REPORT ON THE INVESTIGATION

OF THE WATER QUALITY OF THE

COLORADO RIVER, DOTSERO,

COLORADO TO UTAH BORDER

Colorado Department of Health
Water Quality Control Division
January, 1976

INTRODUCTION

To aid in the preparation of the 303 Water Quality Management Plan, the Water Quality Control Division undertook a survey of the Colorado River from Dotsero, Colorado to the Utah border, a river segment requiring additional data. The Division's Mobile Laboratory was utilized for the field work. This report covers a sampling period extending from October, 1973 through September, 1974. The main emphasis during the sampling period was the gathering of chemical data although some biological studies were also conducted. Additional sampling was scheduled for the Summer of 1975 but manpower limitations caused this to be delayed indefinitely.

SUMMARY

At any given station on the Colorado River during the study, the stream flow was always 1280 c.f.s. (cubic feet per second) or greater. The flows all exceeded the once in ten year [1] low flows. The magnitude of flow was such that point source discharges attributable to wastewater treatment plants were immediately diluted past detection levels. Under these conditions, any degradation of water quality would probably be due to the culmulative affects of several entities and not any single plant.

The water quality of the Colorado River reflected the geology of the land as the River flowed towards the border. In the Glenwood Canyon area, the low conductivities and alkalinities are due to the outcroppings of slow eroding granite rock formations through which the River flows. In the aptly named

1 Once in ten year flow = the lowest flow observable for seven consecutive days once in ten years.

Glenwood Springs area, hot springs increase the chloride and alkalinity concentrations rapidly and significantly. The Roaring Fork River acts as a diluting agent on the Colorado River at Glenwood Springs bringing about a reduction in the chlorides and alkalinities.

Below Glenwood Springs, sandstone and shale formations predominate. The erodable nature of both rock formations and soil of the valley floors is evidenced by the gradual increase of conductivity, hardness, chloride, and sulfate concentrations the farther west the sampling location is situated.

The Gunnison River also had a diluting effect on the water quality of the Colorado River during the sampling period. Below the confluence of the Colorado and Gunnison Rivers, decreases in dissolved salts and hardnesses were noted in all samples. A long mixing zone exists through the Grand Junction area where the water quality of the Colorado River changes dramatically from one side of the River to the other as evidenced at Station CR-19 (Table 8). At this location just downstream from the confluence of the two Rivers, the dissolved salt concentrations were 20-50% lower on the south side of the River due to the influence of the softer waters of the Gunnison River.

Nitrogen concentrations also increased in the downstream portion of the study area. The origin of the nitrogen below Cameo is not known at this time. The presence of nitrites indicates the nitrogen has not been in solution for an extended period of time since nitrite oxidizes rapidly to nitrate. Many factors may increase nutrient concentrations in flowing waters including natural erosion, leaching of fertilizers, sewage treatment plant effluents, runoff from livestock holding areas, and irrigation return flows.

Within the study area, wastewater treatment plant (WWTP) effluents did not appear to increase downstream nutrient concentrations of the River by measurable increments.

Effects of fertilization practices or irrigation return flow on nutrient concentrations in the River are extremely difficult to measure due to the non-point nature of the problem and the large flows in the Colorado River. Plateau Creek, a tributary of the Colorado at Cameo, carries measurable amounts of nutrients into the River. The nutrient concentrations in Plateau Creek increased as the stream flowed through areas where cattle were penned along side the water. It is probable that cattle penned on the Colorado River banks also contribute nutrients to the River's ecosystem.

Natural erosion also contributes nutrients to the Colorado River. As water level, turbidity, and suspended solids increased during the spring runoff, nitrogen levels also increased. The nitrogen compounds, natural components of the soil, were carried into the River with other allocthonous (sedimentary) material.

Changes of the substrate brought about dramatic changes in the benthic populations. Aquatic insects associated with rivers such as the Colorado require fast currents, high dissolved oxygen, and low concentrations of settleable material. Throughout the study area where such conditions existed, a diverse, abundant benthic population was established. Sedimentation did eliminate many insect groups along the eddies and in the pool areas. During September to November, 1973, the mayfly genus <u>Tricorythodes</u> sp. dominated in the areas where *a thin brown sediment covered the rocks. This genus is normally associated with slightly stagnant water. In areas where the sediments became deeper than a few millimeters, further reduction of the benthic fauna occurred and only insects capable of surviving in an oxygen poor environment were present (for example, Chironomus sp.).*

Dissolved oxygen concentrations were not critical during the study period. All measurements were above the six ppm level considered to be the minimum concentration for trout. It is interesting to note that the greatest diurnal fluctuations in D.O. (dissolved oxygen) occurred above De Beque, while the highest nutrient levels were observed downstream from the same location. It is possible that changes have occurred in the animal and plant communities downstream from De Beque. Rates of photosynthesis, reaeration, and respiration may be different below De Beque than farther upstream. The Colorado River within the study area may represent two distinct aquatic systems, one a cold, roily, turbulent river and the other warmer and more placid.

Comparison of data gathered during this study period to State water quality standards now in affect show that the Colorado River is within limitations assigned to the various river sections. From Dotsero to Grand Valley, the River is designated B_1, a cold water fishery. From Grand Valley to Utah, the classification is B_2, a warm water fishery.

The Colorado River during the study period presented a paradox. The water appears to be relatively clean. The presence of rapidly fluctuating fecal coliform groups may indicate periodic enrichment due to man's activities. The substrate of the River presents a nutrient enriched environment characterized by a rapid algal production. A severely reduced benthic population is present in areas of slower current where sedimentation covers the substrate to a depth of more than a few millimeters. The precise origin of these enriched substrates is not presently known. Any suspended matter entering the River may settle thereby increasing the depths of the sediment and enriching the substrate. Continued enrichment will surely bring about further degradation of the Colorado River ecosystem.

RECOMMENDATIONS

1. Although not degrading the water quality of the Colorado River at a detectable level, the New Castle WWTP effluent is of extremely poor quality and is not meeting State effluent requirements. This plant should be upgraded and the plant operator given technical assistance in the operation and maintenance of his facility.

2. The extent and affect of the enriched sediments on the Colorado River ecosystem should be determined. Intensive chlorophyl-a and primary productivity studies may help in this endeavor.

3. Research should be undertaken to determine the reaeration, primary productivity, and benthic oxygen demand rates in the Colorado River within the study area. This information is vital in any future modeling. A future study by this Division will be undertaken to help determine the manpower and time required to attain these three rates.

BACKGROUND INFORMATION

As the River travels the 139 miles through the study area, it drops from 6160 feet above sea level to 4330 feet above sea level with an average drop in elevation of 131 feet per mile (see Figure 1).

The geology of the river valley changes dramatically in this 139 miles. In Glenwood Canyon, from Dotsero to Glenwood Springs, geologic formations exposed consist of Sawatch quartzite, shale, and granite. From Glenwood Springs to Rifle, Colorado, the major groups exposed are red and grey sandstones. Shale and sandstone are the dominant outcroppings from Rifle to the Utah border.

This semi-arid portion of Colorado is characterized by sage and short grass covered valleys with steep hillsides and cliffs leading to mesas and buttes of pinon pine and one-seeded juniper. Available land is used primarily for the raising of cattle and hay. Farming and orchard cultivation increase in the area of Grand Junction.

As the Colorado flows west through the State, irrigation demands increase. Water is diverted from the Colorado and the tributaries to outlying areas. Return water empties into the Colorado River after traveling miles through man-made canals and ditches.

Through the winter months, large numbers of cattle are penned and fed on the banks of the Colorado and its tributaries. Only in a few instances are the cattle separated by a physical barrier from direct access to the River. The River and the tributaries provide water for the animals. This practice provides a pathway for potential nutrient enrichment of the Colorado River each year by direct contamination and runoff.

Physical characteristics of the Colorado River remain much the same throughout the study area. Short stretches of riffles and white water are separated by long runs of deep, slower water. The white water stretches are more common in the Dotsero-New Castle area than downstream. Large eddies, backwaters, and pools are common along the banks where the river bed curves bend. Hot springs in the river bend are common from Dotsero to New Castle. In winter months, steam coming off the water marks exact locations of these springs.

Changes in the substrate, brought about by sedimentation, alter the river bottom in some areas. Sediment, in this report, is defined as a dense muck, brown on the water substrate interface and turning grey or black a few millimeters deep into the substrate. From Dotsero to the state line, the depth of the sediment increases from a few centimeters along the eddies and river banks to approximately one meter along the pool areas below De Beque. In addition, rocks in the main channel are gradually covered with a thin brown "Aufwuchs" composed of sand grains, diatoms, and blue-green algae as summer progresses into winter.

WASTE SOURCES

Industry, at present, has little impact on the Colorado River within the study area. Four industrial sites are located on the main stem. In Glenwood Canyon, the Shoshone Power Plant diverts water for hydro-electric use, periodically reducing the river flow for a distance of approximately three miles below the diversion to a trickle. All diverted water is returned to the River. Union Carbide operates a nondischarging uranium and vanadium mill immediately west of Rifle. At Cameo, another power plant diverts water from the River, the water being returned to an irrigation canal. American Gilsonite Company has a plant west of Fruita discharging 100,000 gallons per day of effluent into the River.

Wastewater treatment plant effluents were entering the River along the entire length of the study area. Mechanical plants at Glenwood Springs, West Glenwood Springs, New Castle, Grand Valley, and Grand Junction; aerated lagoon systems at Rifle and De Beque; and Fruita with two lagoons in series were all discharging during the study period. Other lagoons at Talbot Mobile Home Trailer Park, Silt, Clifton #1, Clifton #2, and Palisade were not discharging during the sampling period.

SAMPLING LOCATIONS

Twenty-three sampling stations were established to determine causes and locations of chemical and biological changes occurring as the River flows west through the State (for exact station locations see Table 1). Other locations were sampled but were dropped from the program if changes in water quality were not shown.

Two stations, one below Dotsero and the second immediately upstream from Grizzly Creek, provide baseline information on the River as the water enters the study area. Other stations were established above and below sewage treatment plant effluents and/or the confluence of tributaries with the Colorado.

METHODS AND MATERIALS

Chemical

Sampling and analysis techniques in general adhere to practices described in "Standard Methods for Examination of Water and Wastewater", 13th edition, 1971. Water samples for chemical analysis were collected in two liter polyethylene containers. The mobile lab was equipped during this study to perform the following chemical and physical analyses; nitrate, nitrite, ammonia, orthophosphate, sulfates, chlorides, dissolved oxygen, residual chlorine, BOD, COD, alkalinities, hardnesses, pH, conductivity, and temperature. For precise methodology, see Appendix A.

Bacteriological

Samples for bacteriological analysis were collected in autoclaved wide mouth bottles with a metal screw-on cap. Millipore Filter Company methods and equipment were used to determine fecal coliform population counts.

Biological

Benthic fauna and algal collections were made and chlorophyl-a[2] production measured. For a methodology, see Appendix B.

ANALYTICAL RESULTS

Chemical

Results of the chemical and physical analyses from each station are tabulated separately in Tables 2 - 9. Historic data available for CR-7, CR-16, and CR-22 were tabulated to show monthly averages and one standard deviation, Tables 10 - 12.

The major change in the River during the sampling period was the onset of runoff in March and April, 1974. Data collected prior to March, when the bulk of the sampling took place, represents winter conditions of low flows and temperatures. Data collected in March and April of 1974 represent transitory conditions leading to the high water period of May and June. Stream flow data supplied by the U. S. Geological Survey (USGS) show flows increasing in late March and the first of April (see Table 13).

2 A sugar producing plant pigment.

Temperatures measured during the sampling period ranged from 32-59° F. Most stations sampled during December, 1973 to February, 1974 had temperatures of 32° F. The high temperatures of 59° F were recorded at stations in and around De Beque on September 26, 1973.

Dissolved oxygen concentrations (D.O.) generally exceeded 100% saturation. To compare night-time D.O. concentrations with daylight hours, twenty-four hour D.O. curves were determined for three stations, Tables 14 - 16. At Glenwood Springs, the largest fluctuation of 1.7 ppm (from 9.4 to 11.1) occurred. The D.O. rapidly increased during the early morning hours indicating primary productivity, the production and growth of plants, was taking place even in the cold months of winter. Farther downstream at CR-16, the Cameo Power Plant, the D.O. varied only 1/2 ppm indicating a lower rate of productivity. At no time during this twenty-four hour period on the Colorado River was a D.O. of less than 6.0 ppm measured. A D.O. of 6 ppm is the minimum recommended level for trout waters. Note that the Colorado River below Grand Valley is classified as B_2, warm water fisheries.

To further explore the possibility of significant variation in D.O. fluctuations in this stretch of the Colorado River, a dissolved oxygen study was conducted during September of 1974, Appendix C. Results of the two sample series were similar. No D.O. levels of less than 6 ppm were encountered. Upstream from De Beque, D.O. fluctuations of greater than 1.0 ppm existed in a twenty-four hour period at all stations. From the Cameo Power Plant downstream, all twenty-four hour D.O. fluctuations were less than or equal to 0.6 ppm. The possibility exists that the reaeration and photosynthetic rates for these two segments of the Colorado River are quite different.

Measurement of several parameters in the River indicative of dissolved salts (chloride, conductivity, alkalinity, hardness and sodium) followed a general pattern. Lower concentrations were obtained in the upstream reaches above Glenwood Springs. A rapid increase was noted immediately downstream from the springs in the Glenwood area followed by a gradual increase as the River flows west towards Grand Junction. Decreases in dissolved salts were measured below the confluences of both the Gunnison and Roaring Fork Rivers. To illustrate the above phenomenom, the average conductivities for each station from January to March, 1974 have been graphed in Figure 2.

Individual conductivities ranged from 529 umhos (micromhos) at CR-1 on April 1, 1974 to 1273 umhos at CR-20 on January 2, 1974. Specific conductivities in excess of 500 umhos is an indicator of highly mineralized waters but not necessarily degraded water.

Alkalinity determinations increased at a slower rate than other chemical constitutents of the water. There was about a one-third increase in alkalinities from Dotsero to the border while hardnesses increased up to 400%. The highest alkalinity concentration was 224 ppm at CR-3 immediately below the hot springs of Glenwood Springs on March 18, 1974. At CR-4, approximately three-fourths of a mile downstream from CR-3 and one-half mile downstream from the confluence of the Colorado and Roaring Fork Rivers, the alkalinity concentration was 120 ppm.

Chloride concentrations also varied extensively and rapidly. On March 18, 1974, the chloride concentration above the hot springs in Glenwood Springs was 32 ppm, below the springs 120 ppm, and below the Roaring Fork confluence 92 ppm. Below the confluence of the Gunnison and Colorado Rivers, the reduction of chloride *concentration and conductivity is more dramatic. Below Clifton at CR-17, chloride concentrations averaged 157 ppm. At CR-19, downstream from the Gunnison confluence, the chloride concentration on February 19, 1974 was 140 ppm on the north side of the River and 9 ppm on the south side of the River from which the Gunnison enters.*

Nutrient concentrations in the upper portion of the study area were usually too low to measure in December during the time of low, cold water. From CR-17 to CR-23 during the same period, nitrate concentrations of greater than 2.0 ppm were measured (see Figure 3). Detectable levels of nitrite nitrogen were also encountered, Tables 2 - 10. When runoff began and suspended solids increased, measurable amounts of nitrate, ammonia, and orthophosphate were encountered along the entire study area. Nitrite was not encountered during this period. For runoff nitrate results, see Figure 4.

As runoff increased, the concentrations of other constituents such as suspended solids and turbidities increased while chlorides, sulfates, alkalinity, and hardnesses decreased.

Efforts to determine 5-day BOD (biochemical oxygen demand) values for the River were unconclusive. Oxygen depletions were always less than 20% thus making numerical values invalid but indicating a very low oxidation rate in the River. On three occasions, BOD_5 tests were run in situ. Samples were placed in black BOD bottles and incubated in the River for five days. The results are listed as follows:

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Station	Date	Initial D.O. ppm	5-day D.O. ppm	BOD_5
CR-2	12/17/73	12.9	12.8	0.1
CR-4	12/17/73	12.8	12.6	0.2
CR-6	12/17/73	12.7	12.6	0.1

These results also represent less than 20% dissolved oxygen depletion and are inconclusive. However, the results do indicate that oxidizable material placed in the River during the winter months will take an inordinate amount of time to break down.

Chemical analysis of river sediments did not indicate any downstream patterns (see Table 17). Inspection of the data does demonstrate extremely high concentrations of phosphorus, up to 3.6 grams PO_4/Kg of sediment, and nitrogen, a maximum of 864 mg/Kg of sediment in the Colorado River substrate. Nitrogen in the suspended solids settles to the stream bottom and phosphate in the water absorbs rapidly directly onto the substrate or onto suspended matter and settles to the river bottom in eddies and pools. These nutrients in the sediments are generally available to plant life. With the immense concentrations of nutrients on the substrate and dissolved CO_2, moderate alkalinities and high dissolved oxygen flowing past, diatoms and filamentons algae rapidly colonize the river bottom forming the brown mat which covers the river bottom, both rocks and sediments.

Analysis of effluents from wastewater treatment plants and industrial discharges within the study area showed that only three facilities, Rifle, Grand Valley, and American Gilsonite were not violating any of the State Discharge Standards that were in effect at time of sampling (Table 18). BOD_5

values ranged from 18 mg/l at Grand Valley to 153 mg/l at De Beque. Dissolved oxygen measurements varied from zero at Glenwood Springs and West Glenwood Springs to 4.3 ppm at Grand Valley.

During the study period, the WWTP at West Glenwood was being rebuilt and expanded. A sample collected after the plant was at full operation on August 8, 1974, demonstrated that the facility was in compliance on all counts except residual chlorine. A sample collected the same day at New Castle indicated that the facility was well within the discharge standards except for a dissolved oxygen determination 0.2 ppm below the discharge standard. Comparison of data gathered upstream and downstream from the wastewater treatment plants gave no indication of measurable degradation of the Colorado River by the effluents.

Bacteriological

Results from the fecal coliform tests were tabulated along with physical and chemical data (see Tables 2 - 10). In only eight instances did counts exceed 100 organisms per 100 ml samples. At CR-5, downstream from the West Glenwood treatment plant, 110 organisms were counted February 1, 1974. Two hundred and twenty organisms per 100 mls were counted on September 26, 1973 at CR-7, 9, 10, 15, and 16. On January 30, 1974, 640 organisms per 100 ml were collected at CR-14 below the De Beque WWTP effluent. Three hundred and twenty organisms per 100 ml were in a sample from the River at Cameo on March 7, 1974. The remainder of bacterial analyses indicated populations less than 100 organisms/ 100 ml sample. State standards for B_1 waters require fecal coliform counts to be less than 1000 organisms per 100 mls.

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Historic data (Tables 10 - 12) show fecal coliform monthly averages ranged from 18 organisms/100 ml in February at CR-16 to 10,973 organisms/100 ml in July at CR-22. Further examination of historic data reveals that the standard deviation was greater than the mathematical average over 90% of the time indicating large variations may exist in numbers of fecal coliform present at any sampling location. The source of the bacteria is unknown.

Biological

The necessary quantity of benthic samples needed to compare various stretches of the river bottom has not been collected to date. Samples that have been collected indicate different insect communities inhabit different types of river substrate. A diverse group of insect larva inhabited all areas where the River provides a rubble substrate; Caddis fly, Mayfly, Stone fly, beetle, and Dipteran larva. In comparison, few organisms, both in species and number, inhabit the portions of the river substrate covered by sediments. Rocks that were covered by a thin brown sediment during the Fall provided suitable habitat for caddis flies of the family Hydropsychidae and mayflies of the genus Tricorythades sp. Even fewer organisms, both in species and numbers, inhabit the dense muck found on the river substrate. One species of caddis fly (Philopotamidae) not found elsewhere in the River and two mayfly species, Thraulodes sp. and Cynigma sp. were found on the muck-covered rocks down to the depth where the muck turned black. The odoriferous black muck appeared to provide a suitable habitat for only two species of Chironomidae (blood worm) Dipteran larvae. Both species possess a hemoglobin type blood, indicating a possible preference for an oxygen poor or oxygen lacking environment.

Eckman dredge samples from the Colorado River in the Grand Junction area revealed a substrate of sand and muck. The only larva collected were Chironomidae (blood worms) although adults of Baetis (mayflies) and Isogenus (stonefly) were observed emerging from the River. Larva of these two genera were collected elsewhere only on rubble covered substrates indicating this type of environment is present in the lower stretches of the Colorado River.

Algal growths covered most of the riffle areas examined above Rifle, Colorado. Lush, thick strands of Filamentons algae, Cladoporha sp. and Mougeotia sp. up to a foot in length were observed from October, 1973 through February, 1974 apparently surviving and functioning during the coldest period of the year.

The muck deposits on the river bottom were also examined for algal growth. The thin brown layer of matter at the water-sediment interface was found to be heavily colonized by diatoms. Microscopic strands of unidentified origin and composition held the diatoms and particulate material in a mat that could be lifted off the river bottom revealing the black muck underneath.

List of Diatoms Colonizing the Sediment Surface

1. *Nitzchia acicularis*
2. *Caloneis*
3. *Diatoma*
4. *Euglena*
5. *Cocconeis*
6. *Scenedrus quadricanda*
7. *Synedra*
8. *Nitzchia pelea*
9. *Gyrosigma*
10. *Oscillatoria*
11. *Navicula graciloides*
12. *Cymbella*
13. *Lyngbya*

Of these N. pelea is a polluted water species.

Periphyton studies were conducted at CR-2, CR-4, and CR-8. Slides were submerged in the River from January 4, 1974 through January 28, 1974. Results are listed below:

Station	Chlorophyl A mg/m^2	Organic Matter mg/m^2	Autotrophic Index[1]
CR-2	0.00	345	0
CR-4	1.04	1527	1467
CR-8	0.00	915	0

The index obtained at CR-4 suggests the presence of a community containing a large number of heterotrophic, non-oxygen producing organisms. Communities of this nature indicate an enriched environment with an abundance of food material, specifically the nutrient enriched sediments.

1 Autotrophic Index - For definition, see Appendix B.

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Figure I

COLORADO RIVER

STUDY AREA

Sampling Station Locations

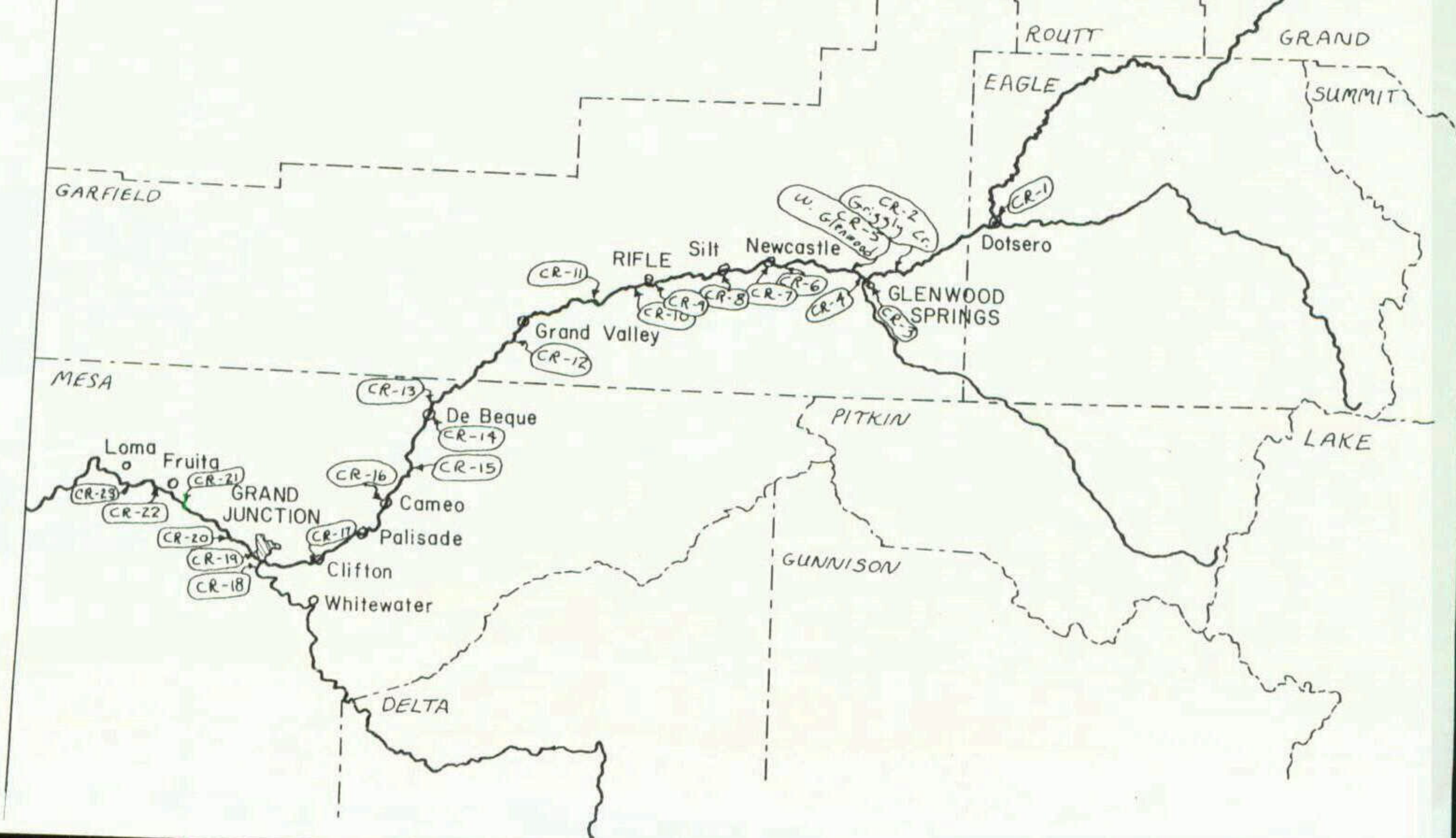

Figure 2

CONDUCTIVITY in the COLORADO RIVER

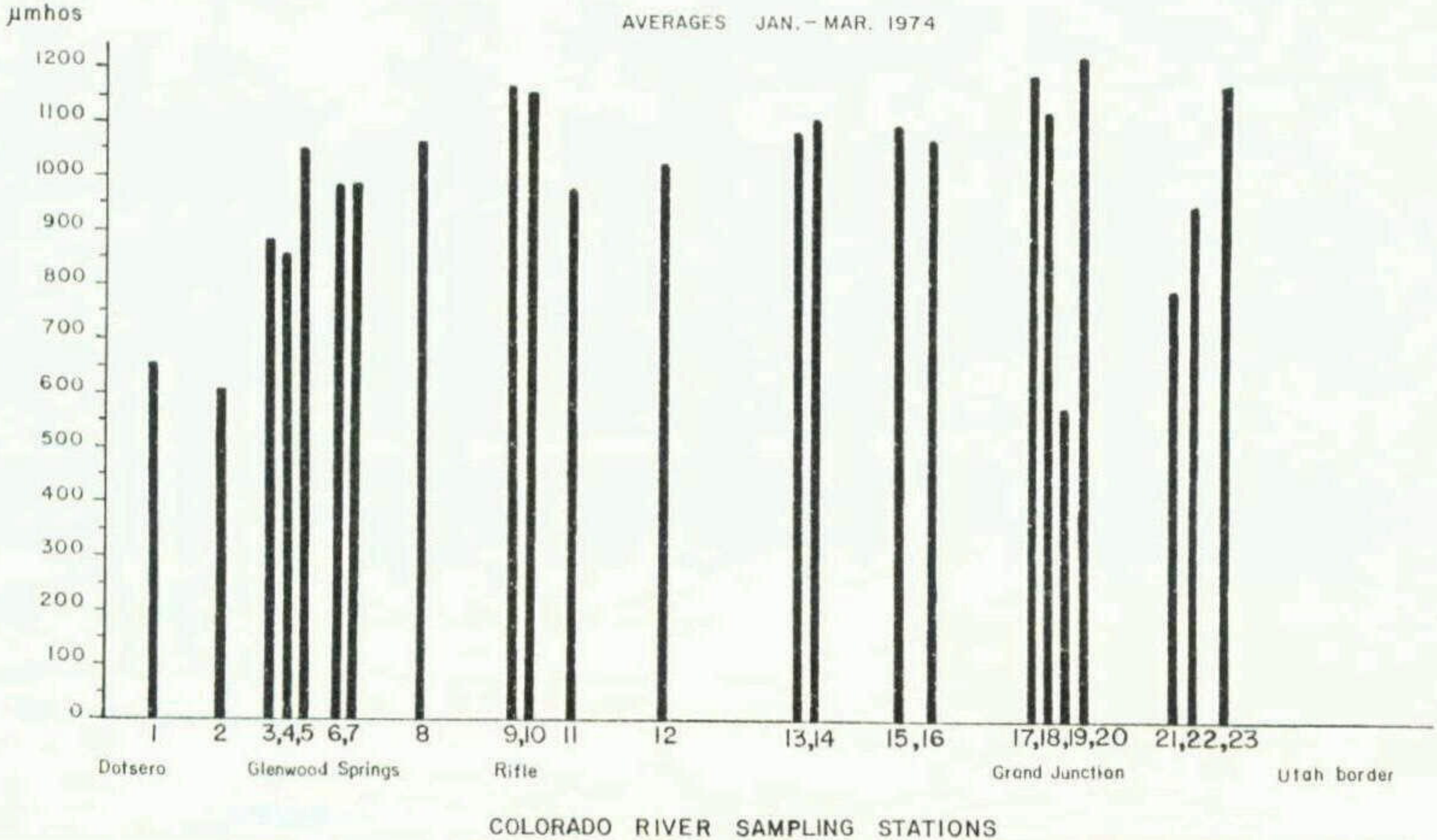

Figure 3

COLORADO RIVER

Nitrate Concentrations

December, 1973

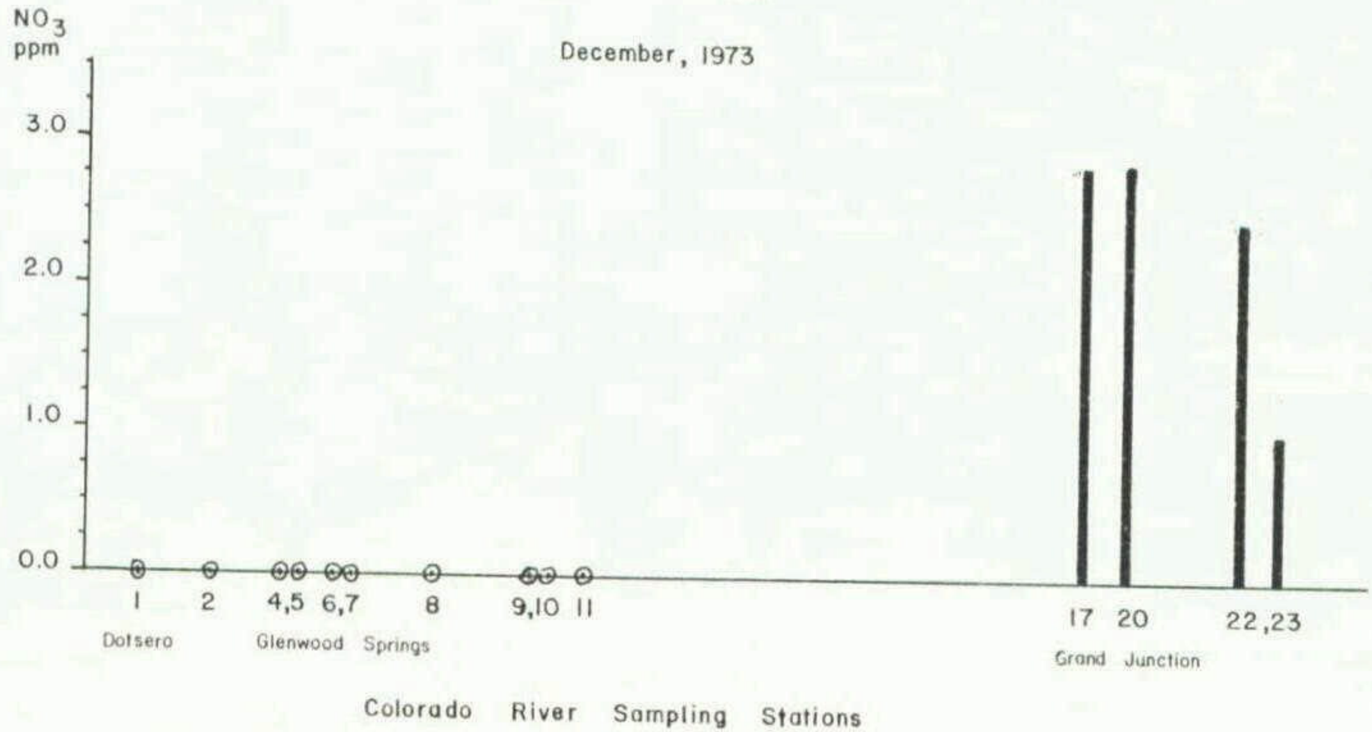

Figure 4

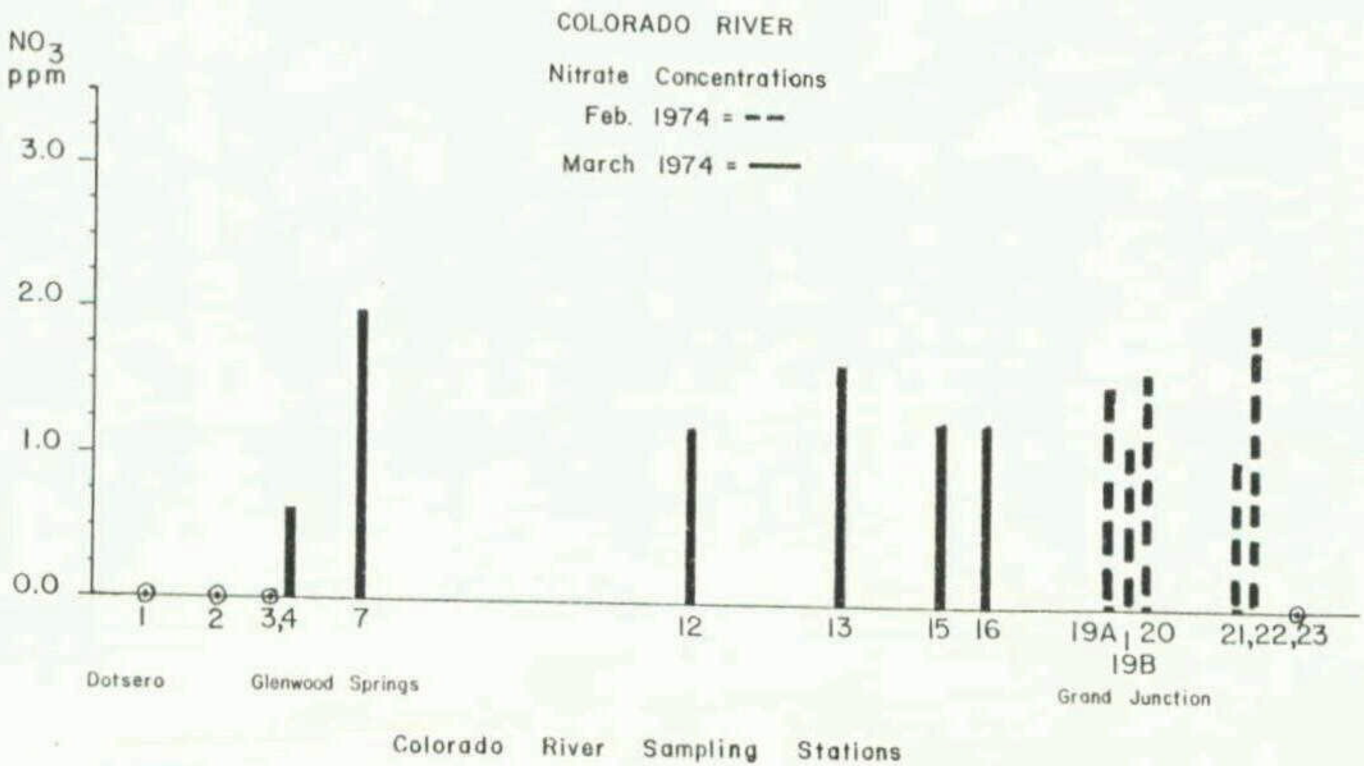
COLORADO RIVER
Nitrate Concentrations
Feb. 1974 = – –
March 1974 = ——
NO_3 ppm
3.0
2.0
1.0
0.0
1
2
3,4
7
12
13
15
16
19A
19B
20
21,22,23
Dotsero
Glenwood Springs
Grand Junction
Colorado River Sampling Stations

TABLE I

SAMPLING STATIONS DESCRIPTIONS

COLORADO RIVER

1.	West of Dotsero	Colorado River 5.1 miles west of the U.S. Highway 6 Bridge that crosses the river at Dotsero, Colorado. A sign reading, "Caution Falling Rocks", on the north side of the road marks the exact location. Elevation - 6,045 feet.
2.	Grizzly Creek	The Colorado River at Grizzly Creek in DeBeque Canyon. A small statue commemorating D.R.G.W. Vista Dome Cars marks the exact location. Elevation - 5,746 feet.
3.	Above Glenwood	Colorado River at Sheriff's office on south bank of the river. Elevation - 5,746 feet.
4.	Glenwood Springs	Colorado River at Coors Warehouse in Glenwood Springs. Going west on Frontage Road paralleling I-70 out of Glenwood, take first left after passing the Restwell Motel. Cross over I-70 and the Colorado River and follow the first dirt road west to the Coors Warehouse. Elevation - 5,746 feet.
5.	West Glenwood	Colorado River, by I-70, 440 yards downstream from the sewage treatment plant. The treatment plant is 0.3 miles west of the I-70 West Glenwood exit. Elevation - 5,746 feet.
6.	East of New Castle, Colorado	Colorado River at bridge immediately south of I-70 New Castle Exit. Elevation - 5,550 feet.
7.	New Castle, Colorado	Colorado River 200 feet below confluence of West Elk Creek and Colorado River. Elevation - 5,550 feet.
8.	Silt, Colorado	Colorado River at I-70 exit to Silt. Turn left and follow cross-road to frontage road. Follow frontage road east 1/4 mile to side road leading to a bridge that crosses the river. The bridge is visible from the frontage road. Elevation - 5,432 feet.
9.	Rifle, Colorado	Colorado River above effluent from Rifle sewage treatment plant. Treatment plant is south of U.S. Highway 6 opposite La Donna Motel. Sampling location is directly south of brick treatment plant building. Elevation - 5,345 feet.
10.	Rifle, Colorado	Colorado River below Rifle treatment plant effluent. 400 yards downstream from station 8. Elevation - 5,345 feet.
11.	Anvil Points Oil Shale Facility	Colorado River approximately 5 miles west of Rifle, Colorado on U.S. Highway 6. At intersection turn left, across tracks to the dead-end. Sample below lagoon effluent. Elevation - 5,265 feet.
12.	Below Grand Valley	Colorado River 5 miles below Grand Valley. Turn left at intersection sample at one lane bridge. Elevation - 5,037 feet.
13.	Above DeBeque, Colorado	Colorado River where U.S. Highway 6 Bridge crosses river at DeBeque, Colorado. Elevation - 4,935 feet.
14.	DeBeque Treatment Plant	Colorado River below treatment plant effluent. Go west on W road off U.S. Highway 6 at DeBeque, Colorado, take first left after old suspension bridge. This road leads to plant. Elevation - 4,935 feet.
15.	DeBeque Canyon	Colorado River 3.2 miles east of Plateau Creek. Elevation - 4,877 feet.
16.	Cameo Power Plant	Colorado River at I-70 Cameo exist. Elevation - 4,820 feet. *Elevation - 4860 feet*
17	Clifton	Colorado River below Clifton Wastewater Treatment Facilities at 32 Road, (Colo. Highway 146) bridge. *Elevation - 4710 feet*
18	Gunnison above Confluence	Gunnison River above confluence with Colorado River of bridge near 253/4 and C Roads. *Elevation - 4586 feet*
19	Above Grand Junction	Colorado River above Grand Junction Waste-water Treatment Facility at Grand Avenue. (Colorado Hinhway 340) bridge. *Elevation - 4586 feet*
20	Below Grand Junction	Colorado River approx. 1/2 mile below Grand Junction Wastewater treatment facility on River Road. *Elevation - 4586 feet*
21	Colorado River Above Fruita	Colorado River above Fruita wastewater treatment facility at Colorado Highway 340 bridge. *Elevation - 4998 feet*
22	Below Fruita	Colorado River approximately 1/4 mile below Fruita wastewater treatment facility - between little salt creek and big salt creek. *Elevation - 4995 feet*
23	Loma	Colorado River south of Loma on 13 Road (Colorado Highway 139)near Horsethief Bottom

TABLE 2

Station No.	CR-1						CR-2				CR-3
Location	Colorado River West of Dotsero						Colorado River at Grizzly Creek				Colo. River in Glenwood Springs above Roaring Fork
Date	9-25-73	10-30-73	12-19-73	1-19-74	3-6-74	4-1-74	9-25-73	10-3-73	12-12-73	3-18-74	3-18-74
Temperature ^{o} F	50.0	46.0	32.0	32.0	37.4	44.6	51.8	53.6	32.0	41.9	43.7
Dissolved Oxygen ppm O_2	9.1	11.8	12.8	12.9	11.2	10.1	9.1	8.9	12.9	11.7	11.7
pH Value			8.1	7.8	8.6	8.1			8.2	8.1	8.2
Total Alkalinity ppm HCO_3			120	98	104	98			110	100	224
Phenolphthalien Alkalinity ppm CO_3			0	0	0	0			0	0	0
NO_3 as N ppm	0		0	0.5	0	2.8	0	0	0	0	0
NO_2 as N ppm	0		0	0	--	0	0	0	0	0	0
NH_3 as N ppm			0	0	--	0			0	--	--
Orthophosphate as P ppm	0.2		0	0	0	0	0	0	0	0	0
Total Hardness as $CaCO_3$ ppm			252	144	144	124			224	152	152
Calcium Hardness as $CaCO_3$ ppm				124	140	120				128	144
Magnesium as Mg ppm				5	1	1				6	2
Turbidity FTU	3		3.5	4.5	5.5	32	4	18	5.5	78	101
Conductivity umhos			740	662	675	529			620	597	860
Suspended Solids mg/l					21	63					223
Volatile Solids mg/l					21	7					24
Chlorides as Cl^- ppm				96	38	54				32	120
Sulfates as $SO_4^=$ ppm				135	62	75				64	78
Fecal Coliform col/100 ml						<20					
BOD_5 mg/l			0.4						0.4		

TABLE 3

Station No.	CR-4							CR-5			
Location	Colorado River at Coors Warehouse in Glenwood Springs							Colorado River at West Glenwood Springs, Colo.			
Date	9-25-73	10-3-73	12-12-73	1-18-74	3-6-74	3-18-74	4-1-74	9-25-73	10-3-74	12-12-73	2-1-74
Temperature ^{o} F	51.8	55.4	32.0	33.8	39.2	42.8	44.6	53.6	55.4	33.8	33.8
Dissolved Oxygen ppm O_2	9.7	9.4	12.8	13.3	12.1	11.7	10.2	10.5	9.1	13.3	12.5
pH Value			8.1	8.1	8.3	8.2	8.1			8.1	7.9
Total Alkalinity ppm HCO_3			128	112	116	120	122			134	126
Phenolphthalien Alkalinity ppm CO_3			0	0	0	0	0			0	0
NO_3 as N ppm		0	0	0.8	0	1.2	1.0	0		0	0.5
NO_2 as N ppm		0	0	0	0	0	0	0		0	0
NH_3 as N ppm			0	0	0	0	--	0		--	0.3
Orthophosphate as P ppm		0.1	0	0	0	0	0	0.4		0	0.4
Total Hardness as $CaCO_3$ ppm			228	216	188	180	164			228	228
Calcium Hardness as $CaCO_3$ ppm				172	188	180	140				212
Magnesium as Mg ppm				11	0	0	6				4
Turbidity FTU		19	2.6	4.1	4.2	57	57	4		3.6	2.0
Conductivity umhos			760	1002	928	732	723			900	1042
Suspended Solids mg/l					10	131	98				9
Volatile Solids mg/l					6	18	9				
Chlorides as Cl^- ppm				136	148	92	80				198
Sulfates as SO_4 ppm				180	85	87	90				123
Fecal Coliform col/100 ml				70			50				110
BOD_5 mg/l			1.0							1.2	
Sodium ppm											225
COD mg/l											< 30

TABLE 4

Station No.	CR-6				CR-7				CR-8		
Location	Colorado River East of New Castle, Colo.				Colorado River at New Castle				Colorado River at Silt, Colorado		
Date	9-25-73	10-3-73	12-12-73	2-1-74	9-25-73	10-3-73	12-12-73	1-30-74	12-11-73	1-19-74	1-30-74
Temperature ^{o} F	49.1	54.5	32.0	32.0	55.4	57.2	32.0	33.8	32.0	33.8	32.0
Dissolved Oxygen ppm O_2	9.0	8.6	12.7	11.9	9.7	8.8	12.2	11.5	12.8	13.0	12.3
pH Value			8.3	7.9			8.3	7.4	8.3	8.1	8.2
Total Alkalinity ppm HCO_3			130	108			138	146	138	124	130
Phenolphthalien Alkalinity ppm CO_3			0	0			0	0	0	0	0
NO_3 as N ppm		0	0	0			0	1.2	0	0.8	0.5
NO_2 as N ppm		0	0	0			0	0	0	0	0
NH_3 as N ppm		--	0	0.2			0	0.3	0	0	0
Orthophosphate as P ppm		0	0	0.2			0	0.2	0	0	0.2
Total Hardness as $CaCO_3$ ppm			332	220			276	309	236	232	236
Calcium Hardness as $CaCO_3$ ppm				174				293		188	185
Magnesium as Mg ppm				11				4		12	12
Turbidity FTU		20	8.2	2.0			3.0	4.0	31	2.0	2
Conductivity umhos			830	991			800	991	830	1018	1119
Suspended Solids mg/l				8.0				10			
Chlorides as Cl^- ppm				198				126		178	214
Sulfates as SO_4 ppm				124				185		180	130
Fecal Coliform col/100 ml				54	220			63			$<$ 20
BOD_5 mg/l			0.4				1.4		0.5		
Sodium as Na ppm				220				170			240
COD mg/l				$<$ 30				$<$ 30			$<$ 30

TABLE 5

Station No.	CR-9			CR-10			CR-11			
Location	Colo. River above Rifle WWTP Effluent			Colorado River below Rifle WWTP Effluent			Colorado River at Anvil Point			
Date	9-26-73	12-12-73	1-30-74	9-26-73	12-12-73	1-30-74	9-26-73	12-12-73	1-17-74	1-30-74
Temperature ^{o} F	51.8	32.0	32.0	51.8	32.0	32.0	53.6	32.0	32.0	32.0
Dissolved Oxygen ppm O_2	9.8	12.0	12.1	9.7	11.9	12.1	9.8	11.8	13.4	12.6
pH Value		8.1	8.1		8.4	8.1		8.3	8.2	8.2
Total Alkalinity ppm HCO_3		144	148		154	150		156	128	134
Phenolphthalien Alkalinity ppm CO_3		0	0		24	0		0	0	0
NO_3 as N ppm		0	0		0	0.5		0.8	1.0	0.5
NO_2 as N ppm		0	0		0	0		0	0	0
NH_3 as N ppm		0	0.38		0	0.92		0	0	0.3
Orthophosphate as P ppm		0	0.2		0	0.2		0	0	0.2
Total Hardness as $CaCO_3$ ppm		332	247		260	247		340	248	243
Calcium Hardness as $CaCO_3$ ppm			205			193			188	208
Magnesium as Mg ppm			10			13			15	9
Turbidity FTU		2.7	5		3.1	5		2.6	1.7	2.0
Conductivity umhos		830	1166		840	1166		860	960	1073
Suspended Solids mg/l			17			16				8
Chlorides as Cl^- ppm			220			220			166	190
Sulfates as $SO_4^=$ ppm			146			152			200	143
Fecal Coliform col/100ml	220		< 20	220		79	22			< 20
BOD_5 mg/l		0.8			0.8			0.5		
Sodium as Na ppm			250			245				220
COD mg/l			< 30			< 30				

TABLE 6

Station No.	CR-12					CR-13				
Location	Colorado River below Grand Valley, Colorado					Colorado River above De Beque, Colorado				
Date	9-26-73	10-4-73	1-17-74	1-30-74	3-31-74	9-26-73	10-4-73	1-17-74	1-30-74	3-6-74
Temperature ^{o} F	55.4	55.4	32.0	32.0	44.6	59.0	42.8	32.0	32.0	44.6
Dissolved Oxygen ppm O_2	9.4	9.5	13.2	12.4	10.1	9.3	10.5	13.4	12.1	11.9
pH Value			8.1	8.2	8.1			8.1	8.2	8.2
Total Alkalinity ppm HCO_3			138	124	124			136	148	144
Phenolphthalien Alkalinity ppm CO_3			0	0	0			0	0	0
NO_3 as N ppm			1.0	0.5	1.2	0	0	1.0	0.5	1.6
NO_2 as N ppm			0	0	0	0	0	0	0	--
NH_3 as N ppm			0	0.28	--			0	0.38	--
Orthophosphate as P ppm			0	0.3	0	0.2	0.2	0	0.4	0
Total Hardness as $CaCO_3$ ppm			248	251	176			248	251	212
Calcium Hardness as $CaCO_3$ ppm			192	220	160			180	216	204
Magnesium as Mg ppm			14	8	4			17	9	2
Turbidity FTU			2.6	3.0	49.0	4	8	2.6	6	34
Conductivity umhos			1114	1061	841			1133	1026	1086
Suspended Solids mg/l				11	91				16	72
Volatile Solids mg/l					7					24
Chlorides as Cl^- ppm			196	185	164			204	184	178
Sulfates as SO_4^- ppm			210	147	100			200	149	100
Fecal Coliform col/100 ml	38			< 20	27	< 22			< 20	
Sodium as Na ppm				230					230	
COD mg/l				< 30					< 30	

TABLE 7

Station No.	CR-14				CR-15					CR-16	
Location	Colorado River below De Beque, Colorado WWTP Effluent				Colorado River in De Beque Canyon					Colorado River at Cameo	
Date	9-26-73	10-4-73	1-17-74	1-30-74	9-26-73	10-4-73	1-10-74	3-7-74	4-3-74	9-26-73	3-7-74
Temperature ° F	59.0	57.2	32.0	32.0	59.0	55.4	RIVER FROZEN	41.0	44.1	59.0	41.0
Dissolved Oxygen ppm O_2	9.3	9.6	13.4	12.2	9.5	9.5		10.4	10.2	9.4	10.7
pH Value			8.1	8.2				8.1	8.3		8.1
Total Alkalinity ppm HCO_3			140	134				148	116		172
Phenolphthalien Alkalinity ppm CO_3			0	0				0	8		0
NO_3 as N ppm		0	1.0	0	0	0		1.2	1.0		1.2
NO_2 as N ppm		0	0	0	0	0		0	0		0
NH_3 as N ppm			0	0.5				0.32	0.41		0
Orthophosphate as P ppm			0	0.2	0.2	0.2		0.8	0		0
Total Hardness as $CaCO_3$ ppm			260	251				220	208		252
Calcium Hardness as $CaCO_3$ ppm			220	216				212	188		248
Magnesium as Mg ppm			10	9				2			1
Turbidity FTU		8	3.0	6.0	7	12		85	130		89
Conductivity umhos			1162	1073				1100	936		1076
Suspended Solids mg/l				20				164	291		220
Volatile Solids mg/l								34	19		21
Chlorides as Cl^- ppm			196	184				170	148		160
Sulfates as $SO_4^=$ ppm			180	149				80	78		88
Fecal Coliform col/100ml	38			640	220	22		60	50	220	320
Sodium as Na ppm				245							
COD				< 30							

TABLE 8

Station No.	CR-17			CR-18	CR-19a	CR-19b	CR-20		
Location	Colorado River below Clifton Lagoons			Gunn. River just above Colo. River Confluence	Colo. R. at Grd. Jct. Hwy. 340 Br. North Side	Colo. River at Grd. Jct. 340 Bridge South Side	Colorado River below Grand Junction WWTP Effluent		
Date	12-17-73	1-2-74	4-16-74	2-19-74	2-19-74	2-19-74	12-17-73	1-2-74	2-19-74
Temperature $^{\circ}$ F	33.8	32.0	53.1	35.6	32.0	33.8	32.0	32.0	32.0
Dissolved Oxygen ppm O_2	12.3	13.2	11.3	11.7	12.1	11.6	12.2	13.1	11.8
pH Value	8.3	8.3	8.4	69	8.0	7.1	8.4	8.4	8.0
Total Alkalinity ppm HCO_3	162	170	140	124	164	116	180	156	144
Phenolphthalien Alkalinity ppm CO_3	20	28	20	0	0	0	20	24	0
NO_3 as N ppm	2.78	1.4	1.0	1.8	1.6	1.0	2.78	2.36	2.6
NO_2 as N ppm	0.02	0.02	0	--	--	--	0.32	0.04	--
NH_3 as N ppm	0	0	--	--	--	--	0	0	--
Orthophosphate as P ppm	0	0	0	0	0	0	0	0	0
Total Hardness as $CaCO_3$ ppm	420	248		200	264	164	444	356	312
Calcium Hardness as $CaCO_3$ ppm				144	216	152			232
Magnesium as Mg ppm				13	12	2			19
Turbidity FTU	5.5	90	20	50	225	95	5.5	10.0	170
Conductivity umhos	900	1207	1105	516	1148	527	1000	1273	1251
Suspended Solids mg/1		63		50	92	40		59	68
Volatile Solids mg/1				23	26	15			17
Chlorides as Cl^- ppm		176	138	8	140	9		134	244
Sulfates as $SO_4^=$ ppm		196	180	160	190	90		325	250
Fecal Coliform col/100 ml				20	29				57
COD mg/1		< 30							

TABLE 9

Station No.	CR-21	CR-22			CR-23	
Location	Colo. River above Fruita	Colorado River Below Fruita Lagoons			Colorado River at Loma, Colorado	
Date	2-19-74	12-17-73	1-2-74	2-19-74	12-17-73	1-2-74
Temperature ^{o} F	33.8	32.0	32.0	33.8	32.0	32.0
Dissolved Oxygen ppm O_2	11.8	12.0	13.0	11.6	12.2	12.7
pH Value	8.1	8.3	8.4	8.0	8.4	8.4
Total Alkalinity ppm HCO_3	128	154	136	140	152	144
Phenolphthalien Alkalinity ppm CO_3	0	0	24	0	28	28
NO_3 as N ppm	1.0	2.37	2.08	2.0	0.98	2.48
NO_2 as N ppm	--	0.028	0.024	--	0.028	0.024
NH_3 as N ppm	--	0	0	--	0	0
Orthophosphate as P ppm	0	0	0	0	0	0
Total Hardness as $CaCO_3$ ppm	192	424	280	208	412	340
Calcium Hardness as $CaCO_3$ ppm	160			196		
Magnesium as Mg ppm	8			4		
Turbidity FTU	190	4.3	9.5	280	4.2	7.7
Conductivity umhos	796	940	1038	853	940	1180
Suspended Solids mg/l	64		78	89		64
Volatile Solids mg/l	19			22		
Chlorides as Cl^- ppm	72		70	73		72
Sulfates as $SO_4^=$ ppm	180		252	150		267
Fecal Coliform col/100 ml	20			24		

TABLE 10

CR-6 Colorado River at New Castle
(68/02/21 - 73/06/26) Historic Data

	Temperature	pH	D.O.	Conductivity	Turbidity	Total Hardness	NH_3	NO_2	NO_3	PO_4	Fecal Coliform	BOD_5
Jan.	32.8	8.1	9.1	1004	9.95	308	.04	.0025	.28	.1	3950	1.8
	.96	.6	.5	112	2.8	7.8	0	.0007	.11	0	1344	0
Feb.	36.3	8.0	11.2	1079	24.4	238	.03	.012	.27	.2	1585	2
	3.3	.6	2	148	33.2	10.4	.03	.018	.21	.2	2001	0
Mar.	42.3	8.4	10.2	925	155	254	.14	.007	.35	.13	1277	3.2
	5.5	0	3	99	183	36.1	.13	.009	.15	.1	1756	.8
Apr.	45.0	8.2	8.4	763	317	207	.11	.01	.3	.09	453	No
	1.4	.5	1.3	128	435	8.7	.15	0	.4	.03	64	Data
May	47.8	8.8	9.1	425	86	164	.01	.007	.33	.8	494	3.0
	6.4	.5	3	70	34	39.6	.02	.009	.22	.03	548	1.7
June	54.8	8.1	8.3	353	54.2	134	.09	.002	.26	1.4	2732	.63
	3.7	.6	2.3	116	51.8	22.1	.11	.003	.31	3.1	5651	.06
July	64.3	8.2	8.7	697	13.6	197	.04	.001	.5	.23	1106	.9
	3.3	.8	2.6	208	7	38.7	.05	.001	.71	.11	1561	0
Aug.	65.3	8.2	7.7	929	4.5	230	.21	.003	0	.1	6358	.8
	5.7	.5	2	72	1.1	53	.29	.004	0	0	11139	0
Sept.	58.5	8.4	8.1	873	15.9	265	.07	.009	.028	.1	6998	1.1
	3.1	.4	1.7	136	11.8	71.6	.08	.013	.044	.12	13100	.4
Oct.	51.4	8.3	9.8	820	8.9	283	.05	.006	.13	.075	1015	1.4
	6.0	.4	1.3	140	4.1	55.6	.08	.006	.19	.029	1361	0
Nov.	33.7	8.3	9.0	815	7.1	308	.05	.002	.27	.2	8334	2.0
	1.5	.6	1.6	187	2.9	7	.09	.002	.25	.26	11930	0
Dec.	34.5	8.1	9.4	832	30.8	350	.08	.004	.4	.075	1511	No
	3.0	.2	.5	184	31.5	82	.09	.001	.3	.035	2106	Data

Top Line - Monthly Average

Bottom Line - One Standard Deviation

TABLE 11

CR-16

Colorado River near Cameo
(68/01/11 - 73/05/17) Historic Data

	Temperature	pH	D.O.	Conductivity	Turbidity	Total Hardness	NH_3	NO_2	NO_3	PO_4	Fecal Coliform	BOD_5
Jan.	32.0	7.9	10.0	1232	80	259	.9	.047	1.05	.1	190	No
	0	.3	.7	257	11	5.7	.14	.046	.07	.14	198	Data
Feb.	34.3	7.9	11.0	1187	507	263	1.4	.012	.22	0	18	4.3
	3.2	.3	2.1	188	697	35	0	0	0	0	5.7	0
Mar.	41.7	7.8	10.4	1106	238	264	.55	.084	.72	.1	54	2.5
	3.4	.5	1.0	131	217	6.5	.32	.093	.39	.08	63	1.1
Apr.	47.8	8.1	7.7	857	55.5	223	.04	0	.5	.03	215	3.5
	3.9	.5	1.2	96	54.5	4.7	.06	0	.71	.04	214	0
May	53.5	8.7	7.4	430	238	155	.08	.094	.46	0	5570	4.0
	3.9	.3	2.7	88	155	21.5	0	.128	.2	0	7538	1.5
June	57.0	8.4	6.7	368	311	137	.21	.048	1.3	.1	438	1.4
	2.6	.3	1.4	158	224	33.6	.11	.029	1.9	.05	382	.8
July	68.0	9.0	6.5	795	24	224	.04	.05	.5	.15	61	No
	0	0	3.3	191	0	28.3	0	0	0	0	69	Data
Aug.	66.5	8.2	6.4	829	305	219	.25	.04	.2	.15	139	1.7
	5.4	.5	1.5	220	418	0	0	0	0	0	234	.9
Sept.	60.0	8.3	6.5	962	89	265	.03	.048	.42	.06	77	2.9
	3.8	.3	1.7	102	156	5.5	.04	.038	.32	.09	125	3.2
Oct.	54.2	8.1	7.7	991	142	266	.09	.093	.21	.09	36.3	.95
	6.2	.5	2.0	161	167	8.7	.11	.145	.19	.08	36	.64
Nov.	35.7	7.9	9.3	970	28.7	297	.45	.057	.51	.15	65	1.9
	3.5	.3	1.9	256	20.4	29.7	.39	.056	.19	.13	63	0
Dec.	34.0	8.4	8.6	1004	17.5	266	.3	.011	.91	.05	8.5	
	2	.3	.5	52	0	0	0	0	0	0	9.2	

Top Line - Monthly Average

Bottom Line - One Standard Deviation

66%

TABLE 12

CR-22

Colorado River near Fruita
(68/01/09 - 73/05/17) Historic Data

	Temperature	pH	D.O.	Conductivity	Turbidity	Total Hardness	NH_3	NO_2	NO_3	PO_4	Fecal Coliform	BOD_5
Jan.	32.5	8.0	9.0	1054	52	329	.6	.018	1.0	0	2000	No
	1.0	.5	.8	151	0	5.7	0	.004	.28	0	2533	Data
Feb.	38.0	8.0	10.2	1096	222	326	1.2	.016	.86	.1	2267	3.7
	2.6	.15	.9	257	266	61	0	0	0	.07	2325	0
Mar.	42.0	8.4	9.2	927	311	334	.24	.031	.39	.08	10194	2.95
	4.9	.8	1.8	534	336	40	.25	.021	.33	.05	12167	.93
Apr.	49.5	8.1	7.2	1008	107	323	.02	0	.9	.13	1463	2.1
	5.5	.6	1.7	175	8.5	56	.03	0	.9	.18	1471	0
May	54.7	8.3	8.5	639	275	192	.08	.29	.68	.28	9800	2.5
	6.4	.3	.3	221	87	45	.08	.47	.28	.11	12493	0
June	59.5	8.3	6.9	490	667	203	.13	.045	1.9	2.7	3298	1.5
	3.8	.4	1.4	163	511	70	.16	.022	2.2	3.1	3183	0
July	70.7	8.2	6.7	1140	155	320	.08	.072	2.6	.3	10973	1.4
	4.6	0	1.8	342	37	54	0	0	2.0	.14	14759	0
Aug.	69.8	8.2	7.3	958	229	463	0	.009	0	.1	2407	2.6
	6.1	.5	.6	473	313	142	0	0	0	0	3979	1.6
Sept.	60.6	8.2	6.3	1286	280	503	.09	.103	1.1	.09	7764	1.8
	4.7	.2	2.1	133	363	67	.14	.086	.58	.09	10001	0
Oct.	54.4	8.1	8.1	1135	192	549	.14	.037	.99	.12	10150	1.2
	6.2	.6	2.0	178	165	116	.1	.032	.33	.04	13606	.3
Nov.	40.0	8.0	7.2	1006	148	374	.23	.021	1.1	.15	1855	1.9
	5.2	.5	3.3	210	194	63	.03	.004	.37	0	1315	0
Dec.	35.0	8.6	8.5	937	8.7	364	.28	.021	.9	.12	3920	No
	3.8	.2	1.3	178	7.6	71	.25	.005	.4	.08	3609	Data

Top Line - Monthly Average
Bottom Line - One Standard Deviation

Call Monday
John Woodling 358 6111

TABLE 13

Colorado River Water Flow Data

Location		Date	Flow (cfs)
CR-1	West of Dotsero	9/25/73	1410
		10/30/73	1280
		12/19/73	2140
		1/19/74	1600 (estimated)
		3/6/74	1600 "
		4/1/74	1640
CR-2	At Grizzly Creek	9/25/73	1415
		10/3/73	1425
		12/12/73	1315
		3/18/74	1800
CR-3	Above Glenwood	3/18/74	1800
CR-4	Glenwood at Coors Warehouse	9/25/73	2120
		10/3/73	2220
		12/12/73	1840
		1/18/74	1800
		3/6/74	1720
		3/18/74	2610
		4/1/74	2530
CR-5	West Glenwood	9/25/73	2120
		10/3/73	2220
		12/12/73	1840
		2/1/74	1770
CR-6	East of New Castle	9/25/73	2140
		10/3/73	2240
		12/12/73	1855
		2/1/74	1785
CR-7	New Castle below Elk Creek	9/25/73	2150
		10/3/73	2300 (estimated)
		12/12/73	1900 "
		1/30/74	2000 "
		3/6/74	1800 "
CR-8	At Silt	12/11/73	1900 (estimated)
		1/19/74	2000 "
		1/30/74	2000 "
CR-9	Above Rifle STP	9/26/73	2190
		12/12/73	1900 (estimated)
		1/30/74	2000 "
CR-10	Below Rife STP	9/26/73	2190
		12/12/73	1900 (estimated)
		1/30/74	2000 "
CR-11	At Anvil Points	9/26/73	2190
		12/12/73	1900 (estimated)
		1/17/74	2000 "
		1/30/74	2000 "
CR-12	Below Grand Valley	9/26/73	2190
		10/4/73	2300 (estimated)
		1/17/74	2000 "
		1/30/74	2000 "
		4/1/74	2600
CR-13	Above De Beque	9/26/73	2190
		10/4/73	2300 (estimated)
		1/17/74	2000 "
		1/30/74	2000 "
		3/6/74	1800 "

(Continued)

TABLE 13 (Continued

Location		Date	Flow (cfs)
CR-14	Below De Beque STP	9/26/73	2380
		10/4/73	2500 (estimated)
		1/17/74	2200 "
		1/30/74	2200 "
CR-15	De Beque Canyon	9/26/73	2380
		10/4/73	2500 (estimated)
		1/10/74	2200 "
		3/7/74	2000 "
		4/3/74	2800 "
CR-16	At Cameo Power Plant	9/26/73	2500 (estimated)
		3/7/74	2150 "
CR-17	At Clifton	12/17/73	2150 (estimated)
		1/2/74	2000 "
		4/16/74	3200 "
CR-18	Gunnison River above Confluence with Colo. River	2/19/74	3400 (estimated)
CR-19	Above Grand Junction STP	2/19/74	5400 (estimated)
CR-20	Below Grand Junction STP	12/17/73	5530 (estimated)
		1/2/74	5470 "
		2/19/74	5400 "
CR-21	Above Fruita STP	2/19/74	5400 (estimated)
CR-22	Below Fruita STP	12/12/73	5550 (estimated)
		1/2/74	5500 "
		2/19/74	5400 "
CR-23	At Loma	12/17/73	5550 (estimated)
		1/2/74	5500 "

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TABLE 14

24 HOUR OXYGEN CURVE

COLORADO RIVER

Sampling Station CR-2

November 17-18, 1973

Time	Temperature ° C	D.O. ppm
0400	5.5	9.6
0600	"	9.7
0800	"	9.9
1000	"	10.2
1200	"	10.3
1400	"	10.4
1600	"	10.4
1800	"	9.9
2000	"	10.0
2200	"	10.0
2400	"	9.9
0200	"	9.9

TABLE 15

24 HOUR OXYGEN CURVE

COLORADO RIVER

Sampling Station CR-4

November 17-18, 1973

Time	Temperature ° C	D.O. ppm
0400	6.0	9.4
0600	"	9.4
0800	"	9.6
1000	"	10.1
1200	"	10.5
1400	"	10.8
1600	"	11.1
1800	"	10.0
2000	"	9.4
2200	"	9.4
2400	"	9.4
0200	"	9.4

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TABLE 16

24 HOUR OXYGEN CURVE

COLORADO RIVER

Sampling Station CR-16

November 17-18, 1973

Time	Temperature °C	D.O. ppm
0400	4.5	9.6
0600	4.5	9.9
0800	5.5	10.1
1000	6.0	10.0
1200	6.5	10.3
1400	6.0	10.4
1600	6.0	10.2
1800	6.0	10.1
2000	5.5	9.9
2200	5.5	9.9
2400	4.5	9.7
0200	4.0	9.7

TABLE 17

Sediment Analysis

Colorado River

Station	Date	Total P PO_4 mg/kg	TKN mg/kg	COD mg/kg	% Volatile Solids	Total Iron mg/kg
CR-1	12/21/73	600.0	0.51	1,300	0.21	--
	4/1/74	2200.0	34.00	12,400	--	8,4000
CR-2	11/1/73	2100.0	0	9,400	3.50	--
CR-4	4/1/74	1700.0	864.0	15,100	--	8,500
CR-12	4/1/74	3600.0	22.0	14,400	--	11,800
CR-13	11/1/73	1590.0	0	39,000	5.5	
	12/21/73	1600.0	0	13,000	3.4	
CR-15	10/4/73	3220.0	840	29,000	--	
	4/3/74	1400.0	685	4,100	--	5,900

TABLE 18

Colorado River Survey Wastewater Treatment Plants Sampling

Name of Facility	Date Sampled	Dissolved Oxygen ppm	Chlorine Residual ppm	Turbidity JTU	Settleable Solids %	BOD_5 mg/l	Nitrate NO_3 ppm	Nitrite NO_2 ppm	Ammonia NH_3 ppm	Orthophosphate PO_4 ppm
Glenwood Springs	1/2/74	0 *	0.117	16.0	0.5	32 *	→0	→0	18.0	21.6
West Glenwood Springs	1/2/74	0 *	0	40.0 *	1.0	>114 *	→0	→0	22.0	21.6
New Castle	8/28/74	3.4	>1.0 *	10	<0.1	8	--	--	1.5	33.0
	1/2/74	0.1 *	2.8 *	16.0	7.0 *	119 *	29	1.12	1.8	10.8
Rifle (Lagoons)	8/28/74	1.8 *	0	20	0.3	10	--	--	2.0	33
	1/10/74	2.7	0	10.0	<0.5	22	→0	→0	40.0	18.8
Grand Valley	1/10/74	4.3	0.1	1.8	<0.5	18	34.8	0.92	19.0	12.4
De Beque (Lagoons)	1/10/74	2.1	0.4	18.0	<0.5	153 *	→0	→0	73.0	16.8
Grand Junction	2/15/74	3.5	1.2 *	12.5	<0.5	30.0	0.72	0.21	52.0	20.8
Fruita (Lagoons)	3/19/74	2.8	0	32	<0.5	21.0	→0	→0	20.0	8.0
Gary Western Refining [1]	3/19/74	15.0	--	5.0	<0.1	8				

* = Violation of State Discharge Standards in effect Winter 1974.

1 = Did not violate permit conditions.

→0 = Concentrations were undetectable with methodology utilized. The determination is said to be approaching zero.

APPENDIX A

METHODOLOGY FOR CHEMICAL AND PHYSICAL ANALYSIS OF WATER SAMPLES

Streamside chemical analysis of each sample generally consisted of pH, dissolved oxygen (D.O.), temperature, conductivity, alkalinity, chloride ion and hardness determinations. If some of these analyses were deleted in the field, the work was done at a later time in the laboratory. The pH of the samples was determined with an Analytical Measurements pH meter Model 707B. Dissolved oxygen concentrations were arrived at by employing the azide modification of the Winkler titration method. Temperatures, in degrees Centigrade, were read directly from pocket thermometers held vertically in the river waters. Alkalinities were measured by titrating with 0.2N H_2SO_4 using phenolphthalein and mixed indicator to determine pH endpoints of 8.3 and 4.4 respectively. The chloride concentration, Cl^-, was arrived at by titration with 0.0141 N silver nitrate using potassium chromate as an indicator. Hardness concentrations were determined by titrating with 0.01 M EDTA (ethylenediaminetetraacetic acid). Total hardness and calcium hardness were determined directly using Calmagite and Hydroxynaphthal blue indicators. Magnesium, as ppm Mg^{++}, was calculated mathematically by subtracting the calcium hardness from the total hardness and multiplying by a correction factor of 0.2432.

Conductivities were measured on a Lab-Line portable conductivity meter and recorded as micromhos, (umhos), of conductance.

Turbidities were determined using a Hach turbidity meter, Model 2100A.

The remainder of the chemical analyses were performed in the mobile laboratory. BOD and COD were run according to methodology developed by the wet laboratory of the Colorado Department of Health, Denver offices.

Sulfate was measured by using a Hach Field Test Kit.

Colorimetric methods were utilized in all other chemical tests using Bausch & Lomb standard model "Spectronic 20" spectrophotometer.

Ammonia concentrations were determined by direct Nesslerization. Errors brought about by high turbidity levels were negated by determining the optical density (O.D.) of the sample before and after Nesslerization process. Deionized water was used to "zero" the "Spec 20" for the O.D. measurement prior to Nesslerization and a procedural blank was utilized for the same purpose before measuring the treated samples. The O.D. prior to Nesslerization is subtracted from the O.D. after treatment. The corrected figure is then translated into terms of mg NH_3/L.

Nitrite determinations were performed using the sulfanilic acid, naphthylamine hydrochloride method. Photometric compensation is used to negate high readings due to turbidity. The methodology is identical to the process described in the preceeding paragraph for ammonia.

Nitrate determinations were performed by evaporating 25 ml of sample, then phenodisulfonic acid treatment and pH adjustments with sodium hydroxide. The resulting sample was read on the Spec 20.

Orthophosphate was determined by the 1 amino, 2 naphthol, 4 sulfonic acid (ANS) method. Turbidity references were cancelled by testing a second aliquot of sample but substituting a strong acid for the ammonium molybdate solution.

Total phosphate was determined by the above method after fuming with nitric and sulfuric acid.

The "Spec 20" was "zeroed" on each sample rather than a procedural blank of deionized water.

APPENDIX B

METHODOLOGY FOR BIOLOGICAL ANALYSIS OF SAMPLES

Quantatative benthic samples were collected by using the most appropriate of three available methods. An Eckman Dredge was used on rare occasions in areas of water over a meter in depth with slow currents and a mud or sand substrate. The Surber Square Foot Sampler was used in shallow riffle areas. The sampler consists of a collapsible metal frame and a tapered net. In use, the metal frame was placed on the substrate; rocks and detritus were then dislodged from within the square foot area by hand. The current carried dislodged material into the net. In fast waters when increasing depth prohibited use of the Surber Sampler, a small mesh seine four feet in length was used. One person held the seine in place while the second man moved eight feet upstream and kicked over rocks and gravel of the substrate while moving down toward the seine. Dislodged material was swept into the net. The seine was then placed on the river bank and benthic organisms were picked rapidly from the seine for ten men minutes. The entire process was repeated three times. Whichever method was used, the material collected was preserved in 70% alcohol, taken to the laboratory, separated and identified. The number of species and number of individuals per species were recorded.

To augment the quantatative samples, qualatative samples were taken by handpicking of rocks and use of dip nets. Adult insects were taken with sweep nets.

Periphyton communities, micro-organisms that grow upon or become attached to submerged surfaces, were analyzed in terms of chlorophyl a, organism counts and dry weight of organic matter. Results were obtained from communities which had developed on glass slides placed below the surface of the River's waters for two weeks.

The optical density of acetone extracts of pigments from periphyton colonies which developed on submerged slides was measured with a spectrophotometer at 663 mm before and after acidification. Both chlorophyl a and pheophyten a, a degradation product of chlorophyl a, concentrations were calculated as described by Lorenzen, 1967.

The ratio between the organic matter and chlorophyl a was utilized to determine the condition of the periphyton. Normally, periphyton communities are dominated by algae. Discharge of degradable non-toxic organic wastes into surface waters usually results in a greater biomass of non-chlorophyllous, heterotrophic organisms than of algae which is reflected in a rise in the total biomass = chlorophyl a ratio. This ratio is termed the Autotrophic Index (Al) and may be calculated by the formula.

$$Al = \frac{\text{Biomass (dry weight organic matter)}}{\text{chlorophyl a}}$$

Where periphyton mass and chlorophyl a are expressed in mg/m^2 of surface area from which the sample was taken.

APPENDIX C

Oxygen Sag Study of Lower
Colorado River

Duration of study: September 16-19, 1974

Area of study: Lower Colorado River from a point at Dotsero, (Eagle Co.) to a point at Loma, (Mesa County).

Participants: Stanley V. May, Principal Engineering Technician
Neil H. Tripp, Engineering Technician

Weather: Clear, Daytime Temperature = $40^{\circ} - 65^{\circ}$ F - Nighttime = $30^{\circ} - 50^{\circ}$ F

On September 16-19, 1974, a study of the lower Colorado River was completed by the above named technicians. The purpose of the study was to determine if levels of dissolved oxygen sags in the River between daylight and nighttime hours, and if ammonia levels are significant. Fifteen stations were established as indicated (see attachment) and a minimum of three samplings taken at each location.

September 16 - 19, 1974

LOWER COLORADO RIVER SURVEY

FIELD DATA

LOCATION	DATE	TIME	TEMP	D.O.	pH	NH_3
CR-1	9/16	1330	14°C	8.2	8.4	0
	9/17	1535	14°C	8.6	8.3	-
	9/18	0250	13°C	8.0	8.0	-
CR-2	9/16	1415	14°C	8.6	8.2	0
	9/17	1500	14°C	8.6	8.3	-
	9/18	0215	14°C	8.2	8.1	-
	9/18	0325	14°C	8.2	8.1	-
CR-5	9/16	1525	15°C	9.2	8.1	0
	9/17	1405	15°C	9.4	8.4	-
	9/18	0145	13°C	8.0	7.8	-
	9/18	0350	14°C	7.8	7.8	-
CR-6	9/16	1550	14°C	9.4	8.4	0
	9/17	1345	14°C	9.0	8.2	-
	9/17	1635	16°C	9.2	8.3	-
	9/18	0125	13°C	8.0	7.9	-
	9/18	0410	13°C	8.0	7.9	-
	9/19	1210	16°C	9.4	8.2	-
CR-8	9/16	1615	15°C	9.8	8.8	0
	9/17	1325	15°C	9.9	8.5	-
	9/17	1655	16°C	8.6	8.4	-
	9/18	0100	14°C	7.4	8.1	-
	9/18	0425	13°C	8.0	7.8	-
CR-9	9/16	1635	16°C	9.1	8.5	-
	9/17	1305	16°C	9.6	8.4	-
	9/17	1720	17°C	8.9	8.4	-
	9/18	0030	14°C	7.5	8.4	-
	9/18	0445	14°C	8.0	8.0	-
CR-11	9/16	1715	15°C	9.3	8.4	-
	9/17	1245	14°C	9.0	8.3	-
	9/17	1800	16°C	8.8	8.5	-
	9/18	0015	15°C	7.8	8.5	-
	9/18	0510	13°C	8.4	7.8	-

3005

LOCATION	DATE	TIME	TEMP	D.O	pH	NH_3
CR-12	9/16	1750	16°C	8.6	8.3	0
	9/17	1220	14°C	9.0	8.3	-
	9/17	1820	16°C	8.6	8.1	-
	9/17	2345	15°C	8.1	8.3	-
	9/18	0530	15°C	8.3	8.2	-
CR-14	9/16	1820	16°C	8.5	8.4	-
	9/17	1200	16°C	9.0	8.3	0
	9/17	1850	16°C	8.9	8.3	-
	9/17	2325	15°C	8.0	8.2	-
	9/18	0550	14°C	8.4	8.1	-
CR-16	9/16	1855	15°C	8.8	8.5	-
	9/17	1110	15°C	8.8	8.4	-
	9/17	1920	16°C	8.8	8.5	-
	9/17	2250	16°C	8.2	8.3	-
	9/18	0615	15°C	8.5	8.3	-
CR-17	9/16	1920	17°C	8.4	8.4	-
	9/17	1050	16°C	8.0	8.2	-
	9/17	1940	17°C	8.4	8.4	-
	9/18	0645	16°C	8.2	8.3	-
CR-19	9/16	2000	17°C	8.3	8.3	0
	9/17	1020	17°C	8.0	8.2	
	9/17	2010	17°C	8.2	8.1	-
	9/18	0700	16°C	8.0	8.1	-
CR-22	9/16	2020	18°C	8.0	8.2	-
	9/17	0945	15°C	8.0	8.2	-
	9/17	2030	17°C	8.0	8.2	-
	9/18	0725	16°C	7.8	8.2	-
CR-23	9/16	2100	18°C	8.4	8.2	-
	9/17	0930	15°C	8.0	8.1	-
	9/17	2050	17°C	7.8	8.1	-
	9/18	0735	15°C	8.2	8.0	-
	9/19	0900	16°C	8.2	8.2	-

STATION LOCATIONS

CR-1	Colorado River at U.S. Geological Survey Gauge just below confluence with Eagle River - Dotsero.
CR-2	Colorado River at Confluence of Grizzly Creek - 100 feet above Glenwood Canyon.
CR-5	Colorado River at S. Canyon Road, Exit #22 west of Glenwood Springs.
CR-6	Colorado River at Bridge at New Castle.
CR-8	Colorado River at Bridge at Silt.
CR-9	Colorado River at Bridge at Rifle.
CR-11	Colorado River at Rulison Bridge at Anvil Points West of Rifle.
CR-12	Colorado River at Bridge on County Road 5 miles below Grand Valley.
CR-14	Colorado River at Bridge to Town of De Beque.
CR-16	Colorado River at Public Service Company Bridge - Cameo Power Plant.
CR-17	Colorado River at Bridge on Colorado Highway 146 south of Clifton, Colorado.
CR-19	Colorado River at Bridge on Colorado Highway 340 (Grand Avenue) in Grand Junction.
CR-22	Colorado River at Bridge on Colorado Highway 340 south of Fruita, Colorado. National Monument Road.
CR-23	Colorado River at R.P.S. Station #50, Loma, Colorado.