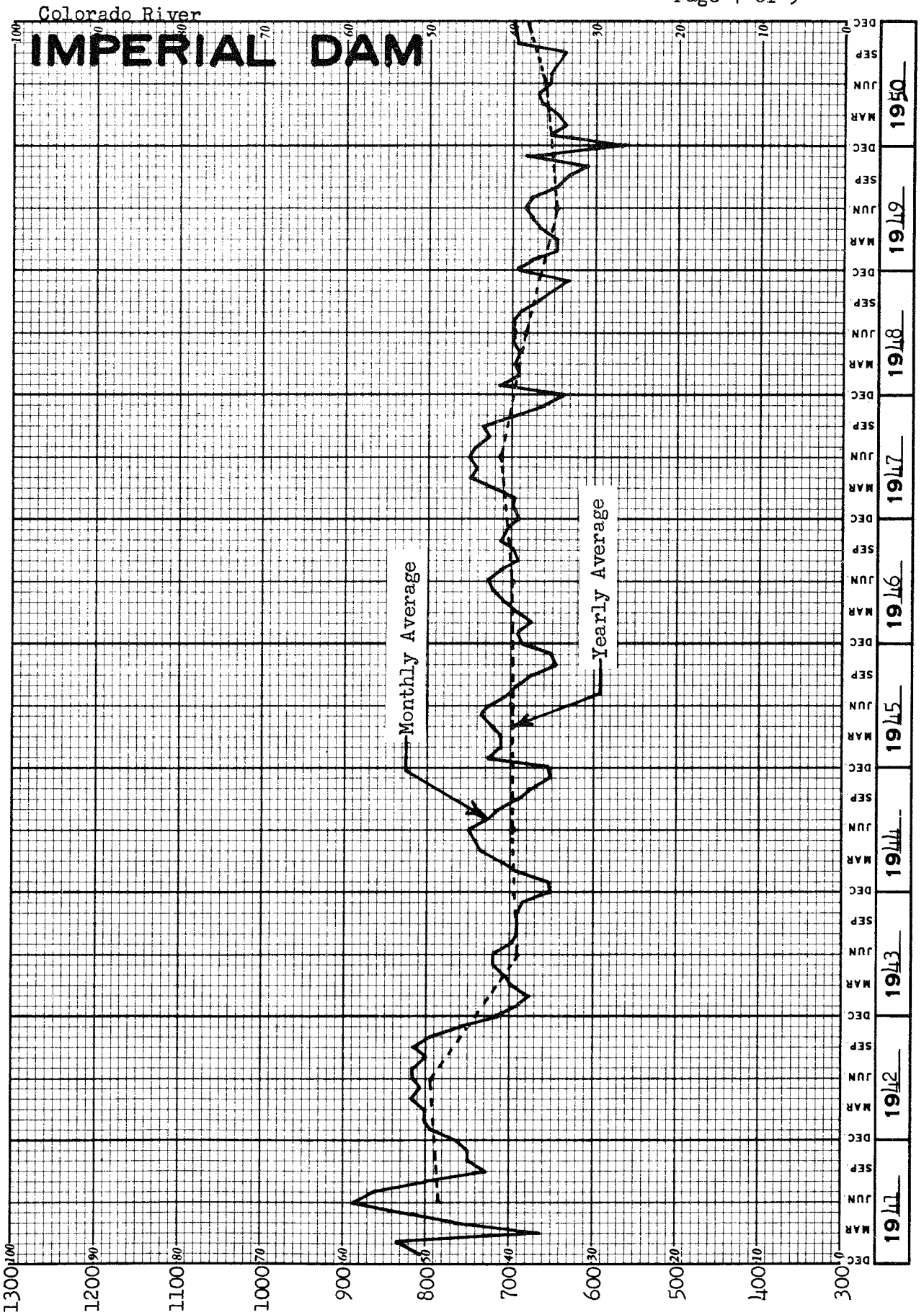

Colorado River
LEES FERRY
1965 & 1966 data is provisional
Monthly Average
Yearly Average
Glen Canyon Dam Gates Closed
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
DEC
MAR
JUN
SEP
1300
1200
1100
1000
900
800
700
600
500
400
300
Total Dissolved Solids, TDS - mg/l

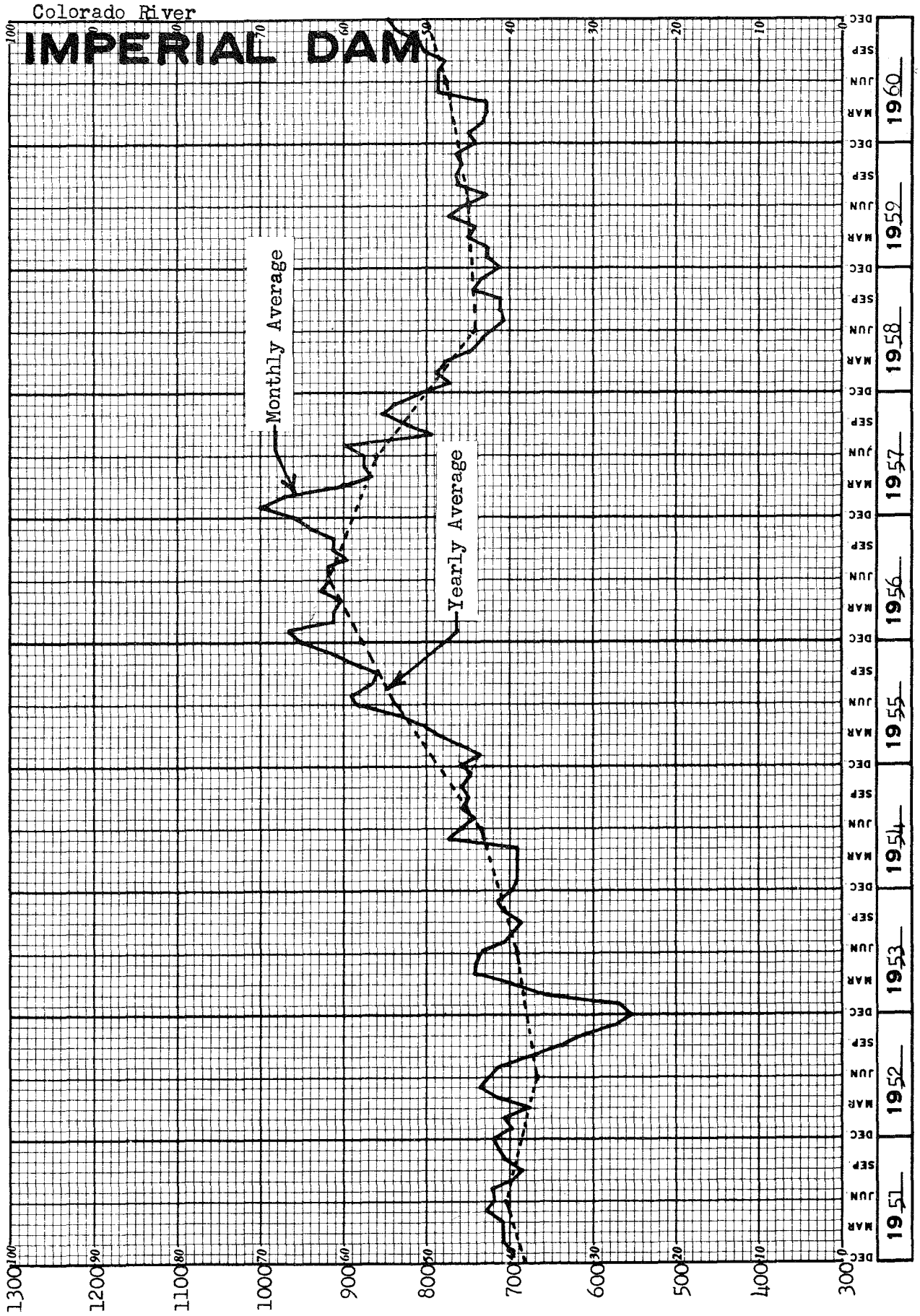

Colorado River
BELOW LAKE MEAD
Monthly Average
Yearly Average
Total Dissolved Solids, TDS - mg/l
1300
1200
1100
1000
900
800
700
600
500
400
300
100
90
80
70
60
50
40
30
20
10
0
DEC
SEP
JUN
MAR
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950

Colorado River




Colorado River
BELOW LAKE MEAD
1965 & 1966 data is provisional
Monthly Average
Yearly Average
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
MAR
JUN
SEP
DEC
1300
1200
1100
1000
900
800
700
600
500
400
300
Total Dissolved Solids, TDS - mg/l


Colorado River
IMPERIAL DAM
Monthly Average
Yearly Average
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
DEC
MAR
JUN
SEP
1300
1200
1100
1000
900
800
700
600
500
400
300
Total Dissolved Solids, TDS - mg/l


Colorado River
IMPERIAL DAM
Monthly Average
Yearly Average
Total Dissolved Solids, TDS - mg/l
1300
1200
1100
1000
900
800
700
600
500
400
300
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
DEC
SEP
JUN
MAR

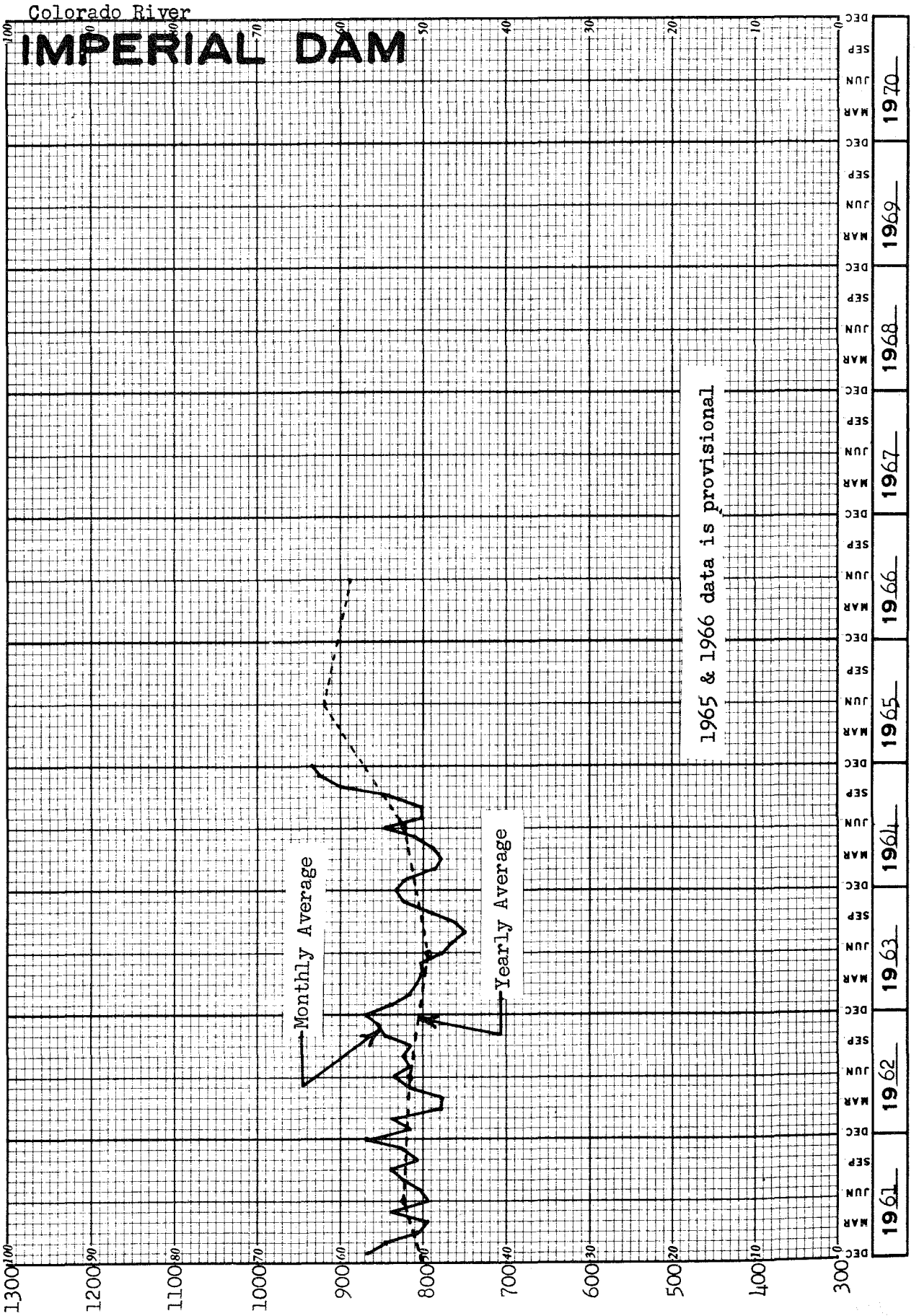

Colorado River
IMPERIAL DAM
1965 & 1966 data is provisional
Monthly Average
Yearly Average
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
MAR
JUN
SEP
DEC
1300
1200
1100
1000
900
800
700
600
500
400
300
Total Dissolved Solids, TDS - mg/l

EXHIBIT 9

TOTAL DISSOLVED SOLIDS VARIATION IN LAKE POWELL

1965

ISOHALINE LINES - TDS, ppm

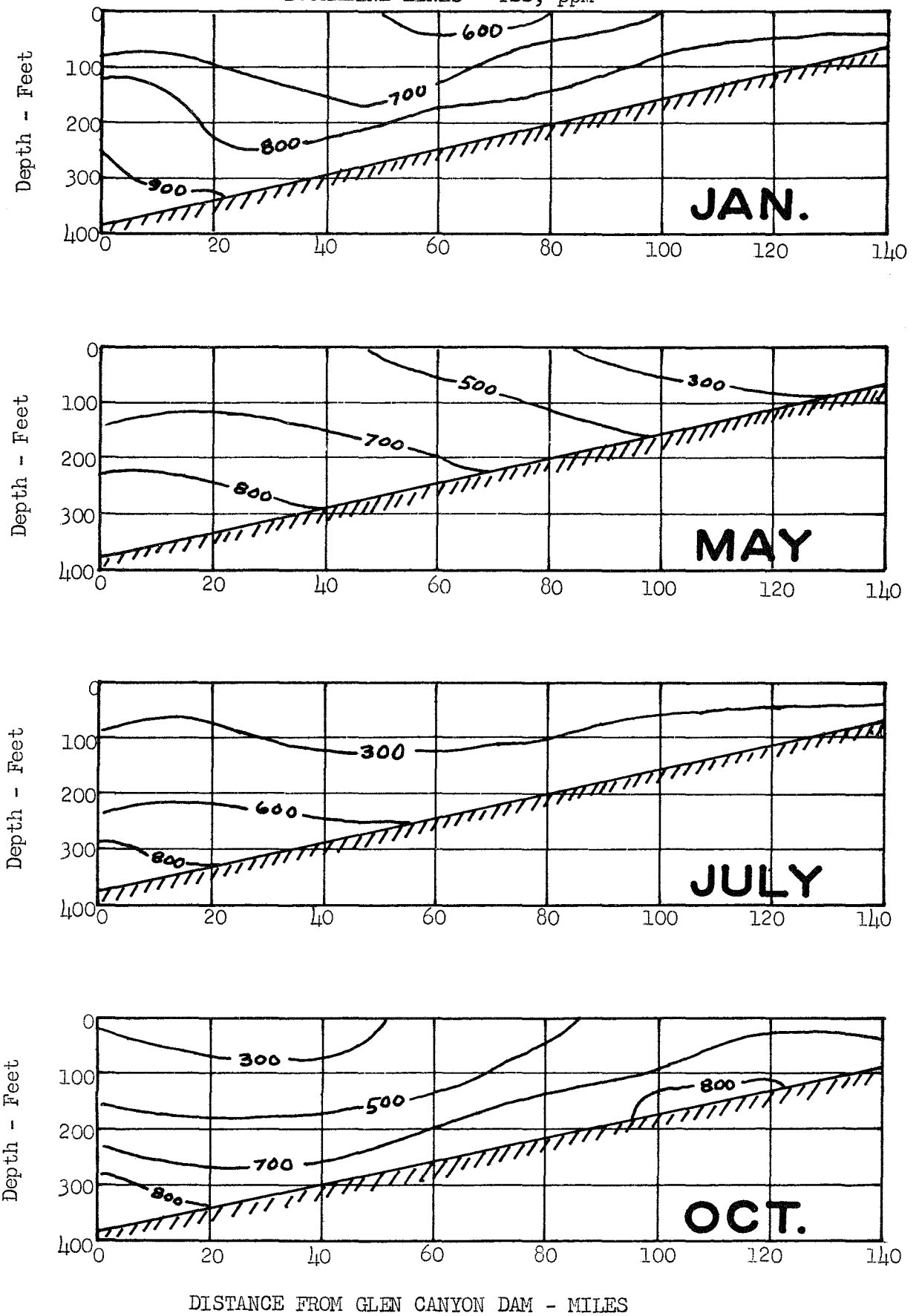
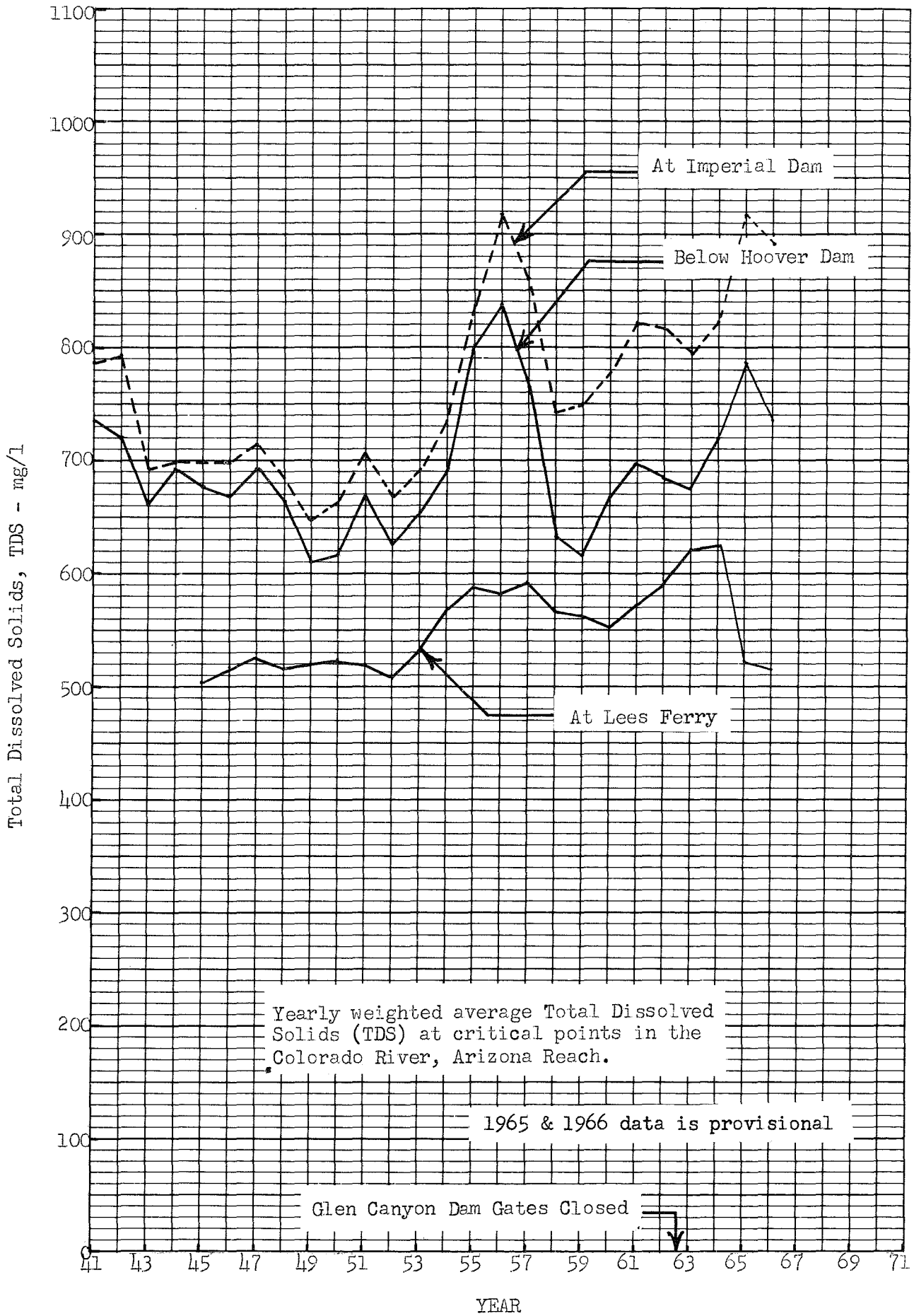


EXHIBIT 10


1100
1000
900
800
700
600
500
400
300
200
100
0
Total Dissolved Solids, TDS - mg/l
At Imperial Dam
Below Hoover Dam
At Lees Ferry
Yearly weighted average Total Dissolved Solids (TDS) at critical points in the Colorado River, Arizona Reach.
1965 & 1966 data is provisional
Glen Canyon Dam Gates Closed
41
43
45
47
49
51
53
55
57
59
61
63
65
67
69
71
YEAR

Exhibits 11 through 19 inclusive are supporting documents requested by the Federal Water Pollution Control Administration (FWPCA). These Exhibits, now being prepared, will be added to the final document presented to the FWPCA.

GUIDELINES FOR FORMULATING WATER QUALITY STANDARDS FOR THE INTERSTATE WATERS OF THE COLORADO RIVER SYSTEM*

January 13, 1967

General Considerations

Past and future economic growth of the States served by the Colorado River System** has been and will continue to be dependent upon the development and utilization of its water resources. Appropriate water quality standards will enhance this development by protecting the quality and productivity of the System's waters. Such standards will not be used to restrict reasonable use and development of each State's apportionment of water in the Colorado River System***. Nothing herein is intended to construe the Colorado River Compacts***.

The System's interstate waters are used for municipal and industrial supplies, irrigation, fish and wildlife, and recreation. Maximum effort must be directed toward maintaining the highest possible water quality for these uses consistent with reasonable beneficial future development and utilization of all resources within States served by the System.

In order to develop practicable and reasonable quality standards for interstate waters of the Colorado River System, full consideration must be given to the numerous factors and variables connected with the control, development, utilization, conservation, and protection of the System's water resources. It is evident that future development and utilization of the System's water resources for expansion of irrigated agriculture, increases in population, and industrial growth will be accompanied by progressive increases in consumptive losses of water and attendant increases in concentrations of dissolved solids.

In view of the anticipated increase in consumptive use of water, augmentation of the Colorado River is essential just to maintain the existing water quality. Enhancement, as contemplated by the Guidelines of the Federal Water Pollution Control Administration, of the present water quality of the Lower Colorado River is most practicable by a major water augmentation program. One objective of a major water augmentation program would be to approach the limits for total dissolved solids, chlorides, and sulfates recommended by the U.S. Public Health Service Drinking Water Standards of 1962.

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*Developed by the State Conferees in the Matter of Pollution of the Interstate Waters of the Colorado River and its Tributaries at a series of meetings during 1966 and 1967, in the interest of compatible State water quality standards. Several water resource interests of each State were involved in most meetings, particularly the last two, held in Scottsdale, Arizona on December 7, 1966 and January 13, 1967.

**The Colorado River and all those streams contributing water thereto.

***California and Nevada do not agree with these two sentences, but propose that there be further negotiations and discussions to resolve this issue.

Basic Principles

1. The States served by the Colorado River System recognize that answers to important questions regarding total dissolved solids, chlorides, sulfates and sodium are lacking or are based on factors that are not yet well-defined. In respect of this recognition the States agree that pending the development of acceptable answers to enable the setting of criteria for total dissolved solids, chlorides, sulfates and sodium for the interstate waters of the Colorado River System, such criteria should be stated in qualitative terms. At the same time it is agreed that all identifiable sources of water pollution will be managed and controlled to the maximum degree practicable with available technology in order to provide water quality suitable for present and potential future uses of the System's interstate waters.

2. Reviews of all available technical knowledge* pertaining to the water quality problem and evaluation of new pollution potentials will be made at intervals of not greater than 3 years by representatives of the seven System States with the view and intent of improving, strengthening, or otherwise modifying the quality standards.

3. Monitoring of the quality of interstate waters will be carried out at designated points near State lines and other key locations for all constituents covered by the standards. In addition, measurements will be made at these locations for total dissolved solids, sulfates, chlorides, and sodium.

4. Any State may convene a meeting of all seven States to discuss remedies in those instances where the quality of water available to that State has been adversely affected or threatened by pollutants discharged into the Colorado River System.

Minimum Quality Criteria Applicable to Interstate Waters at Agreed State Line Sampling Points

1. Free from substances attributable to domestic or industrial waste or other controllable sources that will settle to form sludge or bottom deposits in amounts sufficient to be unsightly, putrescent or odorous, or in amounts sufficient to interfere with any beneficial use of the water.

*During the periodic reviews of technical knowledge full consideration will be given to all new technological or other developments and research which may be utilized to upgrade the standards to provide for the protection and enhancement of water quality. This will include possibilities such as: (1) importation of water of better quality from outside the System; (2) control or management of natural sources of salinity; (3) reduction of total dissolved solids in irrigation return flows through reasonable and practicable means; and (4) other suitable measures.

2. Free from floating debris, oil, grease, scum, and other floating materials attributable to domestic or industrial waste or other controllable sources in amounts sufficient to be unsightly or in amounts sufficient to interfere with any beneficial use of the water.

3. Free from materials attributable to domestic or industrial waste or other controllable sources in amounts sufficient to produce taste or odor in the water or detectable off-flavor in the flesh of fish, or in amounts sufficient to change the existing color, turbidity or other conditions in the receiving stream to such degree as to create a public nuisance, or in amounts sufficient to interfere with any beneficial use of the water.

4. Free from high temperature, biocides, organisms pathogenic to human beings, toxic, corrosive, or other deleterious substances attributable to domestic or industrial waste or other controllable sources at levels or combinations sufficient to be toxic to human, animal, plant or aquatic life or in amounts sufficient to interfere with any beneficial use of the water.

5. Radioactive materials attributable to municipal, industrial or other controllable sources shall be minimum concentrations which are physically and economically feasible to achieve. In no case shall such materials exceed the limits established in the 1962 Public Health Service Drinking Water Standards or 1/10 of the 168-hr values for other radioactive substances specified in National Bureau of Standards Handbook 69.

6. No wastes from municipal or industrial or other controllable sources containing arsenic, barium, boron, cadmium, chromium, cyanide, fluoride, lead, selenium, silver, copper and zinc that are reasonably amenable to treatment or control will be discharged untreated or uncontrolled into the Colorado River System. At agreed points of sampling above Imperial Dam in the Colorado River System the limits for concentrations of these chemical constituents will be set at values that recognize their cumulative effects and which will provide River Water quality consistent with the mandatory requirements of the 1962 Public Health Service Drinking Water Standards.

7. The dissolved oxygen content and pH value of the waters of the Colorado River System shall be maintained at levels necessary to support the natural and developed fisheries.