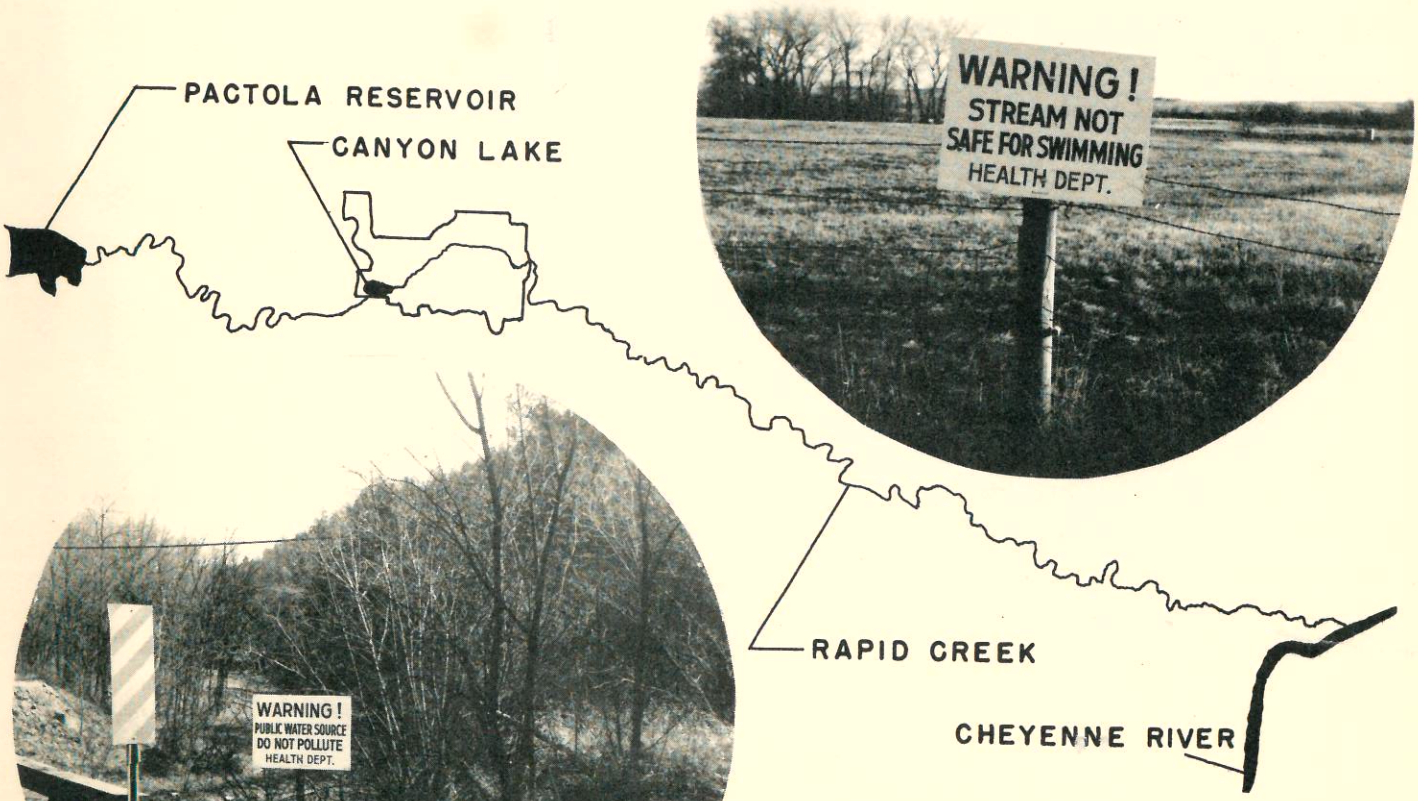
REPORT ON
WATER POLLUTION INVESTIGATION
RAPID CREEK - DEC., 1963
PACTOLA RESERVOIR TO CHEYENNE RIVER



1964

STATE DEPARTMENT OF HEALTH
DIVISION OF SANITARY ENGINEERING
PIERRE, SOUTH DAKOTA

South Dakota

State Department of Health

G. J. VAN HEUVELEN, M. D., STATE HEALTH OFFICER

Pierre

April 8, 1964

G. J. Van Heuvelen, M. D., Chairman Ex-Officio
and State Health Officer
Walter J. Fillmore, Director, Department of Game,
Fish and Parks
Lauren Davis, Chairman, Water Resources Commission
South Dakota Committee on Water Pollution
Pierre, South Dakota

Gentlemen:

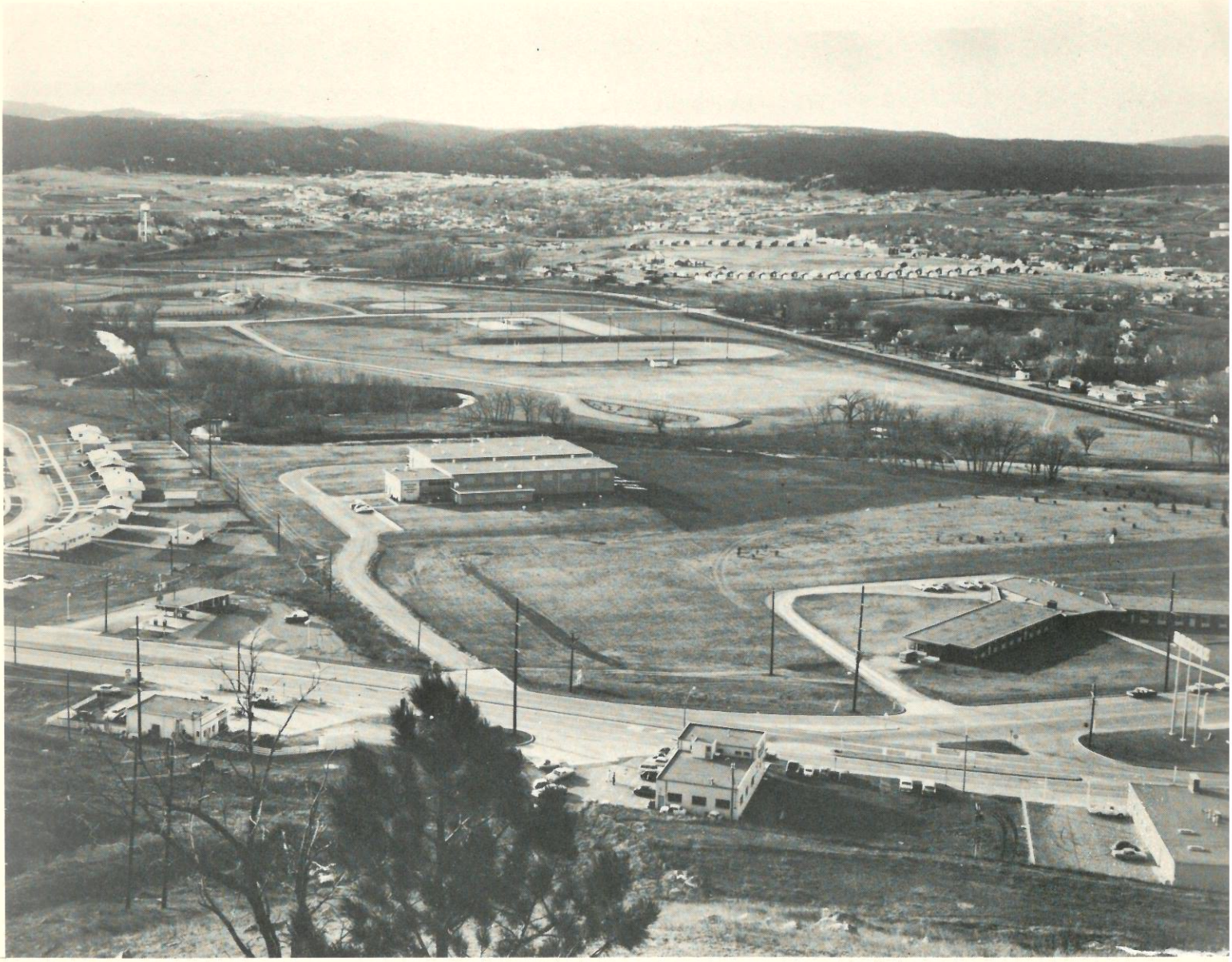
On November 15, 1963 the South Dakota Committee on Water Pollution ordered the Division of Sanitary Engineering, South Dakota State Department of Health, to make an investigation of pollution in Rapid Creek. The investigation has been completed and transmitted herewith is the report of these studies.

Responding to a request from Mayor Schroeder, Rapid City, dated March 31, 1964, a summary of the Report was prepared and submitted on April 8, 1964.

Respectfully submitted,

Charles E. Carl

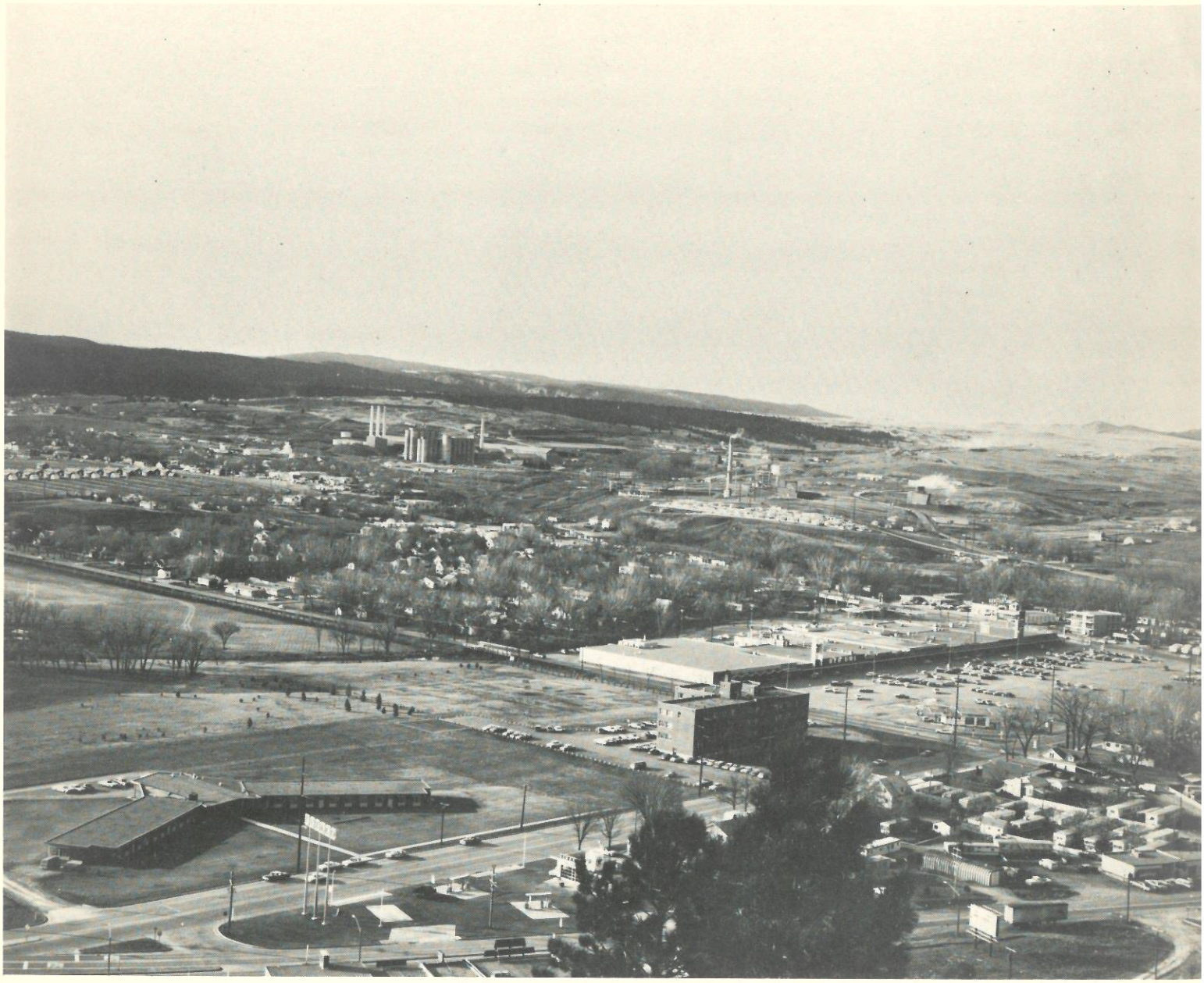
Charles E. Carl, Director
Division of Sanitary Engineering



RAPID CREEK - RAPID CITY SURFACE WATER PLANT (Center of Picture)

SWIMMING POOL - INDIAN HOSPITAL - CAMP RAPID - NURSING HOME - PARKS - HOMES

BLACK HILLS IN BACKGROUND TO THE WEST



SOUTH DAKOTA CEMENT PLANT - POWER PLANT - ROCK AGGREGATE INDUSTRIES

RAPID CREEK BEHIND BAKEN PARK SHOPPING DISTRICT

NURSING HOME AND HOSPITAL

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ACKNOWLEDGMENT

The Division of Sanitary Engineering gratefully acknowledges the interest, assistance and cooperation of many individuals and agencies during this study and report preparation. Region VI, Public Health Service, Kansas City, Missouri assisted with valuable suggestions and one field engineer. The Public Health Service Robert A. Taft Sanitary Engineering Center furnished a mobile laboratory, staffed with a chemist and a bacteriologist, in which most of the analytical work was done; and a biologist who supervised the biological study and furnished the biological report. The South Dakota Department of Game, Fish and Parks provided valuable information, furnished a sample collector, assisted with the biological study and took pictures. The Rapid City officials were most cooperative, particularly with assistance in preparing sampling stations near the wastewater treatment plant and with sample collections at the plant. The U. S. Geological Survey furnished flow data. The Pennington County Health Department assisted with sample collection, analytical analyses, glassware preparation and functioned as a general headquarters office.

SUMMARY

Acting upon requests from local citizens, Pennington County Board of Health, and city officials, a Rapid Creek pollution investigation was conducted between Pactola Reservoir and the Cheyenne River in December, 1963. Included in the investigation was an evaluation of Rapid City wastewater treatment. A special study of rural ground water wells, industries, commercial and private waste systems carried over into January and February, 1964.

Clean stream water quality in Rapid Creek was found above Rapid City. The sanitary and industrial wastes at Rapid City are only partially treated. Repeated by-passing of raw municipal wastes is contrary to health regulations. Improperly treated wastewater from municipal waste treatment facilities creates serious public health hazards and water-course degradation in the receiving stream. The physical, chemical, and biological quality of lower Rapid Creek waters precludes use of this water for safe beneficial purposes.

Although there was clean water quality in Rapid Creek above Rapid City, several isolated and scattered waste sources were located serving privately owned establishments or homes. Enough direct private wastewater connections to Rapid Creek exist to indicate rural development should not be ignored in the future. Active interest and support by local citizens and agencies are necessary to plan for healthy metropolitan and rural growth.

Deplorable water quality existed during the summer of 1963 when raw wastes entered Rapid Creek below Rapid City, South Dakota. The Rapid City wastewater treatment plant has been unable to properly protect receiving waters for several years and critical conditions exist now.

RAPID CREEK SURVEY REPORT

I. INTRODUCTION

The South Dakota Committee on Water Pollution on November 15, 1963 authorized the Division of Sanitary Engineering to make a study of pollution in Rapid Creek from the Pactola Dam to the Cheyenne River. This action followed receipt of a petition by Pennington County residents, requests from the Pennington County Board of Health and the City of Rapid City, and is in accord with South Dakota Statutes (Chapter 61.0142-61.0152 Supplement to the South Dakota Code of 1939). The investigation included Rapid Creek stream pollution and Rapid City municipal wastewater treatment plant efficiency studies December 3-12, 1963; and additional information on industrial wastes, private wastewater outlets and rural water wells was secured during January and February, 1964.

The ultimate purpose of the survey and report is to develop a comprehensive program to protect water resources and improve public health conditions in the Rapid Creek valley below Pactola Dam.

II. BACKGROUND

The bacteriological, chemical, and physical quality of Rapid Creek water have been checked during numerous investigations. The continued growth of the City of Rapid City, and extensive developments in the canyons and Rapid Creek valley, have created considerable local concern.

Rapid Creek drains the central portion of the Black Hills located in western South Dakota. Rapid City is located in the foothills and above a valuable irrigated area. The topography of the Rapid Creek drainage area varies from the steep, forested hills to the irrigated valley and grazing lands. The normal elevation of the Pactola Reservoir is 4,580 feet. Elevation at the Rapid Creek and Cheyenne River junction is approximately 2,400 feet. Elevation in Rapid City is approximately 3,200 feet. Rapid City has a population of approximately 50,000 persons. Approximately 2,000 persons reside in the rural irrigated area below the City. An equal number of persons will soon reside in the narrow canyon above Rapid City and close to the beautiful trout stream. (see reference No. 11)

Pactola Reservoir provides the major storage facilities for water supply in the area. The multiple use of water supply is an important part of development in the area. Water supply uses include domestic and municipal use, industrial water supply, irrigation, tourism, and other recreational uses including fishing, swimming, and boating. The Pactola drainage system in the western Black Hills includes two forks of Rapid Creek, Castle Creek, and the Deerfield Reservoir area. This survey was limited to the drainage area below Pactola Reservoir. Canyon Lake is a small reservoir located at the west edge of the City of Rapid City. Housing areas, parks, golf courses, industrial and commercial areas have been developed along the banks of Rapid Creek. The Rapid City municipal surface water treatment plant is located in Sioux Park below Canyon Lake. The municipal water use is supplemented by ground water sources.

The South Dakota Committee on Water Pollution conducted meetings at Rapid City on May 28-29, 1963 and on August 9, 1963 to discuss the need for adequate waste treatment facilities. The meeting in May 1963 was a joint meeting with the South Dakota State Public Health Advisory Committee. The resolutions and recommendations of these State Committees are included in Appendix C. Early completion of an adequate municipal waste treatment project and proper location of facilities were stressed. The Pennington County Health Department has installed warning signs on

PLATE NO. 1

RAPID CREEK ABOVE CANYON LAKE

(Note Erosion of Bank)

Rapid Creek. Rapid City has not installed adequate emergency chlorination equipment to increase protection for congested downstream housing or irrigated areas.

The Rapid City municipal waste treatment plant is a trickling filter facility with sludge digestion. The original municipal wastewater plant was constructed in 1934 with expansion projects completed in 1950 and 1953. The Rapid City officials received a preliminary report for waste treatment plant expansion or replacement from their consulting engineer, dated April 1962. Bond elections to finance the proposed project were defeated on February 19, 1963 and on September 10, 1963. Official recommendations of the State Department of Health were contained in a survey report covering the Rapid City waste treatment plant, dated May 21, 1963. The status of the Rapid City waste treatment plant project was discussed with South Dakota Governor Archie Gubbrud during a meeting held on October 21, 1963.

The Rapid Valley Water Service Company has been organized to serve public water supply to many rural citizens in Rapid Valley below the city. Most of the shallow private ground water supply wells in lower Rapid Valley are less than 50 feet deep.

III. SAMPLING STATIONS AND SCOPE OF INVESTIGATION

A. Rapid Creek Survey

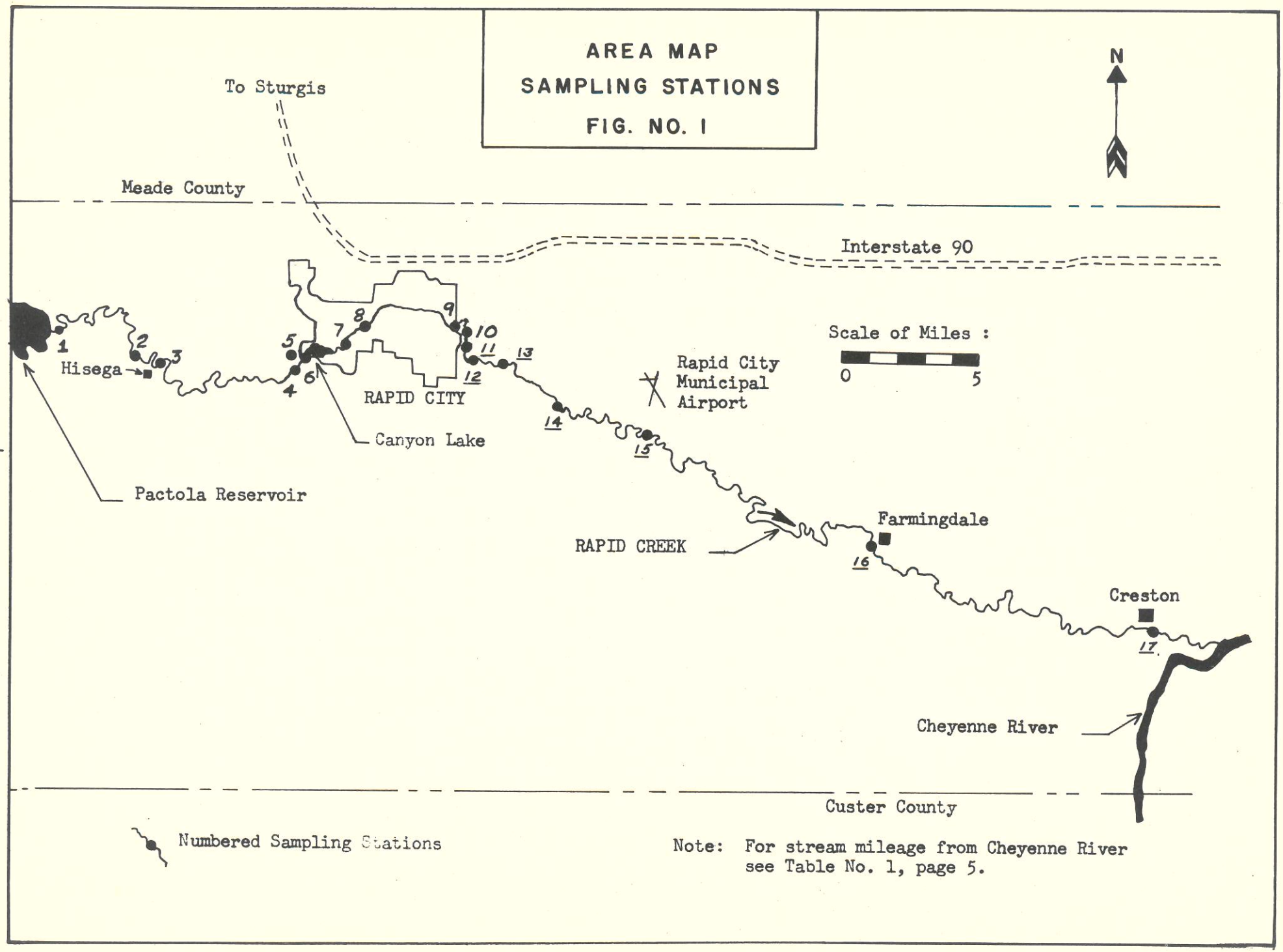
A total of 17 stream sampling stations were selected to cover the reach of stream study requested by local citizens and officials. Figure No. 1 is an area map showing the stream sampling station locations. Table No. 1 includes a description of each sampling station with the stream mileage and estimated stream flow during the sampling period. All sampling stations but one are located directly on the main stream of Rapid Creek. Station No. 5 was on a small tributary carrying the Fish Hatchery pond overflow water. Stream samples were collected between about 7 A.M. and 9 A.M. each morning for ten days during the survey period. The order of sampling was varied by the collectors and they noted and recorded any unusual stream or pollutional conditions. Survey crews walked along the bank of Rapid Creek through the congested areas to determine unauthorized waste discharges.

Analytical determinations were made in the field and in the mobile laboratory. Routine laboratory tests conducted include temperature, pH, dissolved oxygen, biochemical oxygen demand (B.O.D.), alkyl benzene sulfonate (A.B.S.) detergent, nitrate nitrogen, total coliform bacteria, and fecal coliform bacteria. Stream studies also included biological and radiological determinations.

Additional dissolved oxygen tests were completed from stream samples collected below Rapid City during the first two days of the survey. This concentrated sampling established that meaningful dissolved oxygen samples should be collected in the early morning hours.

B. Municipal Waste Treatment Evaluation

Twenty-four hour composite samples were collected each hour at the municipal wastewater treatment plant for a period of 8 days between December 4-12, 1963. The composite samples were kept under refrigeration during the entire 24 hour period. Sampling stations at the treatment plant included the raw (untreated),


AREA MAP
SAMPLING STATIONS
FIG. NO. 1
N
To Sturgis
Meade County
Interstate 90
Scale of Miles :
0
5
Hisega
RAPID CITY
Rapid City
Municipal
Airport
Canyon Lake
Pactola Reservoir
RAPID CREEK
Farmingdale
Creston
Cheyenne River
Custer County
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Numbered Sampling Stations
Note: For stream mileage from Cheyenne River see Table No. 1, page 5.

RAPID CREEK SURVEY
December 1963

SAMPLING STATIONS
STREAM FLOWS AND MILEAGE FROM CHEYENNE RIVER

TABLE NO. 1

Station Number	Stream Flow Est. Cu. ft./sec.	Station Description
1 (109.3)	16.3 *	Bridge directly below Pactola Reservoir
2 (101.3)	17	Bridge at Big Bend
3 (97.9)	17	Immediately below Hisega cabins
4 (87.9)	18.2 *	At Jackson Springs above Fish Hatchery
5 (87.6)	25	Fish Hatchery overflow above Canyon Lake **
6 (87.4)	25	Bridge above Canyon Lake within city limits
7 (86.7)	25	38th Street Bridge below Canyon Lake
8 (84.4)	27 *	Rapid City water treatment plant (Sioux Park area)
9 (79.4)	27	Campbell Street Bridge (east edge of city limits above Rapid City waste treatment plant)
10 (77.9)	27	Just above Rapid City waste treatment plant outlet
11 (77.6)	37	Just below Rapid City waste treatment plant outlet
12 (75.7)	37	Valley Drive bridge below city
13 (73.5)	37	Bridge at Valley Hi Country Club
14 (68.1)	37	County road bridge (Wm. Anderson home)
15 (61.9)	38	Rapid City Airport (bridge south of Airport road)
16 (34.7)	39.9 *	Bridge southwest of Farmingdale
17 (12.6)	42	Bridge at Creston on Hwy. 40 and above Cheyenne River junction

* Denotes approximate location of U. S. Geological Survey gauging stations where flows were measured on December 3, 1963. Flows at other stream stations estimated by U.S.G.S.

** Sampling station not located on Rapid Creek.

(Photo courtesy of Rapid City Daily Journal)

PLATE NO. 2

SAMPLING AT STATION NO. 11 - BELOW CITY WASTE OUTLET
TEMPORARY BRIDGE BUILT BY CITY WASTEWATER TREATMENT PLANT OPERATORS

(Photo Courtesy of Rapid City Daily Journal)

PLATE NO. 3

CHEMIST

U. S. PUBLIC HEALTH SERVICE MOBILE LABORATORY

primary effluent, and plant effluent discharged to Rapid Creek. Wastewater flow data was secured from the Parshall flume and continuous liquid level recorder operated by city personnel.

Figure No. 2 shows the wastewater treatment plant flow diagram. The final clarifier was not functioning during the survey because of lift pump failures.

Routine plant tests at all 3 stages included biochemical oxygen demand (B.O.D.), total and volatile suspended solids, temperature and pH. Total coliform bacteria and fecal coliform bacteria analyses were completed on only raw and plant effluent samples.

C. Special Private Well Study

A total of 22 private sources of ground water supply were investigated in Rapid Valley below the Rapid City wastewater treatment plant from December 31, 1963 through January 6, 1964. The well water survey included a physical evaluation of the well construction and location. Eighteen of the wells were reported as domestic water sources, 2 were State Water Resources Commission observation wells, and 2 were reported as livestock water sources.

Samples collected from the individual wells were tested in the laboratory for one bacteriological and two chemical determinations. The standard drinking water or coliform bacteria tests were completed in the Pennington County Health Department laboratory for all but the 2 observation wells. Chemical tests for A.B.S. detergent and nitrate nitrogen were carried out on all 22 samples.

D. Tests and Their Significance

All examinations and analyses were made in accordance with the basic procedures set forth in the Standard Methods for the Examination of Water and Wastewater, 11th Edition, 1960, of the American Public Health Association, American Water Works Association, and Water Pollution Control Federation.

Temperature

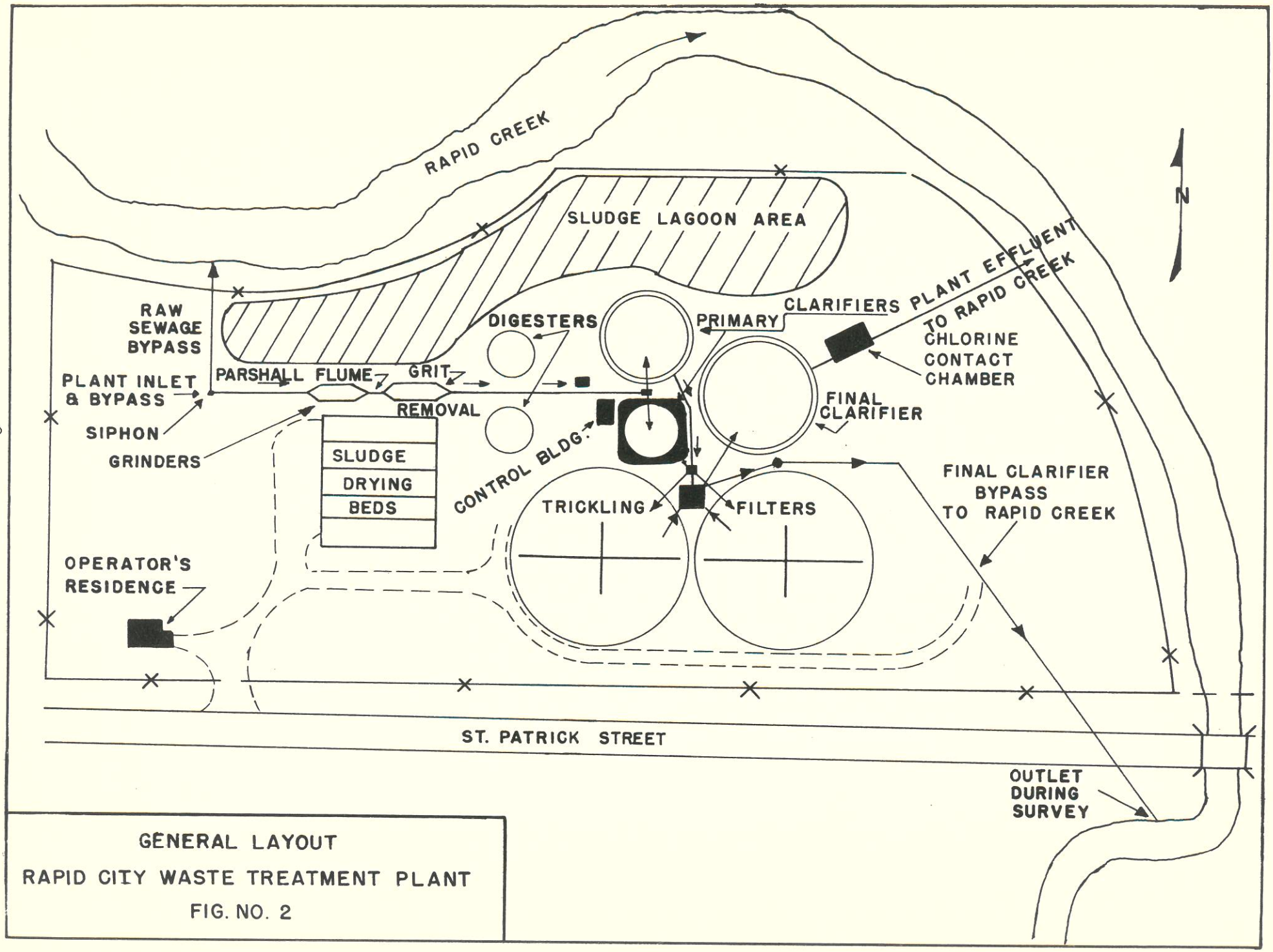
Water temperature is one of the factors which controls oxygen solubility and thus the saturation level of dissolved oxygen in a stream. The rate of natural purification and bacterial growth is effected by changes in temperature.

Hydrogen Ion Concentration (pH)

This indicates the relative acidity or alkalinity of the water. The pH value of 7.0 is neutral, those values above 7.0 are alkaline, and those below 7.0 are acid.

Dissolved Oxygen

The oxygen dissolved in wastewater or water is expressed in mg/l or milligrams per liter. Dissolved oxygen must be present to support fish and other aquatic life and for natural purification of stream water. The oxygen is drawn upon to support biochemical oxidation of organic waste and is replaced by absorption from the atmosphere and by photosynthetic action of water plant life including algae. A measure of the



GENERAL LAYOUT
RAPID CITY WASTE TREATMENT PLANT
FIG. NO. 2

PLATE NO. 4

RAPID CITY WASTEWATER OUTLET

MUNICIPAL PLANT IN BACKGROUND

degree of pollution of a particular area is given by deficiency dissolved oxygen content below saturation.

Biochemical Oxygen Demand (B.O.D.)

This determination indicates the amount of dissolved oxygen which may be utilized in 5 days at 20°C. (68°F.) to satisfy the biochemical oxidation requirements of the pollution material present at the time the sample was collected. The polluting strength of organic wastes is expressed in mg/l. If wastes in a receiving stream are not sufficiently stabilized or diluted, the dissolved oxygen content of the stream may be reduced to a point where aquatic life will suffer because of the oxygen demand of the pollution material.

Alkyl Benzene Sulfonate (A.B.S.) Detergent & Nitrate Nitrogen (NO_3 as N)

These chemical determinations were included to indicate the presence of domestic wastes or other organic pollution material. The results are expressed in mg/l.

Coliform Group Organisms (MPN)

Two bacteriological determinations were completed and expressed as the most probable number (MPN) of coliform bacteria per 100 milliliters of sample. This is a sensitive and specific test for the degree of pollution in a stream. The total coliform bacteria present indicates pollution from human wastes, food processing industrial wastes, and surface runoff. The fecal portion of the total coliform concentration is more specific for the intestinal organisms of warm-blooded animals and is discharged in large numbers in human and animal feces. The fecal organisms are more indicative of serious sources of water pollution.

Bacteriological objectives included the quantitative estimation of pollution indicator organisms. The coliform group of bacteria, total and fecal, were determined using the gas production or tube methods. The elevated temperature test was used to indicate the organisms from the intestines of warm-blooded animals (fecal coliform).

Suspended Solids

The suspended solids determinations, including total and organic (volatile) solids, were completed on samples collected at the municipal waste treatment plant. The solids are reported in mg/l for the raw, primary effluent, and effluent to the stream.

Biological Data

Special biological studies were made to determine the effects of wastes on stream biota. The results of these studies are described in the appended "Biological Survey Reports", prepared by the U.S. Public Health Service.

Radiological

Rapid Creek liquid and mud samples were composited over the 10 day period for analysis in the Cincinnati, Ohio laboratory of the U. S. Public Health Service.

IV. SOURCES OF WASTES AND EFFECTS ON WATER QUALITY

A. Sources of Wastes

The various sources of wastes located and investigated during the survey are shown on Figures No. 3 and No. 4. Figure No. 3 includes the reach of Rapid Creek studied. Figure No. 4 shows a map of Rapid City and the waste sources located in or near the city limits. The major source of organic material is the effluent from the Rapid City municipal wastewater treatment plant. Other classifications of wastes include industrial, commercial (trailers and other lodging), refuse, oil products, animal wastes, fish hatchery, private individual homes, and an emergency sanitary sewer overflow.

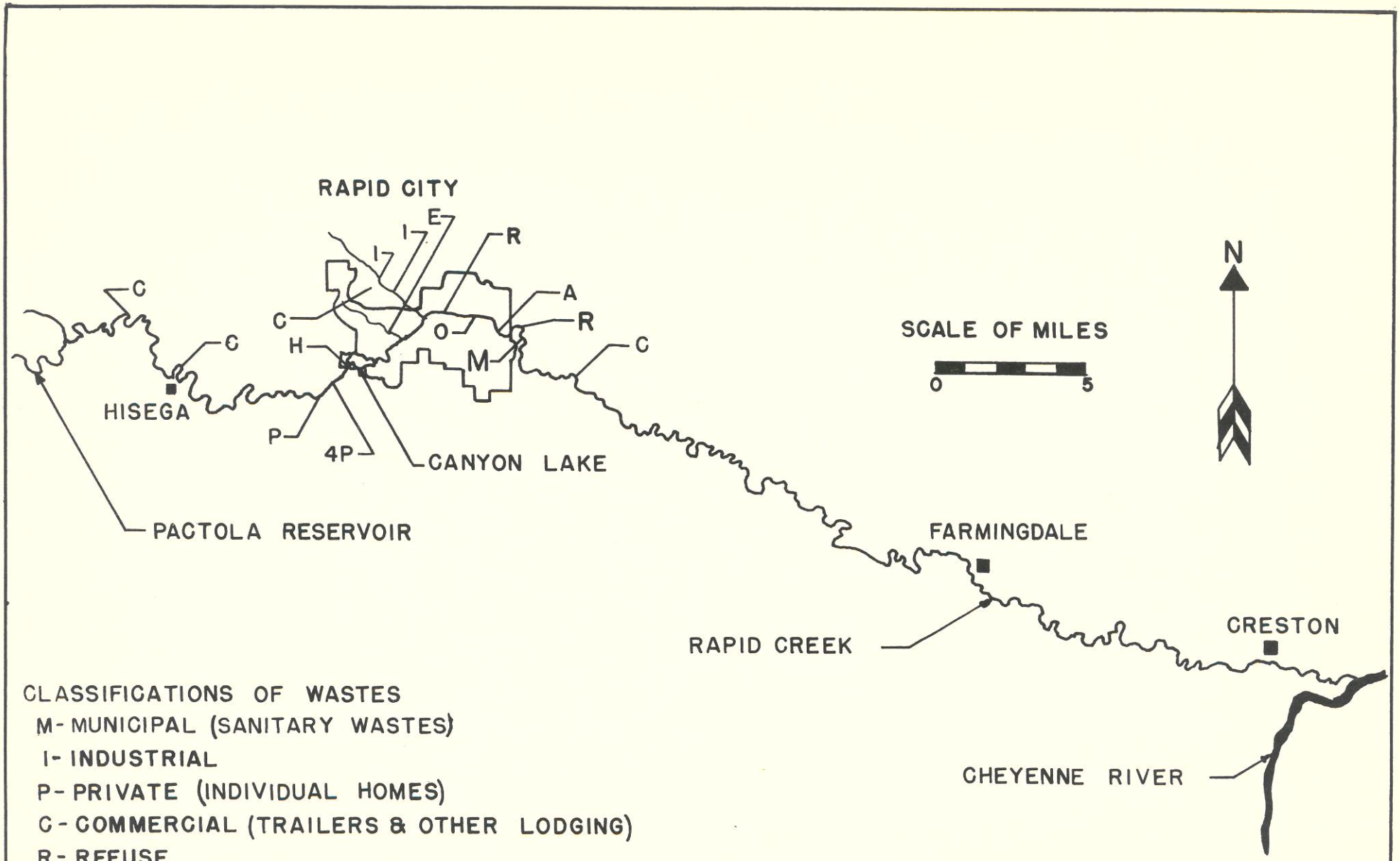
The City of Rapid City is by far the greatest contributor of wastes to Rapid Creek. The average municipal wastewater volume discharged to Rapid Creek during the eight day period was 6.4 million gallons per day (MGD). The municipal plant effluent contained an average B.O.D. of 58 mg/l or 3,078 lbs. per day. Total suspended solids average in the municipal discharge was 79 mg/l or 4,180 lbs. per day. The median bacteriological concentrations for the municipal wastewater plant effluent were 4,900,000 total coliform MPN per 100 ml and 1,820,000 fecal coliform MPN per 100 ml.

Major industrial waste sources connected to the municipal collection system include meat packing companies and dairy plants. Most industries located inside the city limits were connected to the municipal system for combined waste treatment. The city consulting engineer and city engineer's office have information regarding volume and organic loadings from the local industries. A detailed inplant study of industrial wastes was not a part of this investigation.

Rural potential sources of Rapid Creek pollution include two lodging establishments and 5 homes located above Rapid City. The private home wastewater systems discharge mostly laundry or sink wastes to Rapid Creek. The Pennington County Health Department has the data, location, and names of establishments and individuals involved for local enforcement.

The South Dakota State Fish Hatchery is discharging approximately 4 MGD to Rapid Creek directly above Canyon Lake. Average analytical results from Table No. 2 (pond overflow water) were temperature - 9.1°C., pH - 7.9, dissolved oxygen 7.6, A.B.S. - 0, nitrate nitrogen - 0.3, total coliform MPN/ml - 513, and fecal coliform MPN/100 ml - 53. Continued judicious use of chemicals and cleaning of the trout rearing ponds should not create a significant problem in Rapid Creek or Canyon Lake. The South Dakota Department of Game, Fish & Parks recently connected the sanitary wastes produced to the Rapid City municipal collection system. This eliminated a previous serious source of wastes.

Two additional industries investigated were the Black Hills Power & Light Company power plant and the South Dakota State Cement Plant. These two industries are located outside the city limits and northwest of the community. The Ben French power plant has an aeration unit waste treatment plant to treat sanitary wastes from approximately 21 persons. The maximum population at the power plant is about 15 during the day hours. The small treatment plant effluent is discharged with approximately 0.04 MGD of cooling water to a large pit containing the fuel ashes. A visual inspection December 10, 1963 indicated satisfactory treatment in the aeration unit. The small volume of overflow from the fuel ashes pit to the receiving stream was not creating a noticeable pollution condition.



SOURCES OF WASTES
RAPID CREEK SURVEY
FIG. NO. 3

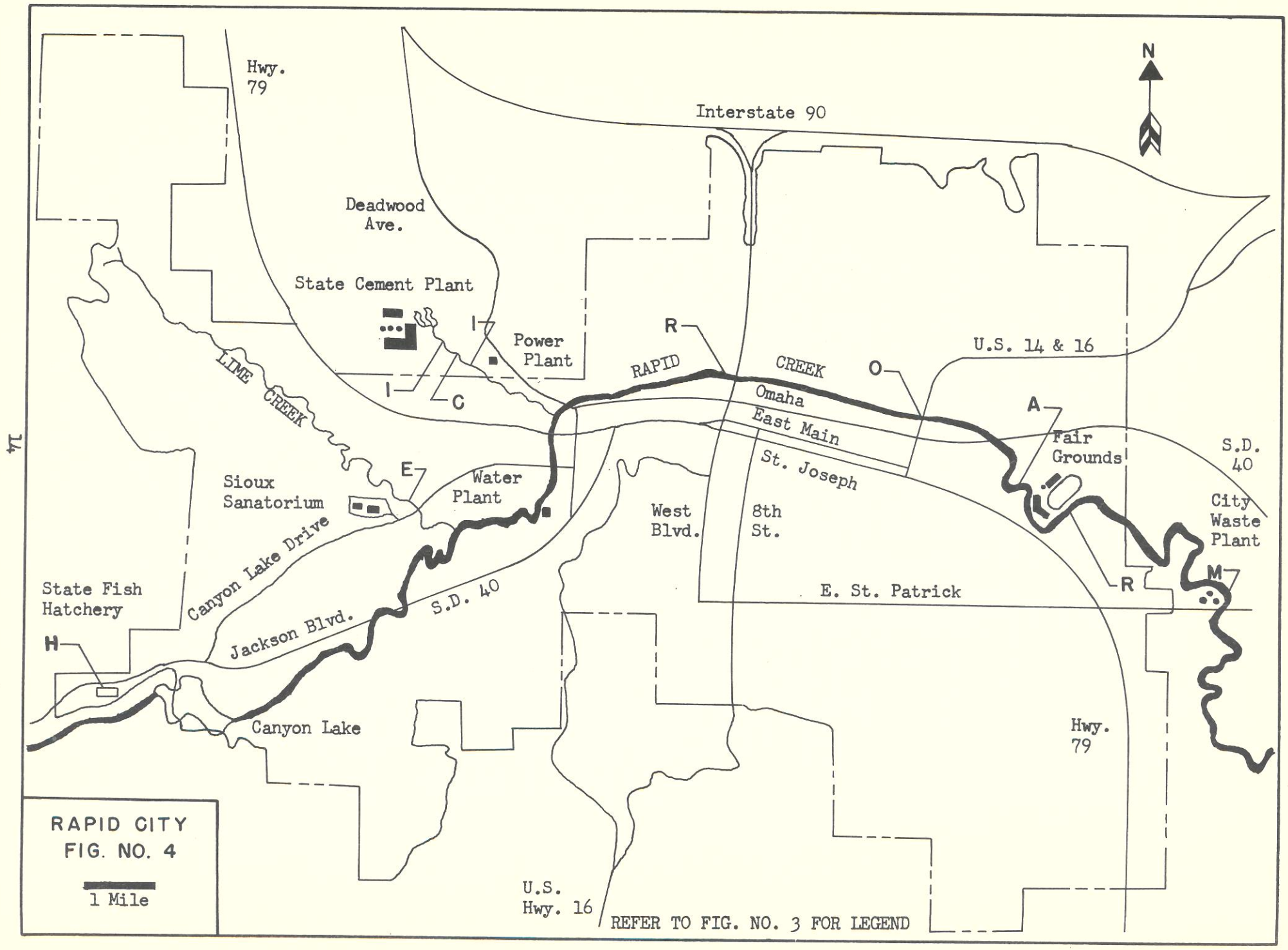

Hwy. 79
Interstate 90
N
Deadwood Ave.
State Cement Plant
I
Power Plant
R
U.S. 14 & 16
LIME CREEK
RAPID
CREEK
O
I
C
Omaha
East Main
St. Joseph
A
Fair Grounds
S.D. 40
E
Water Plant
Sioux Sanatorium
West Blvd.
8th St.
City Waste Plant
Canyon Lake Drive
M
R
E. St. Patrick
State Fish Hatchery
S.D. 40
Jackson Blvd.
H
Canyon Lake
Hwy. 79
U.S. Hwy. 16
RAPID CITY
FIG. NO. 4
1 Mile
REFER TO FIG. NO. 3 FOR LEGEND

PLATE NO. 5
OIL WASTES (NOTE TIRE IN CREEK)

REFUSE ON CREEK BANK

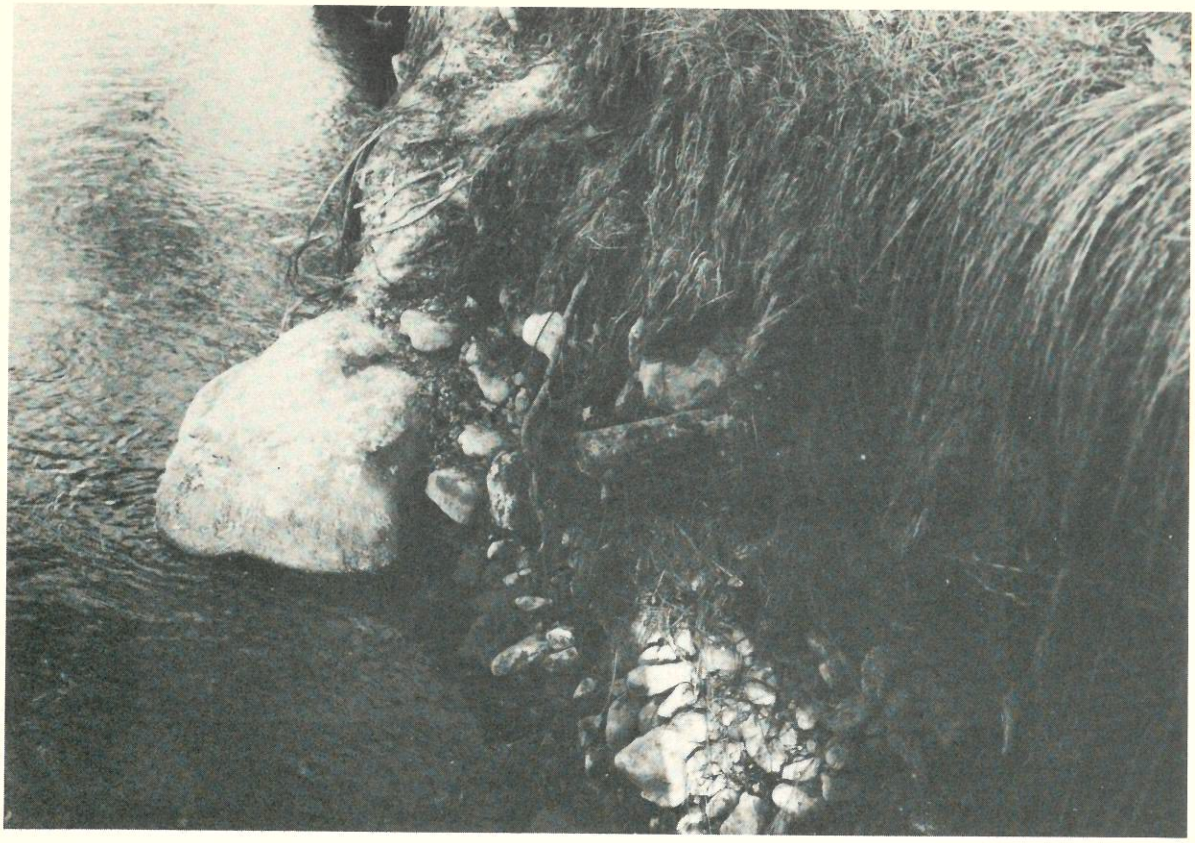
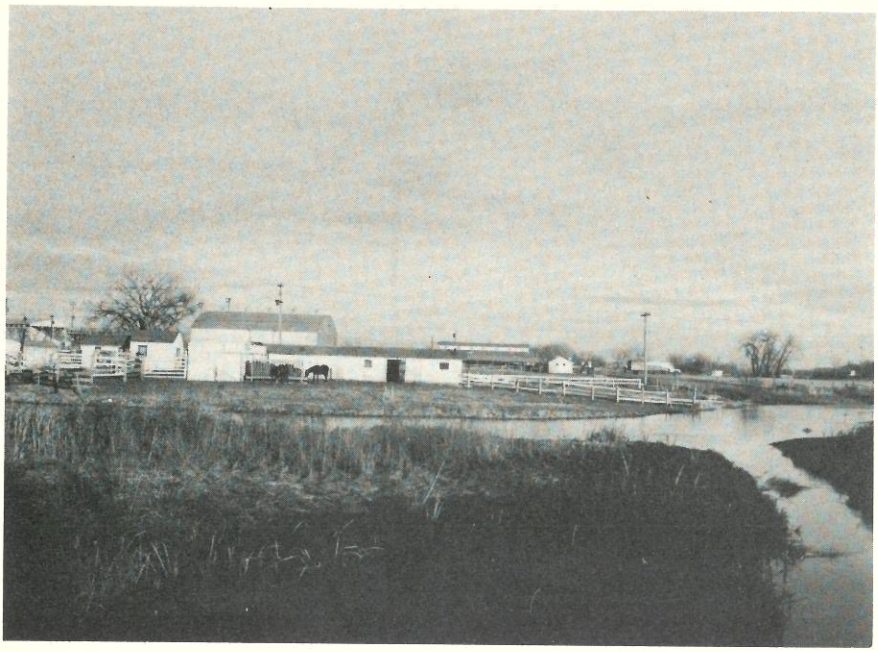


PLATE NO. 6
PRIVATE HOME WASTE OUTLET (RURAL AREA)



ANIMAL WASTES ON CREEK BANK (INSIDE CITY LIMITS)
COUNTY FAIRGROUNDS IN BACKGROUND

RAPID CREEK SURVEY
FISH HATCHERY OVERFLOW - POND WASTES (STATION NO. 5)
SUMMARY OF ANALYTICAL DATA - DECEMBER 1963

TABLE NO. 2

Date	Temp. °C.	pH	D.O. mg/l	A.B.S.	Nitrogen NO_3	Coliforms MPN/100 ml	Fecal MPN/100 ml	Remarks
12-3-63	10.0	8.1	7.5			700	*200	Flow = 4 MGD
4	10.0	7.9	7.6			---	---	
5	10.0	7.8	7.5	0	0.3	490	*20	
6	10.0	7.9	7.3			220	*20	
7	9.0	7.9	7.7			490	*20	
8	9.0	7.9	7.9			110	*20	
9	9.5	7.8	7.7			490	*20	
10	7.0	7.9	7.5	0	0.3	1,300	140	
11	7.0	7.9	7.8			490	20	
12	9.0	7.9	7.8			330	*20	
Avg.	9.1	7.9	7.6	0	0.3	513	*53	

MGD = Million Gallons per Day
* = Less than

The South Dakota State Cement Plant was discharging partially treated sanitary wastes to a small creek tributary to Rapid Creek inside the Rapid City limits and close to the Baken Park shopping district. The South Dakota State Cement Plant waste disposal facilities were inspected on December 10, 1963 and February 7, 1964. The cement plant has approximately 50 persons on duty at any one time and 3 shifts per day. A 9,000 gallon septic tank is adequate for the volume of sanitary wastes, but septic tank treatment alone is not sufficient for the small receiving creek. Odor, sludge banks, and other visible evidence of pollution were observed below the septic tank outlet pipe. The cement plant industrial wastes, including limestone, shale, and water receives excellent treatment in four large ponds operated in series. The pond area is greater than 3 acres for the industrial wastes. Wastewater from a private mobile home park located in the general area receives only primary treatment through a septic tank and the overflow may also be gaining access to the receiving creek. County Health Department investigations have revealed past operation problems at the mobile home park.

The Rapid City municipal officials have maintained a fairly effective program to control unauthorized dumping and discharge of wastes inside the city limits. Two small refuse dumps were discovered on the bank of Rapid Creek inside the Rapid City limits. One dump location is near West Boulevard and one on County Fairgrounds property. The only other source of wastes noted was a discharge of oil products entering the stream near East Boulevard.

One other trailer court waste system is discharging into an irrigation ditch which is tributary to Rapid Creek below the municipal wastewater treatment plant.

B. Rapid Creek Water Quality

The results of individual stream sample analysis for the December 1963 studies are presented in the Appendix. Table No. 3 includes a summary of the median, average, maximum, and minimum results of the stream sample analysis.

Flow Data

Estimated Rapid Creek flows on December 3, 1963 ranged from 16.3 CFS (cubic feet per second) at Station No. 1 to 42 CFS at Station No. 17. The stream flow just above the Rapid City wastewater plant outlet was approximately 27 CFS. Flows essentially remained constant during the first two weeks of December. Dilution of the Rapid City wastewater was therefore approximately 3 to 1 during this investigation. The U. S. Geological Survey records indicate that minimum flows above the Rapid City waste outlet will be approximately 10 CFS or about equal to the amount of 1963 winter daily average wastewater discharge. Minimum stream flows of approximately 10 CFS at the present plant site can be expected during dry years, following the irrigation season in the fall, or prior to the irrigation season in the spring of the year.

Minimum stream flows directly above Rapid City are about 1 or 2 CFS during extreme dry weather. Stream flows at Farmingdale below Rapid City may reduce to zero during the irrigation season. This will result in 100% use of the municipal wastewater for irrigation purposes.

RAPID CREEK SURVEY
LABORATORY DATA
SUMMARY OF STREAM SAMPLE ANALYSIS - DECEMBER 1963

TABLE NO. 3

Rapid Creek Sampling Point No. (Miles from Cheyenne River)	No. of Samples	Results	Chemical			Bacteria	
			Dissolved Oxygen		5 Day BOD mg/l	Coliforms MPN per 100 ml	Fecal MPN per 100 ml
			mg/l	% Sat.			
1 (109.3) Below Pactola Lake	D.O.-10 B.O.D.-8 Bact.-9	Median	10.3	88	0.69	*20	*20
		Average	10.2	88	0.77	*36	*20
		Maximum	10.7	91	1.13	130	*20
		Minimum	9.9	86	0.58	*20	*20
2 (101.3)	D.O.-9 B.O.D.-0 Bact.-9	Median	11.7	92	----	*20	20
		Average	11.7	91	----	*31	*20
		Maximum	12.0	93	----	60	20
		Minimum	11.3	87	----	*20	*20
3 (97.9)	D.O.-10 B.O.D.-0 Bact.-9	Median	12.2	93	----	70	20
		Average	12.2	93	----	*104	*26
		Maximum	12.4	95	----	230	70
		Minimum	11.8	92	----	*20	*20
4 (87.9)	D.O.-10 B.O.D.-0 Bact.-9	Median	11.4	89	----	220	20
		Average	11.3	89	----	284	42
		Maximum	11.8	94	----	490	80
		Minimum	10.7	85	----	110	*20
5 (87.6) Fish Hatchery overflow (see Table No. 2)	-	-	-	-	-	-	-
6 (87.4) Above Canyon Lake	D.O.-10 B.O.D.-8 Bact.-9	Median	9.2	80	0.76	270	70
		Average	9.2	81	0.75	379	80
		Maximum	10.2	89	0.99	790	230
		Minimum	8.5	77	0.61	170	*20
7 (86.7)	D.O.-10 B.O.D.-0 Bact.-9	Median	11.6	95	----	*200	50
		Average	11.6	95	----	241	*66
		Maximum	11.9	98	----	460	130
		Minimum	11.3	93	----	80	*20
8 (84.4)	D.O.-10 B.O.D.-0 Bact.-9	Median	11.5	92	----	130	20
		Average	11.7	92	----	1,917	64
		Maximum	12.3	94	----	16,000**	330
		Minimum	10.9	90	----	20	*20

* Indicates less than
** Refer to report section IV B. Bacteriology

LABORATORY DATA
SUMMARY OF STREAM SAMPLE ANALYSIS - DECEMBER 1963

Rapid Creek Sampling Point No. (Miles from Cheyenne River)	No. of Samples	Results	Chemical			Bacteria	
			Dissolved Oxygen		5 Day BOD mg/l	Coliforms MPN per 100 ml	Fecal MPN per 100 ml
			mg/l	% Sat.			
9 (79.4)	D.O.-10 B.O.D.-0 Bact.-9	Median	12.2	95	----	1,300	490
		Average	12.2	95	----	6,254	641
		Maximum	12.9	98	----	34,800**	2,300
		Minimum	11.2	90	----	490	170
10 (77.9)	D.O.-10 B.O.D.-9 Bact.-10	Median	11.9	93	1.87	790	330
		Average	11.9	94	1.9	6,785	475
		Maximum	12.7	98	2.4	54,200**	1,090
		Minimum	11.4	91	1.59	490	130
11 (77.6) Below City Outlet	D.O.-10 B.O.D.-9 Bact.-10	Median	9.9	83	8.6	1,300,000	330,000
		Average	9.9	83	10.8	1,570,000	419,000
		Maximum	10.5	89	17.2	5,420,000	1,300,000
		Minimum	9.5	75	7.55	460,000	11,000
12 (75.7)	D.O.-9 B.O.D.-9 Bact.-9	Median	6.4	55	9.96	278,000	109,000
		Average	6.5	53	10.1	304,100	98,330
		Maximum	7.8	60	12.5	490,000	172,000
		Minimum	4.9	43	7.44	172,000	49,000
13 (73.5) Golf Course	D.O.-10 B.O.D.-0 Bact.-9	Median	4.2	34	----	130,000	33,000
		Average	5.0	40	----	110,900	32,780
		Maximum	6.7	51	----	172,000	49,000
		Minimum	3.0	26	----	17,000	13,000
14 (68.1)	D.O.-10 B.O.D.-9 Bact.-9	Median	6.4	50	8.88	23,000	13,000
		Average	6.5	51	12.7	50,910	27,290
		Maximum	8.1	62	29.9	141,000	70,000
		Minimum	5.1	44	5.52	3,300	1,700
15 (61.9)	D.O.-10 B.O.D.-9 Bact.-9	Median	10.5	82	5.4	3,300	*2,000
		Average	10.6	82	5.2	11,866	4,530
		Maximum	12.2	93	6.81	49,000	13,000
		Minimum	9.7	74	2.56	2,000	800
16 (34.7)	D.O.-10 B.O.D.-0 Bact.-9	Median	12.3	94	----	790	230
		Average	12.1	93	----	836	243
		Maximum	12.7	97	----	1,750	790
		Minimum	11.6	89	----	230	40
17 (12.6) At Creston	D.O.-10 B.O.D.-9 Bact.-9	Median	12.7	97	1.5	490	50
		Average	12.7	97	1.6	659	48
		Maximum	13.1	100	2.17	1,300	80
		Minimum	12.2	93	1.2	170	20

* Indicates less than
** Refer to report section IV B. Bacteriology

Temperature

Stream sampling crews measured and recorded field temperatures in degrees Centigrade. The stream water temperature reduced to $0^{\circ}C$. above Rapid City during the second week of the sampling. The Rapid City municipal wastes raised the average temperature of the stream water approximately $2^{\circ}C$. below the city outlet. Other wastes did not measurably effect the temperature of the stream water.

pH (Hydrogen Ion Concentration)

Average pH values of stream samples varied from 7.7 to 8.3. The lowest average pH value was located at Station No. 13 near the Valley Hi Country Club. Most of the pH determinations at stations above Rapid City were greater than 8.0.

Dissolved Oxygen

The average dissolved oxygen concentrations and percentage of saturation values are presented graphically on Figures No. 5, 6, and 7. Dissolved oxygen average concentrations were generally above 10 milligrams per liter (mg/l) above and through Rapid City. The average concentration dropped to 5.0 mg/l or 40% saturation at Station No. 13, approximately 4 miles downstream from the Rapid City municipal waste outlet. The minimum daily oxygen concentration measurement was 3.0 mg/l at Station No. 13, considerably below the minimum of 6.0 mg/l considered desirable for trout.

Dissolved oxygen levels were deficient for a distance of approximately 12 miles below Rapid City. The zone between 2 and 8 miles below the city outlet is critical with respect to fish life. Figures No. 6 and No. 7 illustrate the oxygen depletion and reaeration in a stream used to stabilize organic material being discharged.

Biochemical Oxygen Demand (B.O.D.)

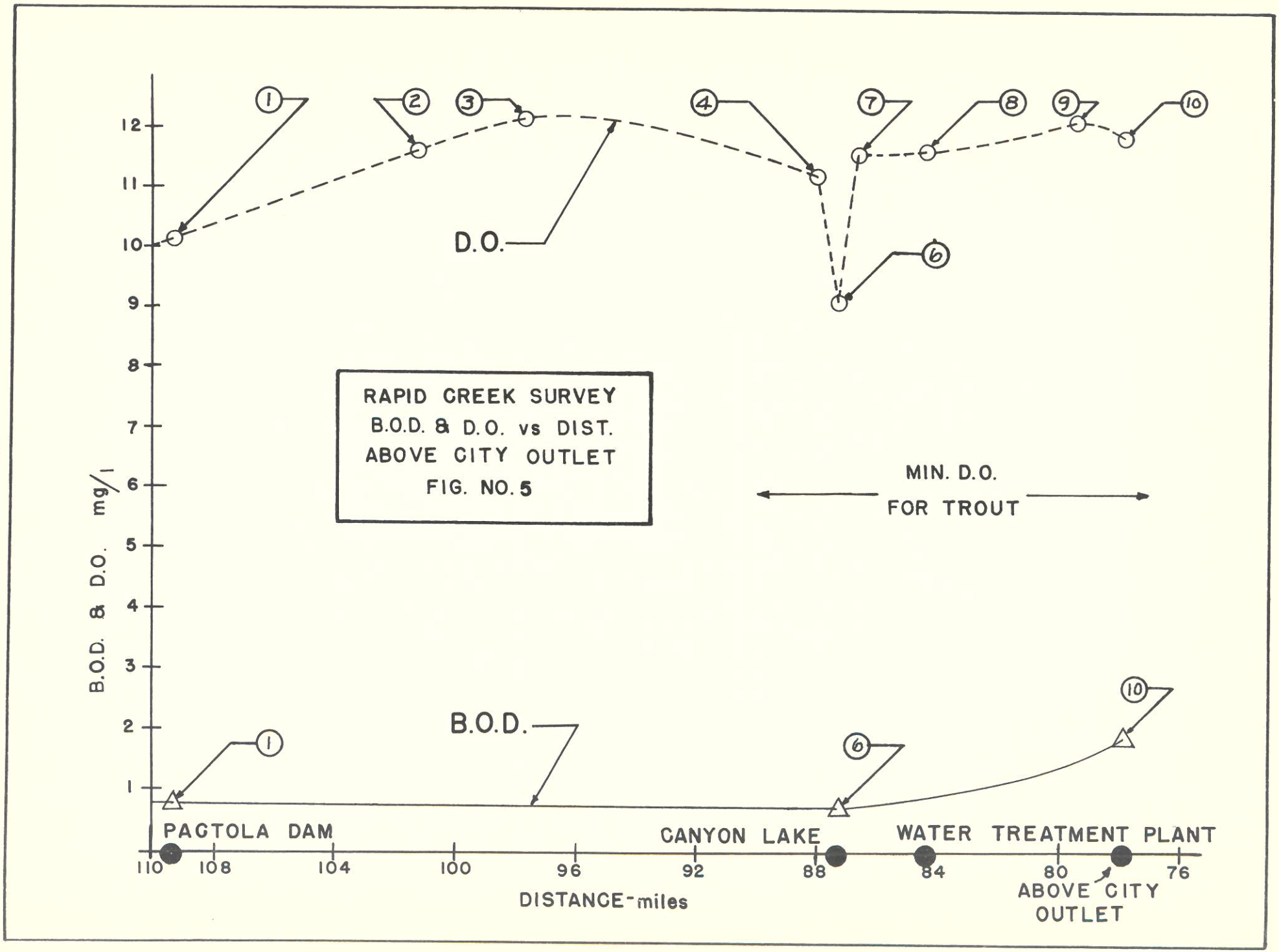
B.O.D. values above Rapid City were generally less than 1 or 2 mg/l and insignificant. The increases below the city outlet are shown graphically on Figures No. 5 and 6. The median values increased to 9.96 mg/l at Station No. 12 with the maximum daily concentration measurement of 29.9 mg/l noted at Station No. 14. The median B.O.D. values exceed 5 mg/l for a distance of approximately 15 miles below Rapid City.

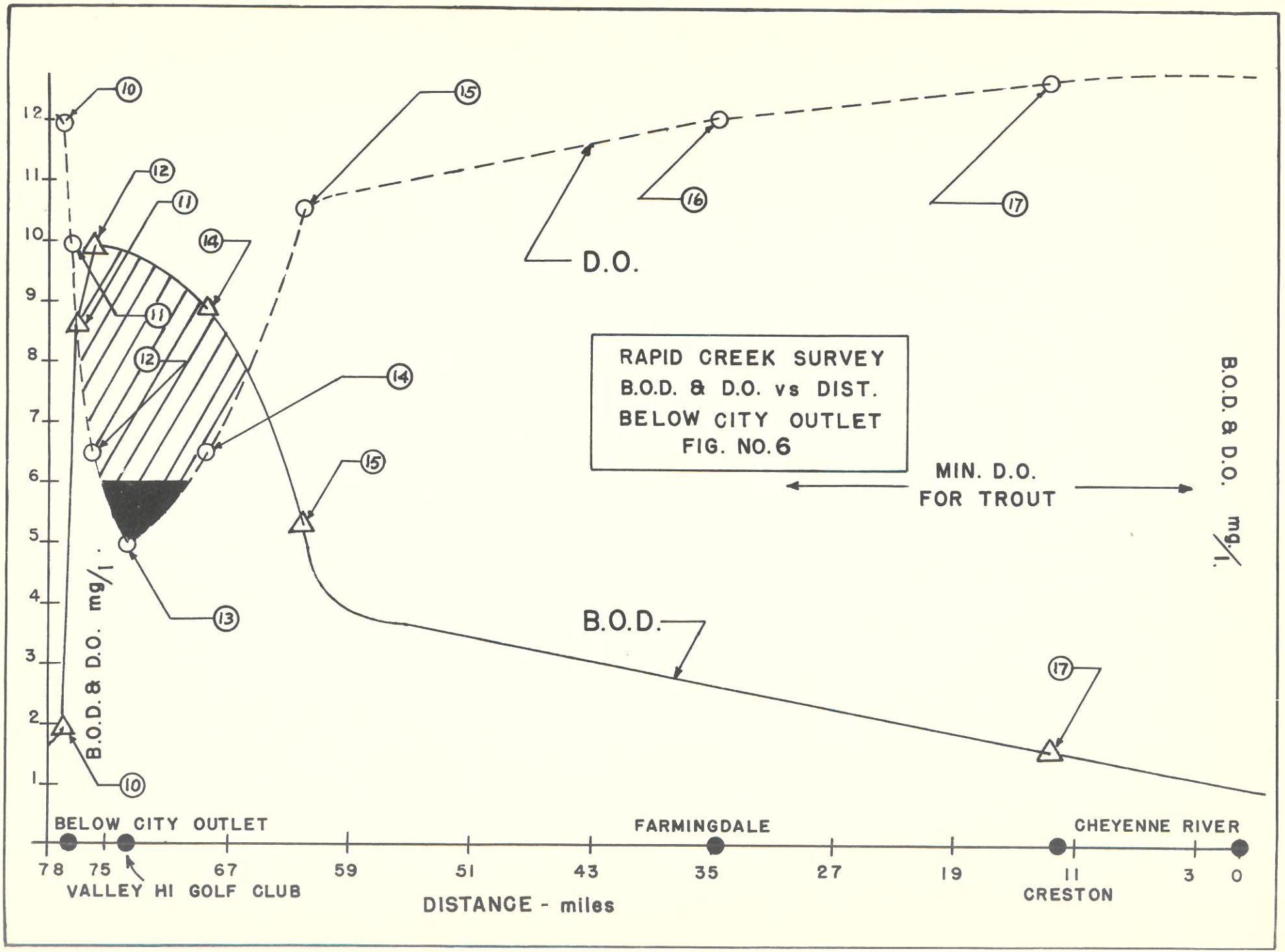
A.B.S. Detergent and Nitrate Nitrogen (NO_3 as N)

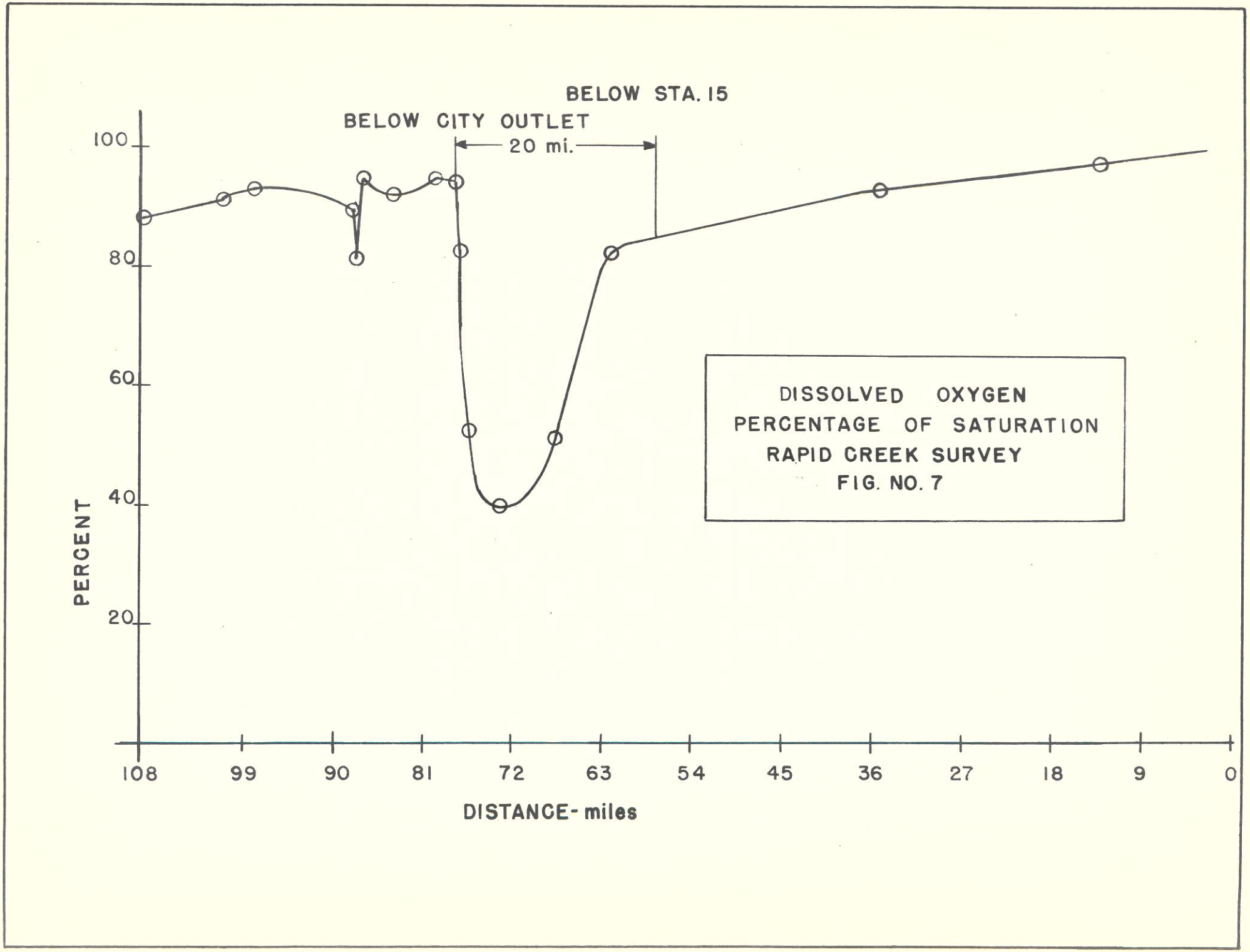
The samples were composited over 5 days to produce two samples at each stream sampling station. All A.B.S. detergent tests above the city waste outlet were zero. The A.B.S. detergent concentration increased to a maximum of 1.0 mg/l at Station No. 13 below the city outlet. Nitrate nitrogen started to appear at Station No. 6 and increased to a maximum of 9.3 mg/l at Station No. 14. The values given here are the average of the two 5-day composite samples.

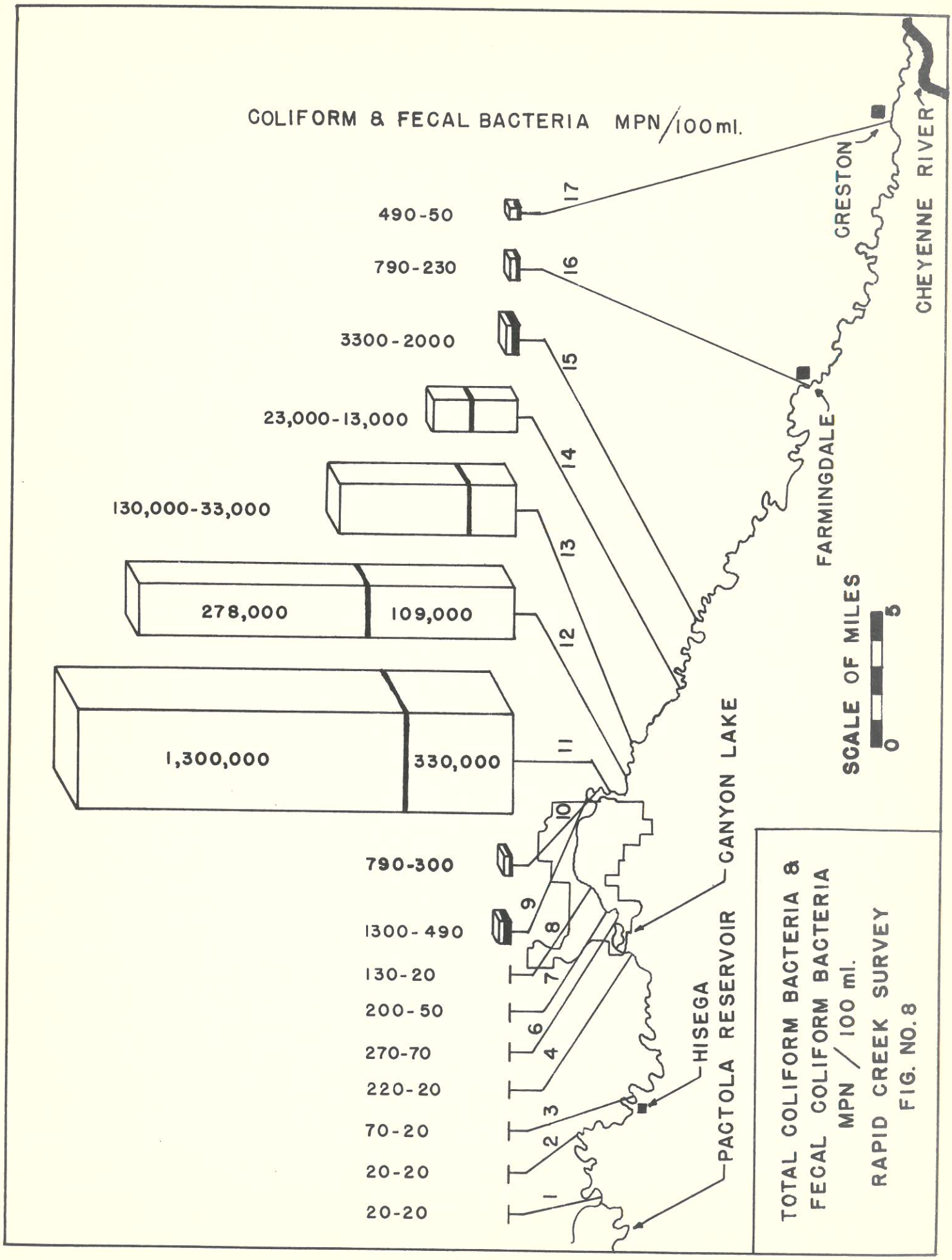
Bacteriological

Figure No. 8 presents the median bacteriological results for each station between Pactola Reservoir and Cheyenne River. The most probable number of


RAPID CREEK SURVEY
B.O.D. & D.O. vs DIST.
ABOVE CITY OUTLET
FIG. NO. 5
D.O.
B.O.D.
MIN. D.O.
FOR TROUT
B.O.D. & D.O. mg/l
DISTANCE-miles
PACTOLA DAM
CANYON LAKE
WATER TREATMENT PLANT
ABOVE CITY OUTLET
110
108
104
100
96
92
88
84
80
76
12
11
10
9
8
7
6
5
4
3
2
1


RAPID CREEK SURVEY
B.O.D. & D.O. vs DIST.
BELOW CITY OUTLET
FIG. NO. 6
D.O.
B.O.D.
MIN. D.O.
FOR TROUT
B.O.D. & D.O. mg/l.
B.O.D. & D.O. mg/l.
BELOW CITY OUTLET
FARMINGDALE
CHEYENNE RIVER
VALLEY HI GOLF CLUB
CRESTON
DISTANCE - miles
78 75 67 59 51 43 35 27 19 11 3 0
1 2 3 4 5 6 7 8 9 10 11 12


BELOW STA. 15
BELOW CITY OUTLET
20 mi.
100
80
60
40
20
PERCENT
108
99
90
81
72
63
54
45
36
27
18
9
0
DISTANCE- miles
DISSOLVED OXYGEN
PERCENTAGE OF SATURATION
RAPID CREEK SURVEY
FIG. NO. 7


COLIFORM & FECAL BACTERIA MPN/100ml.
490-50
790-230
3300-2000
23,000-13,000
130,000-33,000
278,000
109,000
1,300,000
330,000
790-300
1300-490
130-20
200-50
270-70
220-20
70-20
20-20
20-20
17
16
15
14
13
12
11
10
9
8
7
6
4
3
2
1
CRESTON
CHEYENNE RIVER
FARMINGDALE
CANYON LAKE
HISEGA
PACTOLA RESERVOIR
SCALE OF MILES
0
5
TOTAL COLIFORM BACTERIA & FECAL COLIFORM BACTERIA MPN / 100 ml.
RAPID CREEK SURVEY
FIG. NO. 8

total coliform bacteria per 100 ml varied from less than 20 to 1,300,000. The fecal coliform MPN per 100 ml varied from less than 20 to 330,000. The maximum bacteriological concentrations were noted at Station No. 11 directly below the city outlet. Bacteriological concentrations above and through Rapid City are generally low and represent clean water conditions.

Higher concentrations on December 12, 1963 at Station No. 8, No. 9 and No. 10 indicated an accidental discharge of sanitary wastes or the dumping of animal manure. The tuberculosis hospital experienced a sewer stoppage and overflow of raw sanitary sewage into Lime Creek which is tributary to Rapid Creek in the west section of the city. The Rapid City water treatment plant was not being operated at the time of this accident or investigation. Dumping of animal manure was also observed on Rapid Creek bank at the east edge of the community.

Biological

Appendix A is the biological survey report prepared by the U.S. Public Health Service. The stream biota, including fish food organisms, were changed below the Rapid City wastewater outlet. Unfavorable aquatic conditions for trout existed for at least 20 miles. Figure No. 1 (Appendix) shows the difference between a healthy and polluted stream. Pollution indicator organisms were observed at Station No. 11, No. 12, and No. 13. Pollution sensitive organisms were also absent at the same sampling stations below the city outlet.

Radiological

Data on radiological sample test results have not been received from the U. S. Public Health Service laboratory. The data will be forwarded at a later date to provide background information for future reference.

C. Rapid City Wastewater Treatment Efficiency

Flow Data

Wastewater flows recorded at the municipal plant are presented in Tables No. 4 and 5 and also graphically on Figures No. 9 and 10. The 24 hour flow of raw wastewater varied from 6.03 MGD on Sunday, December 8, 1963 to 6.52 MGD on Wednesday, December 4, 1963. The average 24 hour flow was 6.4 MGD for the eight-day sampling survey. The per capita average flow was 128 gallons per day for a population of 50,000 persons.

Instantaneous rates of flow during a 24 hour period ranged from approximately 4.5 MGD to 8.5 MGD (see Figure No. 9). All raw wastewater flows in excess of 9.0 MGD are by-passed directly to Rapid Creek. It was not necessary to discharge raw wastewater during the December 1963 survey. Minimum wastewater flows after midnight remained near the 4.5 MGD design capacity of the present treatment facilities. The city officials were initiating a study of ground water infiltration into the collection system. Studies will likely include location of sources of clear water that will be economical to control over a period of several years.

Temperature and pH

Raw, primary effluent, and plant effluent waste temperatures were recorded every hour between December 4, 1963 and December 12, 1963. The pH tests

ANALYSES AT RAPID CITY WASTEWATER TREATMENT PLANT
DECEMBER 1963

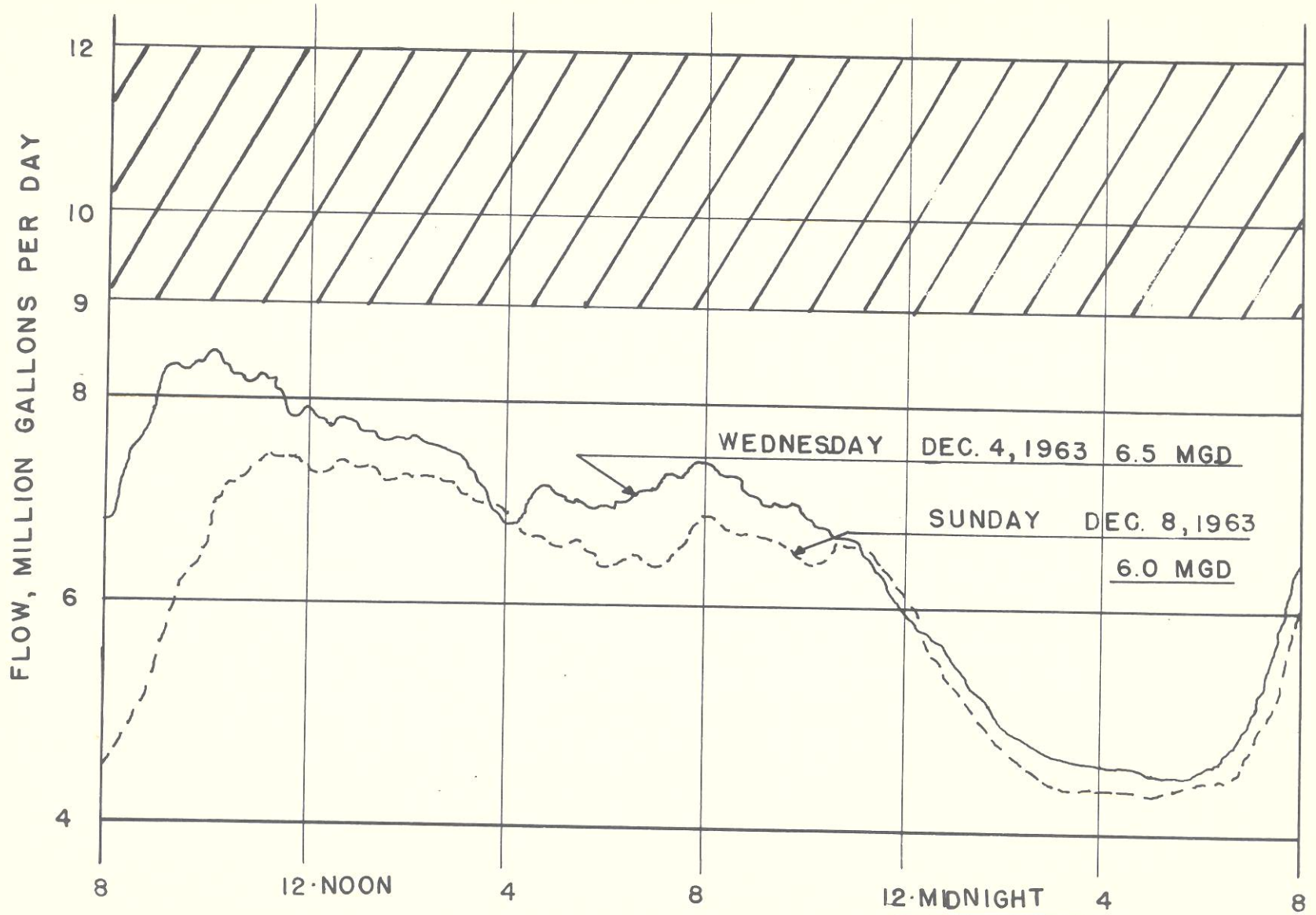
TABLE NO. 4

Date	Flow MGD	Sampling Point	Suspended Solids								Avg. Temp. F.	pH
			Total				Volatile					
			mg/l	#/day	% Removal		mg/l	#/day	% Removal			
					Primary	Overall			Primary	Overall		
12-4-63 Wed.	6.52	Raw	160	8,720			141	7,700			58.7	7.7
		Primary Effluent	104	5,660	35.1	50	83	4,520	41.2	56.5	58.6	7.6
		Plant Effluent	80.5	4,380			61.5	3,350			57.8	7.6
12-5-63 Thurs.	6.50	Raw	150	8,130			128	6,950			59	7.6
		Primary Effluent	106	5,750	29.2	43	91	4,930	29	49	59	7.6
		Plant Effluent	85.5	4,630			65.5	3,550			58.3	7.5
12-6-63 Fri.	6.50	Raw	156	8,460			130	7,050			58.6	7.7
		Primary Effluent	111	6,030	28.7	43.3	90	4,880	20.7	50.2	57.5	7.6
		Plant Effluent	88.5	4,800			63	3,510			57.0	7.7
12-7-63 Sat.	6.29	Raw	163	8,550			136	7,150			56.6	7.7
		Primary Effluent	119	6,240	27.1	62	101	5,310	25.6	65.9	56	7.7
		Plant Effluent	62.0	3,250			46.5	2,440			53.7	7.8
12-8-63 Sun.	6.03	Raw	140	7,050			123	6,200			57	7.6
		Primary Effluent	106	5,330	24.4	23.8	90	4,530	27	33.6	55.4	7.6
		Plant Effluent	107	5,380			81.5	4,110			53.8	7.7
12-9-63 Mon.	6.50	Raw	196	10,630			162	8,800			57	7.7
		Primary Effluent	134	7,270	31.6	60.5	100	5,420	38.4	65.2	56	7.7
		Plant Effluent	77.5	4,200			56.5	3,060			54.5	7.7
12-10-63 Tues.	6.38	Raw	156	8,300			130	6,930			56	7.6
		Primary Effluent	119	6,330	23.8	60.6	90	4,780	31	65.5	55.6	7.6
		Plant Effluent	61.5	3,270			45	2,390			53.6	7.6
12-11-63 Wed.	6.33	Raw	185	9,780			148	7,830			57.1	7.8
		Primary Effluent	120	6,330	35.3	63.3	89	4,700	40	66.6	55.2	7.7
		Plant Effluent	68	3,590			49.5	2,610			53.8	7.7
Average	6.4	Raw	163	8,700			137	7,320			57.4	7.7
		Primary Effluent	115	6,100	30	52	92	4,880	33	57	56.7	7.6
		Plant Effluent	79	4,180			59	3,120			55.2	7.7

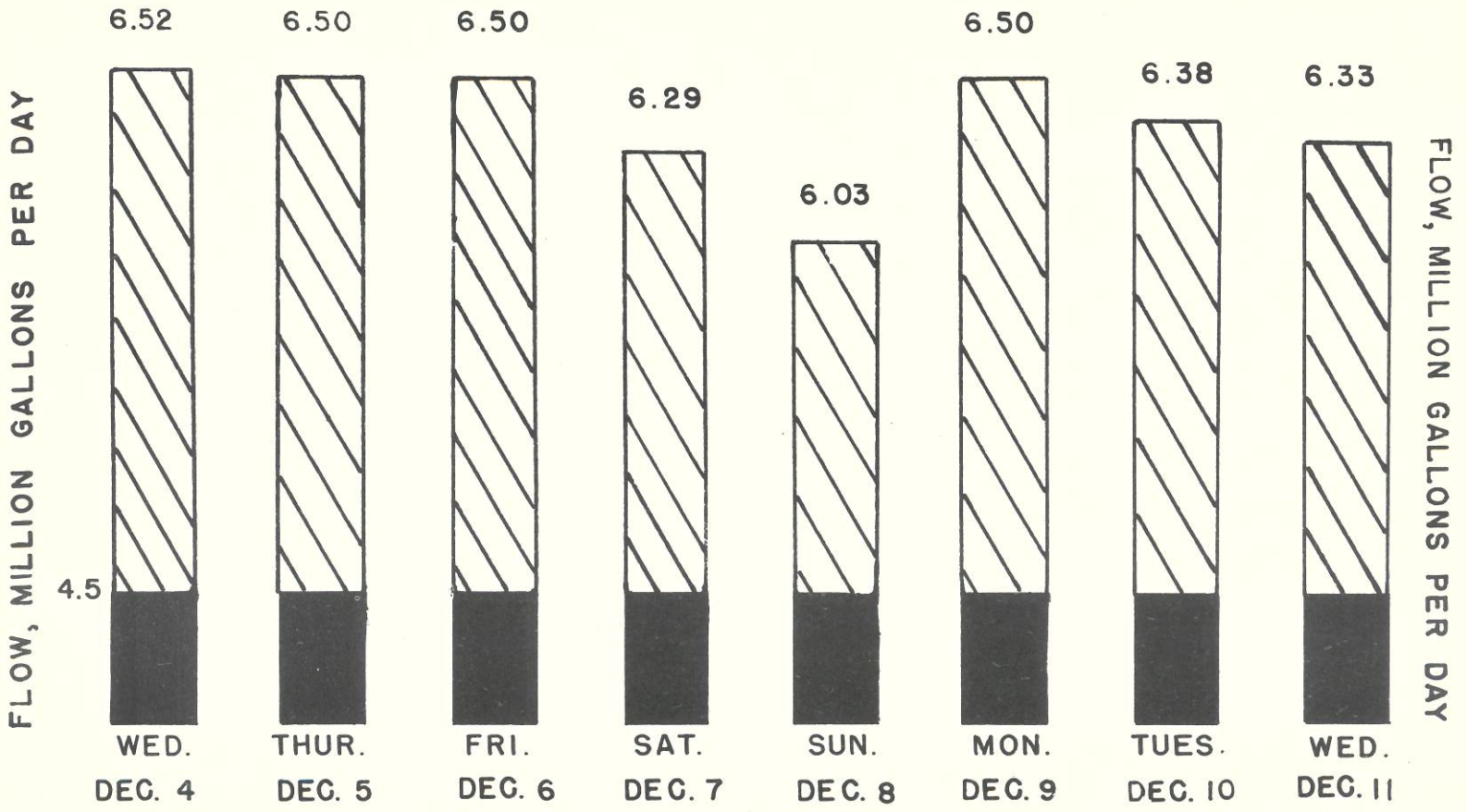
ANALYSES AT RAPID CITY WASTEWATER TREATMENT PLANT
DECEMBER 1963

TABLE NO. 5

Date	Flow MGD	Sampling Point	B.O.D. mg/l	B.O.D. #/day	B.O.D. % Removal Primary	B.O.D. % Removal Overall	Bacteriological Coliform MPN/100 ml	Bacteriological Fecal MPN/100 ml
12-4-63 Wed.	6.52	Raw	144	7,830			23,000,000	2,700,000
		Primary Effluent	108	5,880	25	73		
		Plant Effluent	39	2,120			4,900,000	2,300,000
12-5-63 Thurs.	6.50	Raw	149	8,080			49,000,000	10,900,000
		Primary Effluent	128	6,940	14.1	64		
		Plant Effluent	53.5	2,900			4,600,000	230,000
12-6-63 Fri.	6.50	Raw	160	8,670			7,900,000	1,300,000
		Primary Effluent	139	7,540	13.1	50.6		
		Plant Effluent	79.0	4,280			2,780,000	700,000
12-7-63 Sat.	6.29	Raw	160	8,400			23,000,000	3,300,000
		Primary Effluent	133	6,980	17	71.6		
		Plant Effluent	45.4	2,380			24,000,000	1,720,000
12-8-63 Sun.	6.03	Raw	134	6,740			13,000,000	7,900,000
		Primary Effluent	100	5,030	25.4	47.3		
		Plant Effluent	70.6	3,550			7,900,000	3,300,000
12-9-63 Mon.	6.50	Raw	200	10,850			23,000,000	7,900,000
		Primary Effluent	122	6,610	39	70.3		
		Plant Effluent	59.2	3,210			3,300,000	2,300,000
12-10-63 Tues.	6.38	Raw	178	9,480			27,800,000	7,900,000
		Primary Effluent	149	7,930	16.3	66.3		
		Plant Effluent	60	3,190			7,000,000	2,300,000
12-11-63 Wed.	6.33	Raw	170	8,970			13,000,000	3,300,000
		Primary Effluent	132	6,970	22.4	66.6		
		Plant Effluent	56.6	2,990			4,900,000	1,720,000
Average	6.4	Raw	162	8,634			22,400,000	5,660,000
		Primary Effluent	126	6,739	21.8	64.4		
		Plant Effluent	58	3,078			7,430,000	1,820,000
					Median Raw		23,000,000	5,660,000
					Plant Effluent		4,900,000	1,820,000
					% Removal		79%	68%



DAILY FLOW VARIATIONS
RAPID CITY, S. DAK.
WASTE TREATMENT PLANT
FIG. NO. 9



4.5 MGD = DESIGN FLOW CAPACITY

DAILY WASTE FLOW
RAPID CITY, S. DAK.
WASTE TREATMENT PLANT
SCALE 1" = 0.66 MGD
FIG. NO. 10

were completed in the mobile laboratory after each 24 hour composite sampling period. Average Fahrenheit temperatures and pH are included in Table No. 4.

The waste temperatures in degrees Fahrenheit varied from 52 to 61 degrees. The lower temperatures were recorded of the plant effluent during the last few days of the survey.

The average pH values were between 7.6 and 7.8. The alkaline conditions indicate fresh, raw waste.

Uniform temperature and pH levels indicate no abnormal discharge of unusual wastes during the survey in December 1963, although visual observations did indicate that volumes of blood and milk plant wastes are discharged for short periods of time during the day.

Total and Volatile Suspended Solids

Table No. 4 contains the daily results of suspended solids determinations. The raw wastes contained an average of 163 mg/l or 8,700 lbs. of total suspended solids per day. The primary effluent average was 115 mg/l or 6,100 lbs. per day. Plant effluent average result was 79 mg/l or 4,180 lbs. per day. The maximum amount of total suspended solids discharged to the receiving stream was 5,380 lbs. on December 8, 1963. The average percent removal of total suspended solids through the primary units was 30% and through the entire facilities was 52%.

The volatile or organic portion of the suspended solids was 137 mg/l or 7,320 lbs. per day in the raw wastes. Primary effluent contained an average of 92 mg/l or 4,880 lbs. per day. Plant effluent was 59 mg/l or 3,120 lbs. per day. Removal efficiencies showed an average of 33% for the primary and 57% for overall treatment. Figure No. 11 graphically shows the efficiency variations and average value for the percent removal during the eight-day survey.

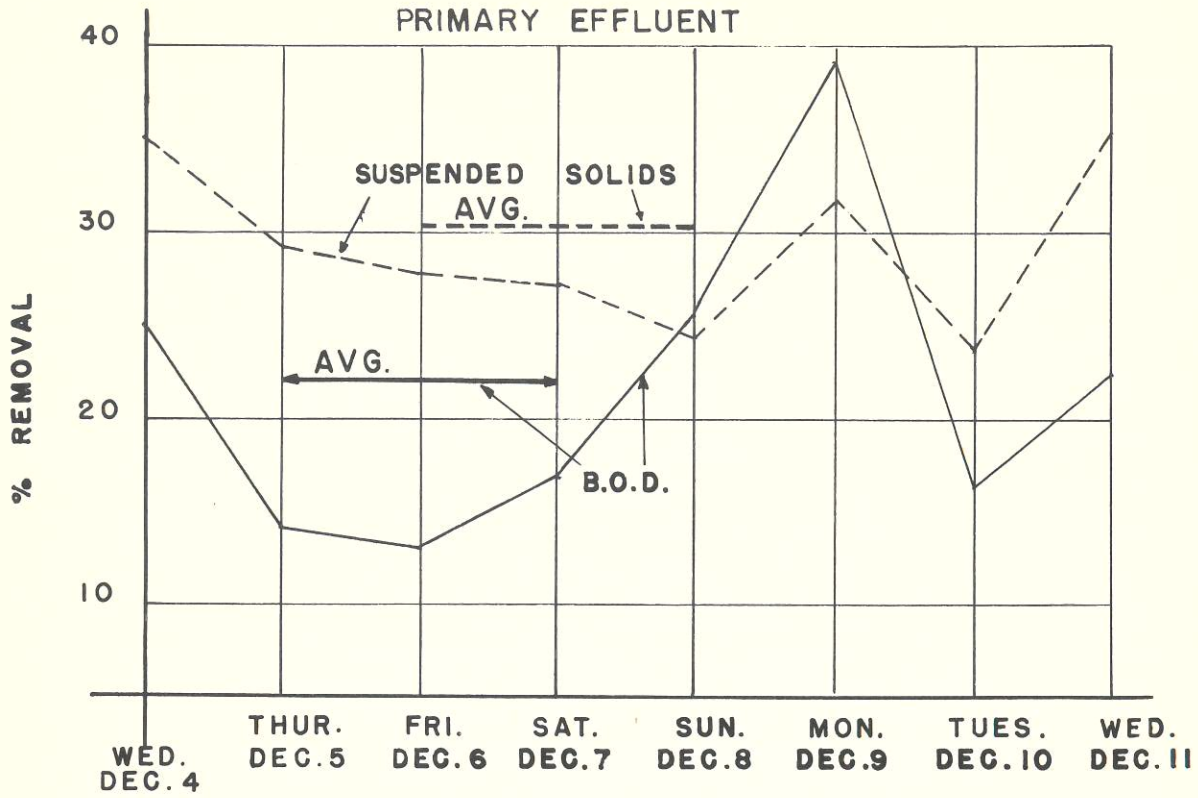
Biochemical Oxygen Demand (B.O.D.)

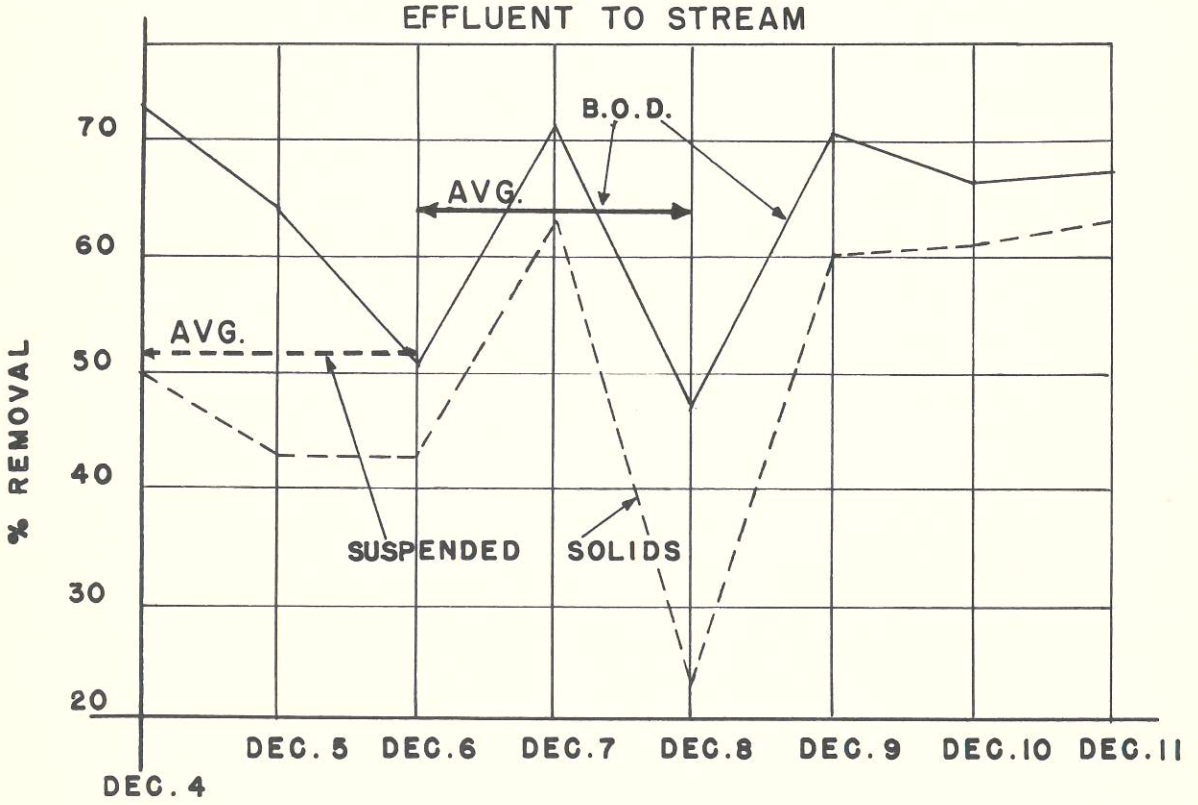
Daily B.O.D. results are tabulated in Table No. 5. Average results show the raw wastes contained 162 mg/l or 8,634 lbs. per day. The primary effluent average was 126 mg/l or 6,739 lbs. per day. The plant effluent discharged to the receiving stream contained an average 58 mg/l or 3,078 lbs. per day. Figure No. 11 shows the variation in percent removal between December 4 and December 12, 1963. The average primary unit removal was 21.8% and overall average removal of B.O.D. was 64.4%.

Assuming a Rapid City connected population of 50,000 persons, the average per capita contribution was 0.17 lbs. of B.O.D. per day. It should be emphasized that the industrial and tourist load in Rapid City varies greatly and would create higher loadings during other seasons. The per capita calculation includes the industrial wastes received at the waste treatment plant during this investigation.

Bacteriological

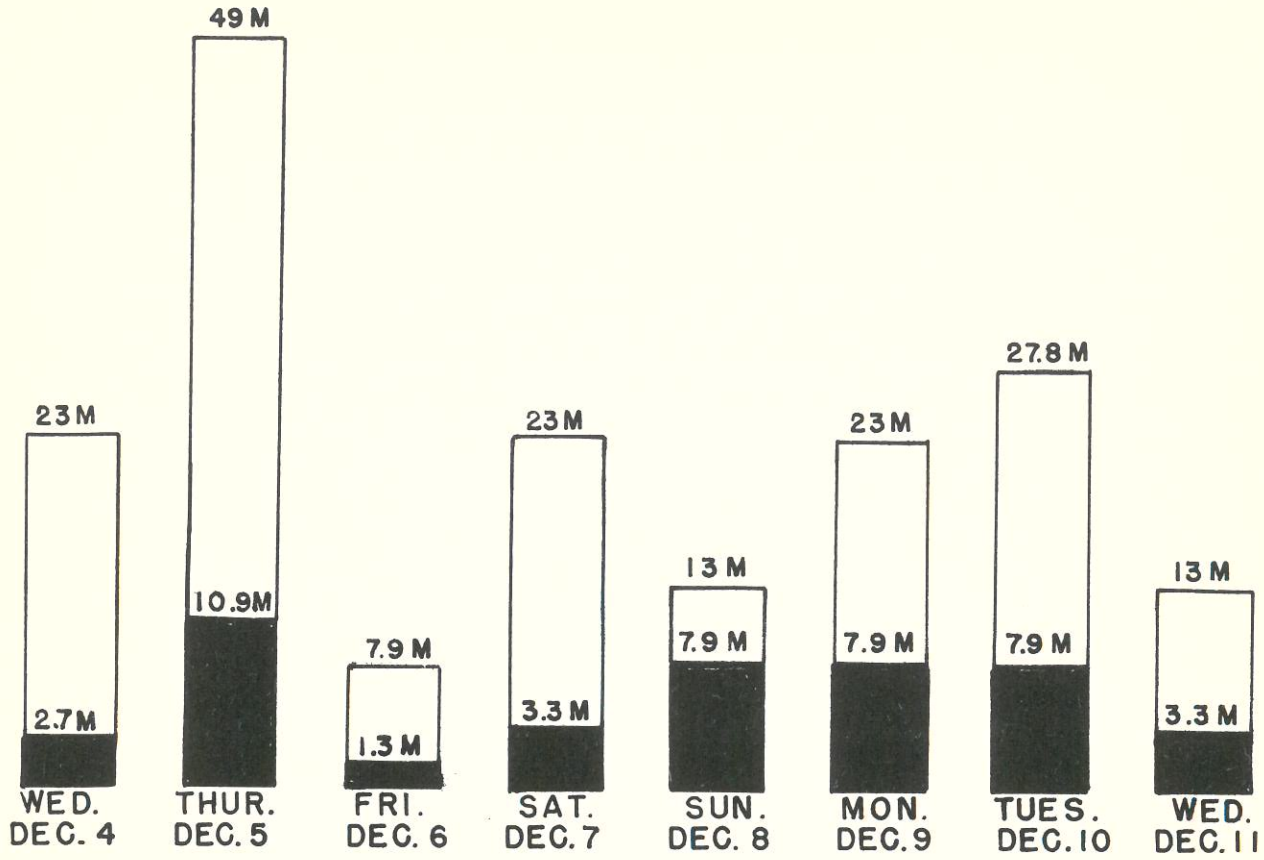
Daily total coliform and fecal coliform results for raw and plant effluent samples are presented in Table No. 5 and Figure No. 12. Median values for





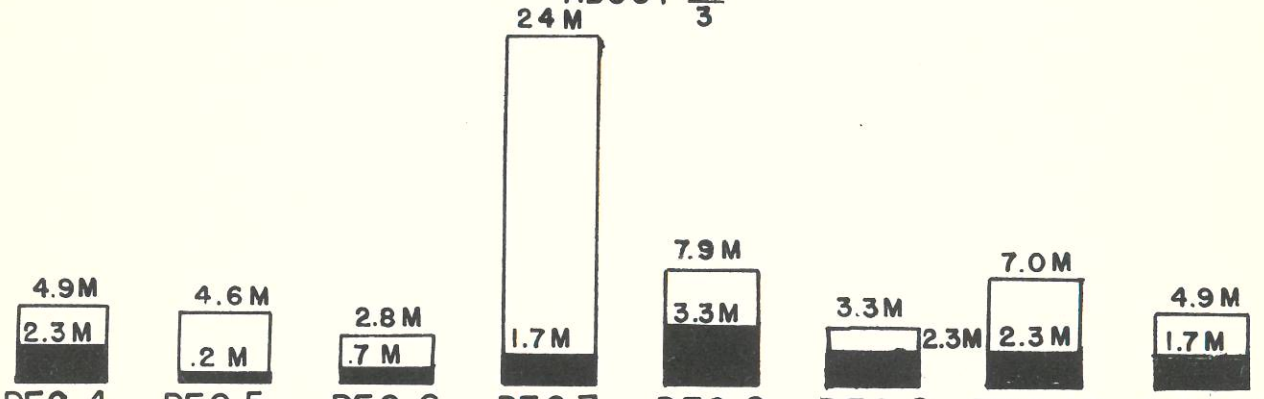
RAPID CITY WASTE TREATMENT PLANT EFFICIENCY

FIG. NO. 11



RAW MPN/100 ml.

AVERAGE REDUCTION THROUGH PLANT
ABOUT $\frac{2}{3}$



EFFLUENT TO STREAM MPN/100 ml.

M=MILLION

■=FECAL PORTION

TOTAL & FECAL COLIFORM BACTERIA
RAPID CITY WASTEWATER
AT PLANT
FIG. NO. 12

total coliform MPN per 100 ml were 23,000,000 in the raw and 4,900,000 in the plant effluent. Percent removal through the treatment plant was 79%. On the basis of 50,000 connected population, each person in Rapid City contributed 113,360,000,000 coliform bacteria per day. The fecal coliform MPN per 100 ml (median value) in the raw wastes was 5,660,000. Plant effluent contained 1,820,000. Percent removal of fecal coliform bacteria was 68%. The approximately one-third remaining fecal organisms are being discharged in the receiving stream above congested housing areas and irrigated land.

D. Special Private Well Study

The 22 wells investigated were all less than 50 feet deep, and 20 were used by ranchers and non-farm rural families living below Rapid City. Table No. 6 is a summary of the construction, location, and laboratory data. Over one-fourth of the wells investigated were less than 25 feet deep. Nearly one-half of the sources were not properly constructed to exclude contamination from the top of the well. More than 50% of the wells were located too close to private waste disposal systems, irrigation ditches carrying Rapid City wastewater effluent, or animal feed yards. Coliform bacteria or contamination was detected in 30% of the samples. A.B.S. detergent was detected in 40% of the samples. Nitrate nitrogen was noted in 20% of the samples tested. All of the nitrate nitrogen and all of the A.B.S. detergent tests but one were less than the U. S. Public Health Service Drinking Water Standard recommended maximums for these chemicals. A trace does indicate the presence of existing or past pollution material.

V. DISCUSSION AND CONCLUSIONS

A. Rapid Creek

Above Rapid City

Physical, chemical, bacteriological, and biological information compiled during the December 1963 Rapid Creek survey disclosed that essentially clean water conditions existed between Pactola Reservoir and Rapid City. The volume of wastes discharged during the winter months by the 7 known commercial and rural home waste sources was low and difficult to measure. The Rapid Creek stream flow volume following a wet year was sufficient to prevent any significant problems during the colder months. The raw water quality at the modern Rapid City water treatment plant was well within recommended maximums for the processes and equipment provided.

Rapid Creek water quality above Rapid City has improved during the past several years with less potential or direct waste connections to the receiving stream. Publicity and action by the Pennington County Health Department has reduced the amount of upstream Rapid Creek pollution.

Ground water pollution, however, is likely increasing in the rural area above Rapid City because additional septic tank and underground disposal systems are being installed each year. The volume of wastes above Rapid City will likely increase during the summer months with more habitation outside the city limits. Many private waste disposal systems are concealed or located behind rock walls constructed on the creek bank. Many potential pollution sources by private waste disposal are difficult to locate. The Pennington County Health Department conducted a premises survey above Rapid City during the summer of 1963 and reported these problems.

PRIVATE WELL SURVEY - RAPID VALLEY IRRIGATION AREA
(Shallow Wells Below City)

TABLE NO. 6

Wells Sampled	Depth		Not Sealed		Faulty Location			Lab. Data		
	0'-25'	25'-50'	Curbing	Cover	Private Waste	Irrigation Water	Animal Waste	Bac.	ABS *	NO_3 as N *
22	16	6	6	9	4	6	2	6	8	4
% of Wells Sampled	73%	27%	27%	41%	18%	27%	9%	30%	40%	20%
					54%					

* Test indicates at least a trace or the presence of pollution material - (mg/l)

A coordinated or effective program to prevent pollution by private homes in rural areas is non-existent. Private individuals, private contractors, developers, usual lending institutions, Farmers Home Administration, Federal Housing Administration, Veterans Administration, and others are involved in rural housing development. These agencies and developers do not have the advantage of guide lines based on adequate local studies. Septic tank systems are often backfilled without compliance with existing regulations. The City of Rapid City has questionable planning authority to encourage proper development adjacent to the city limits. The existing private sources of upper Rapid Creek pollution need to be controlled because children, fishermen, and other persons could have body contact with the stream water directly below the point of waste discharges.

Public or central sanitary facilities in Jackson Park, Braeburn Addition, and Starner Tract would serve a majority of the congested rural areas along Rapid Creek and close to the Rapid City limits. Most of the private waste systems discharging to Rapid Creek were located in Jackson Park directly above Canyon Lake. The city and Game, Fish and Parks officials are to be commended for extending the public sewer system to collect the sanitary wastes produced at the State Fish Hatchery. Continued efforts of the Pennington County Commission, local Health Department, and States Attorney should eliminate other localized nuisance and potential health hazards.

Inside Rapid City Limits

Degradation of Rapid Creek water quality starts with the flow through congested housing and commercial areas. The present local Health Department and city personnel are responsible for good enforcement of existing city ordinances. Flood conditions and surface water runoff problems during the past two years have created serious erosion problems and other damaging effects in the stream channel. The surface runoff problems and lack of storm drainage facilities require special study.

A relatively small volume of wastes from the industrial area to the northwest does enter Rapid Creek within the city near the Baken Park shopping district. The industrial officials were cooperative and will welcome additional conferences with city, county, and state officials. Certain improved treatment of wastes on an individual basis will be required if combined treatment with municipal wastes is not economical or feasible.

A sanitary sewer stoppage did occur in the western section of the city on December 11, 1963. Some raw sewage entered Lime Creek and Rapid Creek before city and commercial sewer cleaning crews could eliminate the solid material causing a stoppage in a sanitary sewer. Maintenance officials indicated that the sewer contained considerable debris that was introduced during a school fire. The school building burned down completely and material was carried into the sanitary sewer system. This occurence illustrates that emergencies do occur and that most municipalities and institutions need to devote more time to good preventive maintenance with qualified personnel. Reporting of the difficulty to the State Health Department by local officials was appreciated.

Below Rapid City

The only gross pollutional conditions found in Rapid Creek were below the Rapid City municipal outlet. Insufficient dissolved oxygen to support trout was measured between 2 and 8 miles downstream from the municipal plant outlet.

Dissolved oxygen, organic material (B.O.D.), and bacteriological tests indicate critical conditions for a distance of at least 10 miles below Rapid City. Biological studies of stream bottom organisms show that unsatisfactory aquatic conditions were noted for a total distance of at least 20 miles.

The bacteriological concentrations in the stream water for a distance of 10 miles below Rapid City are extremely high. The water supply is unsatisfactory for body contact purposes or for irrigation. The high bacterial densities downstream from the City of Rapid City are the most serious effect of the wastes. The median total coliform concentration of 1,300,000 MPN per 100 ml at Station No. 11 is many times greater than the 5,000 coliform per 100 ml considered to be desirable irrigation water quality.

The B.O.D. concentrations for at least 10 miles are approximately twice the maximum of 5 mg/l considered indicative of a fairly clean stream. Median values of bacteria and B.O.D. were utilized to report representative values. The B.O.D. values in the stream water were not consistent below the city outlet. This discrepancy likely was created by the mixing zone for the discharged wastes and scouring of the bottom and other factors associated with sampling under cold weather conditions. A number of samples at each station were necessary to determine fluctuations.

Odor, nuisance conditions, and greater potential public health hazards can be expected during other seasons of the year when the waste volumes increase, stream flow decreases, or when necessary to by-pass raw or untreated municipal sanitary wastes. Maximum waste flows during the summer months coincide with the heighth of the irrigation season. For several years potentially dangerous floating, dissolved and suspended material has been placed on land close to water supply wells, crops, a golf course, and residences. The cover of this report shows pictures of the signs installed by the Pennington County Health officials at the recommendation of the State Committees.

This field investigation was conducted after the close of the summer irrigation season. Irrigation water return flows to Rapid Creek can be expected to have some adverse effect on Rapid Creek water quality. Irrigation waters normally contain significant quantities of hardness and other suspended or dissolved solid material. Additional future studies may be needed to determine water quality degradation by irrigation waters. Flood control and miscellaneous land use studies are desirable to reduce silt and other forms of surface water pollution.

B. Rapid City Wastewater Treatment Plant

The average raw wastewater flow at the municipal plant of 6.4 MGD during the December 1963 survey is approximately 2 MGD in excess of the design capacity for the existing treatment plant. The flows and estimated 50,000 connected population overloads all of the present plant units. The sludge digesters at the Rapid City plant are heavily overloaded and not in satisfactory structural condition. The removal of total solids, organic material (B.O.D.), and total coliform bacteria during the December survey averaged only 52%, 64.4%, and 79%, respectively. Operation of the final clarifier or settling tank would not provide a significant increase in overall plant efficiency. Additional removal of final sludge would further aggravate operation of the digesters.

PLATE NO. 7

GOLF COURSE BELOW CITY OUTLET

(NOTE FOOT BRIDGE, TRAILER COURTS)

A much higher degree of overall waste treatment is necessary to protect a small receiving stream that flows through housing, recreation and irrigated areas. Flows during nine other months in 1963 exceeded the volume of December average waste flows. The yearly daily average for 1963 has been estimated by the treatment plant operator, from official records, to be nearly 8 MGD. This is almost double the design capacity for the existing treatment facilities. Frequent peak flows during the past two years have been estimated to be between 11 MGD and 12 MGD during the peak months of June, July, and August. Estimated wet weather flows above 15 MGD rate have been experienced for periods of three or four hours. The high flows are significant when all wastewater over the 9 MGD rate must be by-passed directly to Rapid Creek.

Raw untreated wastes were by-passed every month between March and October of 1963. Planned reduction of infiltration water may reduce the total flow at the treatment plant by 1 or 2 MGD over the next several years but will not eliminate by-passing untreated wastes. The median bacteriological concentrations in the plant effluent in December of 4,900,000 total coliform MPN per 100 ml, and 1,820,000 fecal coliform MPN per 100 ml may contain large quantities of pathogenic bacteria.

Pollution conditions will increase during the summer months because each person contributes more bacteria during the summer months, and untreated wastes have been discharged during the recreation season. The degree of waste treatment provided during each month of the year is unsatisfactory and past summer conditions were disgraceful.

C. Rapid Valley Private Well Water Survey

The partial survey of 22 shallow wells located in Rapid Valley below the city points out the importance of shallow well location and construction. Fortunately, the congested non-farm housing area in Rapid Valley is now serviced by the Rapid Valley Water Service Company. The public water supply system construction has eliminated many unsatisfactory shallow private wells. Some ranch families are hauling their drinking water. Some ranch wells will need to be relocated or sealed to protect the ground water quality.

This investigation did not differentiate between contamination from the Rapid Creek irrigation ditches or from private waste disposal systems. A more extensive investigation is advisable during the summer months to provide additional supporting information. At least 2 shallow ground water sources of drinking supply were located extremely close to the bank of the creek or irrigation ditch carrying only partially treated municipal wastes.

VI. RECOMMENDATIONS

1. It is recommended that the City of Rapid City and industries adopt a coordinated program of planning, financing, and construction of adequate liquid waste treating facilities in a satisfactory location.

2. Facilities for waste treatment and disposal should conform to the requirements of the South Dakota Department of Health and the South Dakota Committee on Water Pollution.

3. In view of pollution conditions below Rapid City, approval for new sanitary sewer extensions should be denied until a construction program for waste treatment is adopted.

4. That the city and county health department officials eliminate dumping of refuse, oil, animal manure, and other solid wastes into or near the banks of streams within their jurisdiction. Enforcement of existing and improved ordinances is recommended.

   The Pennington County Health Department should proceed to eliminate unsafe discharges from the 2 lodging establishments, 5 private homes, and 2 mobile home parks in accord with State law and regulations of the State Department of Health.

5. That the county and city officials improve a cooperative plan to control and prevent water pollution in the rural areas. Some form of metropolitan approach is recommended. The county authorities should exercise or secure additional realistic control over development outside the metropolitan area.

APPENDIX A

U. S. PUBLIC HEALTH SERVICE - BIOLOGICAL REPORT

RAPID CREEK, SOUTH DAKOTA

BIOLOGICAL SURVEY REPORT

DECEMBER 10-12, 1963

Nelson A. Thomas, Biologist
Biological, Chemical, & Oceanographic Activities
Technical Advisory & Investigations Section
Technical Services Branch
Division of Water Supply and Pollution Control

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Bureau of State Services

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

SUMMARY AND CONCLUSIONS

1. Wastes from the Rapid City, South Dakota sewage treatment plant eliminated trout from Rapid Creek below the plant for a distance of about 20 miles, increased the coarse fish population, and adversely affected the population of fish food organisms. Physical effects of the wastes on the stream included sludge deposits on the rock bottom, increased turbidity and temperature, and a reduction in the dissolved oxygen content of the water.

2. Stockyards located above the Rapid City sewage treatment plant adversely affected the stream biota. An increase in these wastes could reduce or eliminate the trout fishery between the stockyards and the sewage treatment plant.

RAPID CREEK, SOUTH DAKOTA

BIOLOGICAL SURVEY REPORT

December 10-12, 1963

On December 10-12, 1963 a biological survey was conducted on Rapid Creek from Pactola Reservoir to the Cheyenne River at the request of the South Dakota Department of Health to determine the effect of wastes on the stream biota. Qualitative and quantitative benthic samples were collected at 16 stations (Chart I).

Information on fish populations, fishing pressure, and fishing success was furnished by the South Dakota Department of Game, Fish and Parks.

Rapid Creek from Pactola Reservoir to just above the Rapid City, South Dakota sewage treatment plant produces a fine rainbow and brown trout fishery (Table 1) that is supported by many fish food organisms such as stonefly and mayfly nymphs and caddisfly larvae (Table 2). The population of these pollution-sensitive types was much greater than that of semi-tolerant and tolerant organisms. This represents a healthy stream that supports many different types of bottom organisms, but because of predation and competition for food and space, there are only a few of each type present. In a stream polluted with organic wastes, pollution-sensitive species are reduced resulting in a decrease in competition for food and space, and a decrease in predation. Large populations of pollution-tolerant bloodworms and sludgeworms develop because of an abundant food supply.

Benthic organisms have been grouped according to their ability to withstand pollution: pollution-sensitive organisms such as stonefly nymphs, mayfly nymphs, caddisfly larvae, and aquatic moth larvae can withstand very little pollution; semi-tolerant organisms such as scuds, snails, and blackfly larvae can withstand moderate pollution; and pollution-tolerant organisms such as some bloodworms and leeches, and sludgeworms can withstand severe pollution.

In the reach of stream above the Rapid City sewage treatment plant 12 different types of benthic organisms, that are considered to be prime trout food, were collected; the majority of these require clean water. The fish population, as well as the benthic population, was diversified above the sewage treatment plant. Major fish species were rainbow and brown trout, mountain sucker, long nose dace, stone catfish, white sucker, and rockbass. In this 30-mile section of stream (Stations F1-F4) trout fishing is heavy and fishing success is good. The naturally reproduced trout are supplemented by reared trout from a fish hatchery located on the stream. This section of the stream is considered to be one of the best trout streams in the area.

Degradation of Rapid Creek begins three miles above the Rapid City sewage treatment plant (below station 8). Between stations 8 and 9 there was a reduction in both kinds and numbers of benthic organisms; stonefly nymphs were completely eliminated, and mayfly nymphs and caddisfly larvae were greatly reduced. Partial reduction in the benthos existed down to an area between stations 9 and 10, where mayfly nymphs and caddisfly larvae were further reduced and occurred sporadically (Figure 1). The runoff from a stockyard probably reduced the pollution-sensitive organisms and created the unbalanced biotic state.

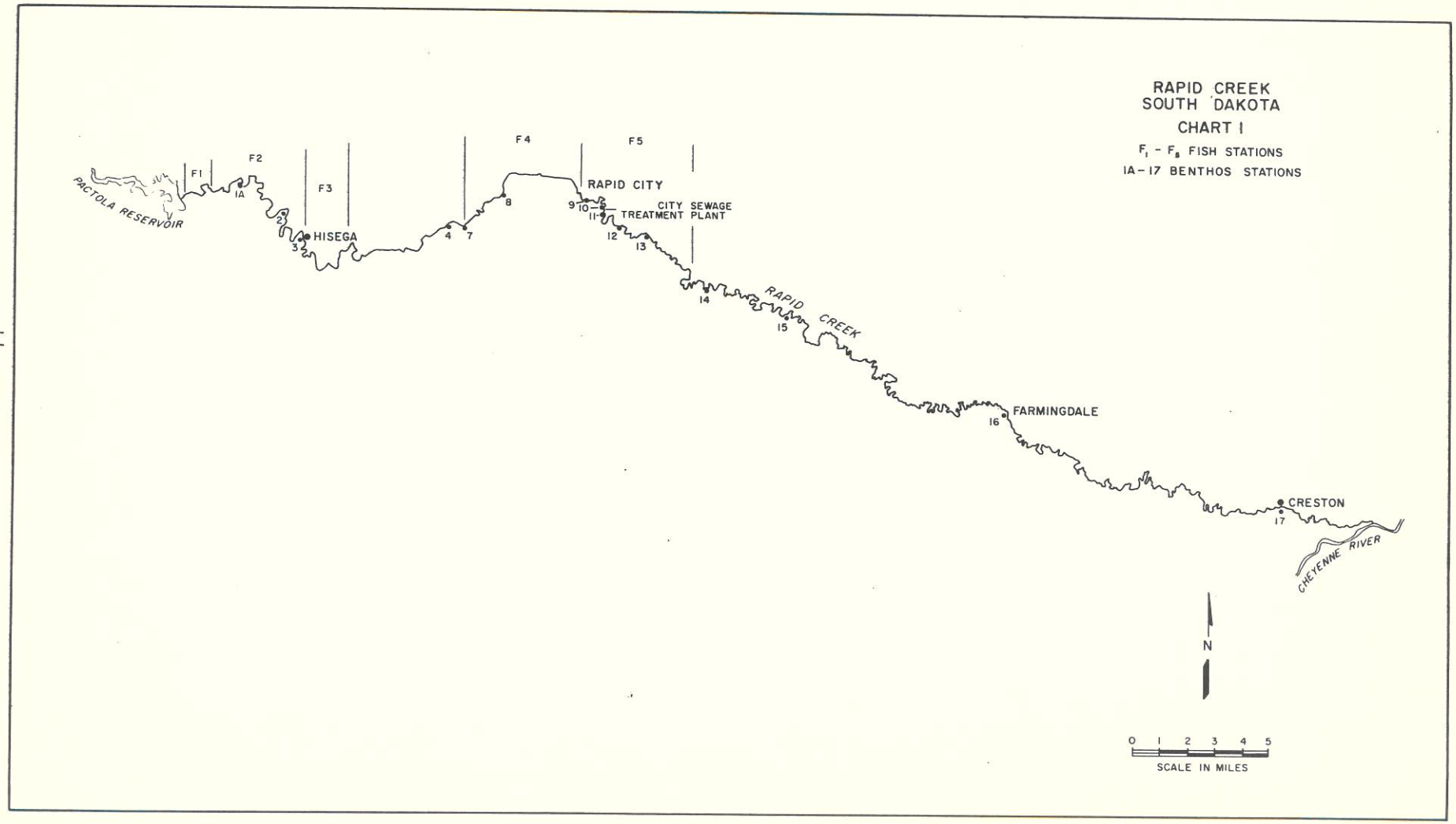

RAPID CREEK
SOUTH DAKOTA
CHART I
F1 - F5 FISH STATIONS
1A-17 BENTHOS STATIONS
PACTOLA RESERVOIR
F1
F2
F3
F4
F5
1A
HISEGA
2
3
4
7
8
RAPID CITY
9
10
11
CITY SEWAGE
TREATMENT PLANT
12
13
14
RAPID CREEK
15
FARMINGDALE
16
CRESTON
17
CHEYENNE RIVER
N
0 1 2 3 4 5
SCALE IN MILES

TABLE 1

RAPID CREEK, SOUTH DAKOTA
FISH POPULATION DATA

Data Obtained by Electro-fishing 1959-1960

P - Species Present
Blank - Species not Collected

SPECIES	F_1	F_2	F_3	F_4	F_5
Rainbow Trout	P	P	P	P	
Brown Trout	P	P	P	P	
Mountain Sucker	P	P	P	P	
White Sucker	P		P	P	P
Longnose Dace	P	P	P	P	
Stone Catfish		P	P	P	
Rock Bass				P	
Shiners					P
Fathead Minnow					P
Carp					P
Green Sunfish					P
Bullheads					P
Fishing Pressure	Moderate	Heavy	Slight	Heavy	Heavy
Fishing Success	High	High	Unknown	Moderate	Moderate

Table 2

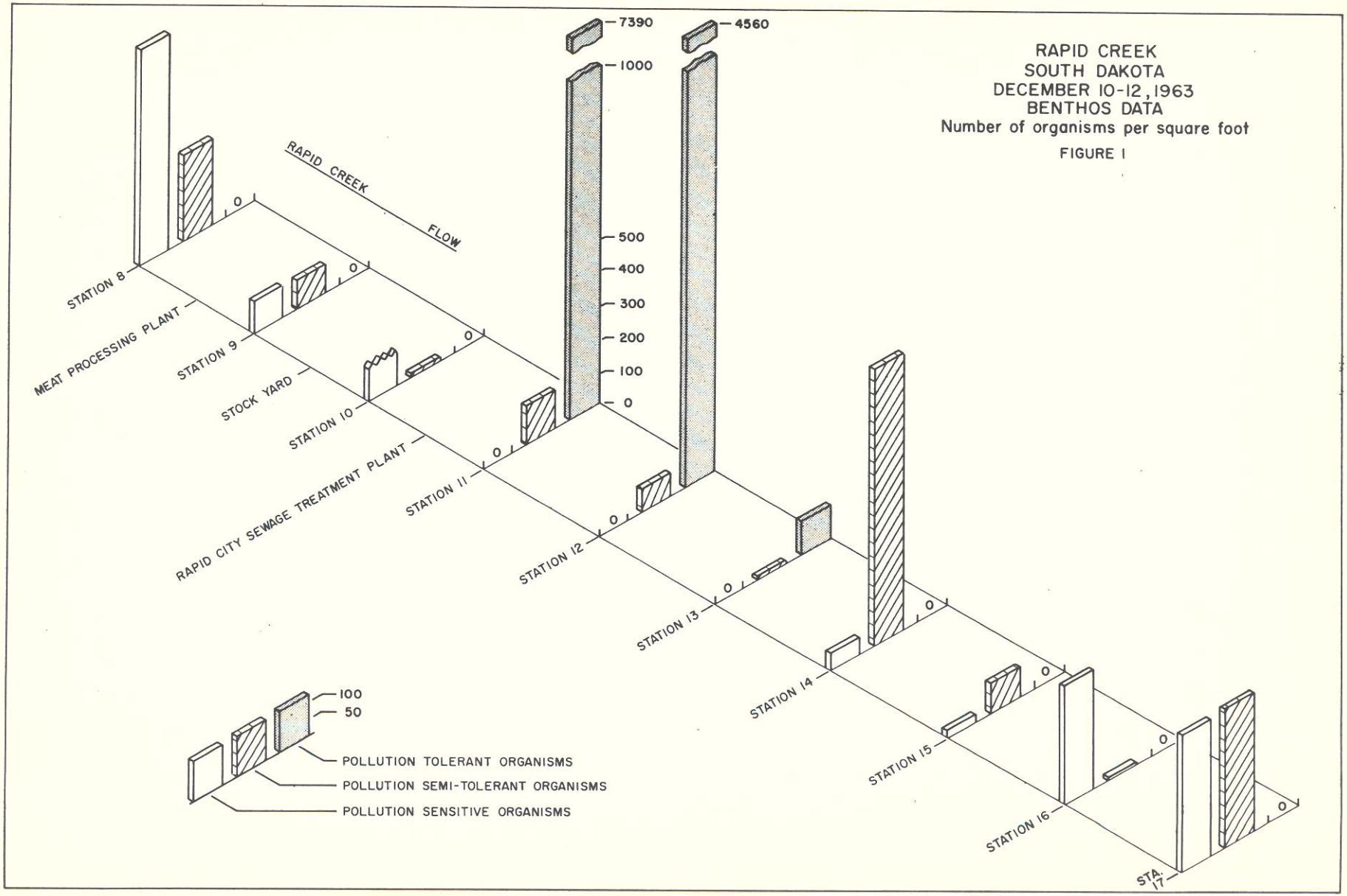
RAPID CREEK SOUTH DAKOTA

BENTHOS DATA
December 10-12, 1963

Organisms[1]	Number of Organisms Per Square Foot														
	1A	2	3	4	7	8	9	10	11	12	13	14	15	16	17
Plecoptera-Stonefly Nymph															
Isoperla sp.		2	7	7	3	83									
Ephemeroptera-Mayfly Nymph															
Baetis sp.	202	138	160	204	340	357	3	*							
Paraleptophebia sp.				5											
Blasturus sp.		7	7	2											
Tricorythodes sp.		17	3	2	24	70	92	*							
Ephemerella sp.			15		8										
Stenonema sp.					3	17									
Trichoptera-Caddisfly Larvae															
Hydropsyche, 3 species				15[3spp.]	5	102[2spp.]	3	*				53	14	365	427
Lepidoptera-Aquatic Caterpillar															
Elophila sp.					10	25									
Coleoptera-Beetle Larvae															
Elmidae		3	10												
Amphipoda-Scud															
Hyalella sp.			2		3	2		*				870	34		
Pulmonata-Snail															
Physa sp.		2					1	7	128				12		
Ancylidae							12				2		7	2	
Diptera-True Fly Larvae		2		2											
Tipulidae						2									
Simuliidae	14			238	935	17					2	2	17	5	425
Psychoda sp.									1340	12					
Tendipes plumosus-tentans, Bloodworm									4800	1712	104				
Unidentified Small Green Midge	68	3			10	235	65								
Rhynchobdellida-Leech			7		5	2	5	12		56	2	12	3	2	2
Turbellaria -Flatworm															
Planaria sp.										12					
Oligochaeta-Aquatic Worm															
Oligochaetes	7	2		8			2					2			
Tubificidae-Sludgeworm	25				2				1250	2836					
Misc.			5												
Total Species	5	9	9	11	12	12	8	6	4	5	4	5	6	4	3
Total Organisms	316	176	216	483	1348	912	183	19	7518	4628	110	886	104	374	853

* Appeared only in Qualitative Sample

1 Tentative Identification


RAPID CREEK
SOUTH DAKOTA
DECEMBER 10-12, 1963
BENTHOS DATA
Number of organisms per square foot
FIGURE 1
RAPID CREEK
FLOW
STATION 8
MEAT PROCESSING PLANT
STATION 9
STOCK YARD
STATION 10
RAPID CITY SEWAGE TREATMENT PLANT
STATION 11
STATION 12
STATION 13
STATION 14
STATION 15
STATION 16
STA. 17
7390
4560
1000
500
400
300
200
100
0
100
50
POLLUTION TOLERANT ORGANISMS
POLLUTION SEMI-TOLERANT ORGANISMS
POLLUTION SENSITIVE ORGANISMS

The greatest biological change occurred in Rapid Creek below the Rapid City, South Dakota sewage treatment plant. Extensive sludge banks were found immediately below the sewage treatment plant; they eliminated all pollution-sensitive organisms and provided food for an abundant population (over 7,000 per sq. ft.) of pollution-tolerant organisms such as sludgeworms and bloodworms (Table 2).

Sewage fly (Psychoda) larvae were also found on the sludge deposits in large numbers (1,300 per sq. ft.). This organism lives on dead decaying matter and often lives in the trickling filters of sewage treatment plants and in the supernatant of sludge drying beds that are slow in de-watering.

The effluent of the sewage treatment plant degrades the stream by releasing solids, raising the water temperature, increasing turbidities and reducing the dissolved oxygen content of the water. Organic solids settled around the rocks below the Rapid Creek sewage treatment plant, thus reducing the habitat for pollution-sensitive benthic organisms. The oxygen demand of the sludge further reduces the dissolved oxygen of the water circulating around the rocks affecting benthic organisms that might inhabit the rocks, as well as fish eggs that might be deposited around the rocks.

Volatile solid (organic content) determinations were made on stream bottom samples collected above and below the sewage treatment plant. Above the sewage treatment plant (station 10) the bottom muds contained 4.3% (dry weight) organic matter. The addition of organics by the sewage treatment plant increased the organic content of the bottom muds to 47.6% (dry weight) at station 11. At stations 12 and 13 the amount of organic matter in the bottom muds was 9.0% and 5.4% (dry weight) respectively (Figure 2). The sludge from the sewage treatment plant was evident in the bottom muds for 4 miles.

Biological degradation below the sewage treatment plant (station F5) was further evidenced by the change in the fish population. Highly desirable rainbow and brown trout are replaced by coarse fish such as carp, green sunfish and bullheads; other species collected were fathead minnows, shiners, and white sucker.

The area below the sewage treatment plant has no fishing pressure or recreational value at the present time as the result of the elimination of game fish from this section of the stream. If the sewage was adequately treated and a trout fishery established, the additional 20 miles of trout stream would provide a recreational area for the local people and be a potential attraction. The potential trout water is almost equal the length of existing trout water above the sewage treatment plant.

Four miles below the sewage treatment plant (between stations 13-14), Rapid Creek starts to recover biologically. Pollution-sensitive caddisfly larvae inhabit the stream from this area to the confluence of the Cheyenne River. The stream does not recover sufficiently before it joins the Cheyenne, however, to possess the same water quality as above the sewage treatment plant. Such pollution-sensitive organisms as stonefly and mayfly nymphs were not found in this section.

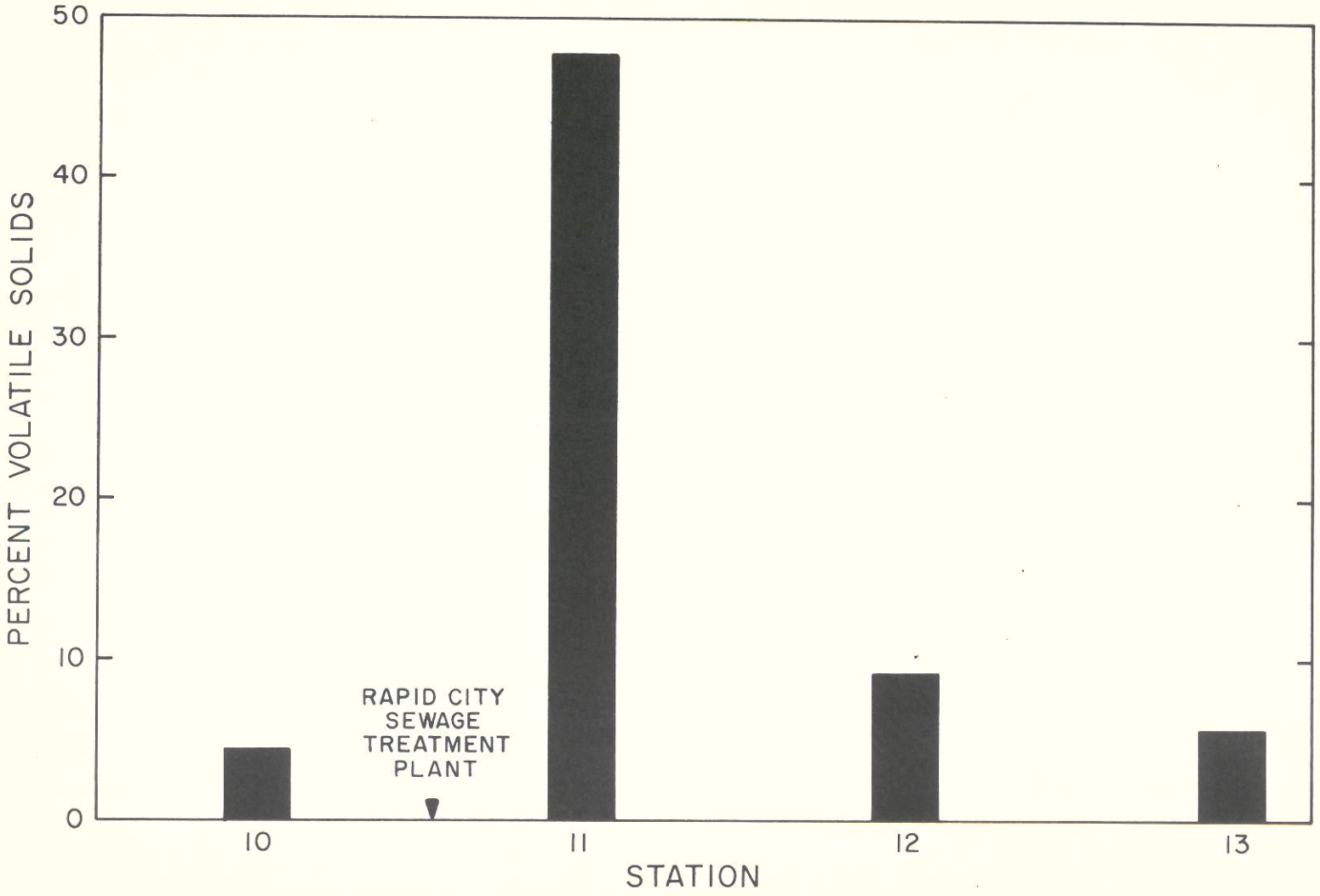


Figure 2. Composition of stream bottom.

APPENDIX B

Results of Individual Stream Samples

RAPID CREEK SURVEY
December 1963
Summary of Individual Water Pollution Analysis Results

TABLE NO. 7

Station No. 1 (109.3)

Month Date Year	Sample Time A.M.	pH	Temp. °C	D.O. mg/l	D.O. % Sat.	B.O.D. mg/l	A.B.S. mg/l	Nitrogen NO_3 mg/l	Coliforms MPN per 100 ml	Fecal MPN per 100 ml	Remarks
12-3-63	7:30	8.3	5.5	10.0	88	1.13			*20	*20	warm - clear
4	7:20	8.2	5.0	10.0	87	----			--	--	" "
5	8:15	8.1	5.5	10.3	90	.68	0	0	*20	*20	" "
6	7:15	8.2	5.0	9.9	86	.59			*20	*20	" "
7	8:05	8.0	4.5	10.1	87	.62			*20	*20	" "
8	7:15	8.1	4.0	10.2	87	.69			50	*20	cold - clear
9	8:15	8.2	4.5	10.4	90	.70			130	*20	" "
10	7:25	8.2	4.0	10.4	89	1.13	0	0	*20	*20	" "
11	8:30	8.2	4.0	10.7	91	.58			*20	*20	" "
12	7:30	---	4.0	10.4	89	----			*20	*20	very cold
Avg.		8.2	4.7	10.2	88	.77	0	0	*36	*20	
Median						0.69			*20	*20	

Station No. 2 (101.3)

12-3-63	7:55	8.4	1.0	11.7	92	----			--	--	warm - clear
4	7:40	8.4	0.5	11.8	92	----			*20	*20	" "
5	7:55	8.2	0.5	11.8	92	----	0	0	50	20	" "
6	7:30	8.3	2.5	11.3	93	----			*20	*20	" "
7	7:50	8.2	0	11.6	89	----			20	*20	" "
8	7:35	8.3	0	12.0	92	----			60	*20	cold - clear
9	8:00	8.1	0	11.9	91	----			20	*20	" "
10	7:50	8.2	0	----	--	----	0	0	50	*20	" "
11	8:05	8.1	0	11.7	89	----			*20	*20	" "
12	7:45	8.1	0	11.4	87	----			*20	*20	very cold
Avg.		8.2	0.5	11.7	91	----	0	0	*31	*20	
Median						----			*20	20	

* Indicates less than

RAPID CREEK SURVEY
December 1963
Summary of Individual Water Pollution Analysis Results

TABLE NO. 8

Station No. 3 (97.9)

Month Date Year	Sample Time A.M.	pH	Temp. °C	D.O. mg/l	D.O. % Sat.	B.O.D. mg/l	A.B.S. mg/l	Nitrogen NO_3 mg/l	Coliforms MPN per 100 ml	Fecal MPN per 100 ml	Remarks
12-3-63	8:05	8.4	0	12.4	95	----			70	*20	warm - clear
4	7:50	8.5	0	12.3	93	----			--	--	" "
5	7:45	8.2	0	12.3	94	----	0	0	230	20	" "
6	7:45	8.5	1.0	11.8	93	----			50	20	" "
7	7:35	8.3	0	12.0	92	----			50	*20	" "
8	7:50	8.4	0	12.4	95	----			*20	*20	cold - clear
9	7:45	8.2	0	12.3	94	----			130	*20	" "
10	8:00	8.2	0	12.1	92	----	0	0	230	20	" "
11	7:50	8.1	0	12.2	93	----			50	*20	" "
12	8:00	8.2	0	12.0	92	----			110	70	very cold
Avg.		8.3	.1	12.2	93	----	0	0	*104	*26	
Median						----			70	20	

Station No. 4 (87.9)

12-3-63	8:25	8.4	1.5	11.8	94	----			---	---	warm - clear
4	8:10	8.2	1.0	11.4	90	----			330	20	" "
5	7:30	8.1	1.0	11.5	91	----	0	0	490	20	" "
6	8:00	8.1	2.0	11.2	90	----			130	*20	" "
7	7:20	8.2	1.0	11.7	92	----			110	20	" "
8	8:05	8.2	0	11.1	85	----			170	70	cold - clear
9	7:25	8.1	2.0	10.7	86	----			490	20	" "
10	8:20	8.2	0.5	11.4	88	----	0	0	130	50	" "
11	7:35	8.2	0	11.5	88	----			490	80	" "
12	8:20	8.1	1.5	11.1	89	----			220	80	very cold
Avg.		8.2	1.1	11.3	89	----	0	0	284	42	
Median						----			220	20	

* Indicates less than

RAPID CREEK SURVEY
December 1963
Summary of Individual Water Pollution Analysis Results

TABLE NO. 9

Station No. 6 (87.4)

Month Date Year	Sample Time A.M.	pH	Temp. °C.	D.O. mg/l	D.O. % Sat.	B.O.D. mg/l	A.B.S. mg/l	Nitrogen NO_3 mg/l	Coliforms MPN per 100 ml	Fecal MPN per 100 ml	Remarks
12-3-63	8:40	8.1	5.0	10.2	89	0.87			---	---	warm - clear
4	8:25	8.0	5.0	9.8	85	----			490	70	" "
5	7:20	7.9	4.5	9.4	81	0.61	0	0.3	270	*20	" "
6	8:10	8.0	6.5	9.1	83	0.94			490	50	" "
7	7:10	7.9	5.0	9.0	78	0.62			490	80	" "
8	8:20	8.0	5.0	9.2	80	0.76			260	130	cold - clear
9	7:15	8.0	6.5	8.5	77	0.61			790	50	" "
10	8:30	8.0	4.5	9.3	80	0.99	0	0.3	220	70	" "
11	7:15	7.9	5.0	9.0	78	0.61			230	230	" "
12	8:35	8.0	6.0	8.8	79	----			170	20	very cold
Avg.		8.0	5.3	9.2	81	0.75	0	0.3	379	80	
Median						0.76			270	70	

Station No. 7 (86.7)

12-3-63	8:50	8.5	3.0	11.8	98	----			*200	*200	warm - clear
4	8:30	8.4	3.0	11.7	97	----			---	---	" "
5	7:10	8.2	3.0	11.3	93	----	0	0.1	330	20	" "
6	8:15	8.3	3.5	11.3	95	----			130	*20	" "
7	7:05	8.3	3.0	11.3	93	----			110	50	" "
8	8:25	8.4	1.5	11.9	95	----			460	130	cold - clear
9	7:05	8.3	1.5	11.7	94	----			90	20	" "
10	8:35	8.3	2.0	11.9	96	----	0	0.1	460	50	" "
11	7:10	8.2	2.0	11.6	94	----			80	*20	" "
12	8:40	8.3	3.0	11.4	94	----			310	80	very cold
Avg.		8.3	2.6	11.6	95	----	0	0.1	241	*66	
Median						----			*200	50	

* Indicates less than

RAPID CREEK SURVEY
December 1963
Summary of Individual Water Pollution Analysis Results

TABLE NO. 10

Station No. 8 (84.4)

Month Date Year	Sample Time A.M.	pH	Temp. °C	D.O. mg/l	D.O. % Sat.	B.O.D. mg/l	A.B.S. mg/l	Nitrogen NO_3 mg/l	Coliforms MPN per 100 ml	Fecal MPN per 100 ml	Remarks
12-3-63	9:00	8.2	3.0	10.9	90	----			--	--	turbid water
4	8:40	8.2	2.0	11.5	93	----			80	20	city wk.on creek
5	7:00	8.1	2.0	11.3	91	----	0	0.3	20	20	no silt
6	8:25	8.3	3.0	11.0	91	----			80	*20	
7	6:55	8.3	1.0	11.5	91	----			90	20	
8	8:35	8.2	0	12.3	93	----			130	20	
9	6:55	8.1	0	----	--	----			130	20	
10	8:45	8.2	0	12.3	94	----	0	0.35	230	80	
11	6:55	8.2	0	12.0	92	----			490	50	
12	8:50	8.2	0.5	12.1	94	----			16,000	330	sewer overflow
Avg.		8.2	1.1	11.7	92	----	0	0.33	1,917	64	
Median						----			130	20	

Station No. 9 (79.4)

12-3-63	6:40	8.3	2.0	11.8	95	----			1,100	500	
4	6:50	8.2	2.0	11.8	95	----			-----	---	
5	8:25	8.2	2.0	12.1	97	----	0	0.3	1,300	170	
6	6:43	8.2	2.0	11.2	90	----			790	790	
7	8:03	8.2	1.0	12.0	94	----			13,000	490	
8	7:20	8.3	0	12.7	97	----			490	230	
9	9:45	8.3	0	12.9	98	----			790	170	
10	8:15	8.2	0	12.7	97	----	0	0.55	1,720	330	
11	8:55	8.1	0	12.8	98	----			2,300	790	
12	7:00	8.1	0	12.2	93	----			34,800	2,300	animal manure
Avg.		8.2	0.9	12.2	95	----	0	0.43	6,254	641	
Median						----			1,300	490	

* Indicates less than

RAPID CREEK SURVEY
December 1963
Summary of Individual Water Pollution Analysis Results

TABLE NO. 11

Station No. 10 (77.9)

Month Date Year	Sample Time A.M.	pH	Temp. °C.	D.O. mg/l	D.O. % Sat.	B.O.D. mg/l	A.B.S. mg/l	Nitrogen NO_3 mg/l	Coliforms MPN per 100 ml	Fecal MPN per 100 ml	Remarks
12-3-63	7:00	8.2	2.0	11.5	93	1.87			500	*200	
4	7:05	8.2	2.0	11.4	92	----			790	790	
5	8:15	8.3	2.0	11.9	96	1.89	0	0.35	490	230	
6	6:50	8.2	3.0	11.0	91	1.59			790	130	
7	7:56	8.2	1.0	11.6	91	1.86			4,900	790	
8	7:28	8.3	0	12.5	95	1.86			790	170	
9	9:37	8.3	0	12.7	97	2.0			1,300	230	
10	8:28	8.2	0	12.4	95	2.4	0	0.45	790	330	
11	8:45	8.2	1.0	12.4	98	1.64			3,300	790	some animal
12	7:10	8.0	0	12.0	92	1.8			54,200	1,090	manure on bank
Avg.		8.2	1.1	11.9	94	1.9	0	0.40	6,785	475	
Median						1.87			790	330	

Station No. 11 (77.6)

12-3-63	7:15	8.0	4.0	9.5	81	8.6			790,000	240,000	below city
4	7:17	7.9	4.0	9.8	84	---			1,090,000	221,000	outlet
5	8:05	8.0	4.0	9.9	85	7.9	0.28	0.40	1,300,000	11,000	
6	7:00	7.9	5.0	9.5	83	7.55			490,000	330,000	
7	7:50	8.0	4.0	10.4	89	7.70			460,000	79,000	
8	7:35	8.1	2.0	10.0	81	9.92			5,420,000	270,000	
9	9:30	7.8	4.0	9.8	84	17.2			1,300,000	1,300,000	
10	8:34	7.9	1.0	9.5	75	15.0	0.45	1.0	1,720,000	1,300,000	
11	8:38	7.8	4.0	10.1	86	15.1			1,410,000	330,000	
12	7:15	7.9	1.0	10.5	83	8.36			1,720,000	109,000	
Avg.		7.9	3.3	9.9	83	10.8	.365	0.70	1,570,000	419,000	
Median						8.6			1,300,000	330,000	

* Indicates less than .

RAPID CREEK SURVEY
December 1963
Summary of Individual Water Pollution Analysis Results

TABLE NO. 12

Station No. 12 (75.7)

Month Date Year	Sample Time A.M.	pH	Temp. °C.	D.O. mg/l	D.O. % Sat.	B.O.D. mg/l	A.B.S. mg/l	Nitrogen NO_3 mg/l	Coliforms MPN per 100 ml	Fecal MPN per 100 ml	Remarks
12-3-63	7:30	7.9	4.0	5.9	50	7.8			-------	------	
4	7:25	7.8	4.0	5.8	50	---			278,000	79,000	
5	7:56	7.8	4.0	5.7	49	7.44	0.6	0.5	172,000	49,000	
6	7:08	7.8	5.0	4.9	43	9.52			230,000	79,000	
7	7:40	7.9	4.0	6.4	55	10.9			330,000	109,000	
8	7:49	8.0	0	---	--	11.4			490,000	130,000	
9	9:16	7.8	2.0	7.3	59	9.76			230,000	79,000	
10	8:46	7.9	0	7.5	57	12.5	0.55	1.8	490,000	109,000	
11	8:32	7.8	0	7.8	60	11.4			345,000	172,000	
12	7:22	7.8	1.0	7.4	58	9.96			172,000	79,000	
Avg.		7.9	2.4	6.5	53	10.1	.58	1.2	304,100	98,330	
Median						9.96			278,000	109,000	

Station No. 13 (73.5)

12-3-63	7:40	7.7	4.0	3.7	32	---			109,000	17,000	golf club
4	7:35	7.7	3.0	3.5	29	---			-------	------	
5	7:48	7.5	3.0	3.9	32	---	1.0	3.5	79,000	17,000	
6	7:16	7.6	4.0	3.0	26	---			17,000	13,000	
7	7:30	7.7	2.0	4.2	34	---			141,000	22,000	
8	7:56	7.8	0	6.7	51	---			79,000	49,000	
9	9:07	7.7	1.0	6.0	47	---			141,000	46,000	
10	9:56	7.7	0	6.4	49	---	1.0	5.5	130,000	33,000	
11	8:25	7.7	0	6.3	48	---			172,000	49,000	
12	7:28	7.7	1.0	6.2	49	---			130,000	49,000	
Avg.		7.7	1.8	5.0	40	---	1.0	4.5	110,900	32,780	
Median						---			130,000	33,000	

RAPID CREEK SURVEY
December 1963
Summary of Individual Water Pollution Analysis Results

TABLE NO. 13

Station No. 14 (68.1)

Month Date Year	Sample Time A.M.	pH	Temp. °C.	D.O. mg/l	D.O. % Sat.	B.O.D. mg/l	A.B.S. mg/l	Nitrogen NO_3 mg/l	Coliforms MPN per 100 ml	Fecal MPN per 100 ml	Remarks
12-3-63	7:45	7.8	2.0	5.6	45	5.52			-----	-----	
4	7:46	7.8	3.0	5.5	45	----			4,900	1,700	
5	7:38	7.7	3.0	5.5	45	7.56	0.8	6.5	4,900	2,300	
6	7:25	7.7	4.0	5.1	44	8.04			3,300	1,700	
7	7:24	7.8	2.0	6.2	50	11.2			14,100	4,900	
8	8:05	7.9	0	8.1	62	8.88			23,000	13,000	
9	8:58	7.9	0	7.9	60	6.28			109,000	49,000	
10	9:05	7.8	0	7.5	57	15.0	0.75	12.0	109,000	70,000	
11	8:15	7.7	0	7.1	54	29.9			49,000	33,000	
12	7:38	7.7	0	6.4	49	22.3			141,000	70,000	
Avg.		7.8	1.4	6.5	51	12.7	0.78	9.3	50,910	27,290	
Median						8.88			23,000	13,000	

Station No. 15 (61.9)

12-3-63	7:55	8.2	0	10.7	82	5.4			2,000	*2,000	
4	7:55	7.9	1.0	10.4	82	---			-----	-----	
5	7:28	8.0	2.0	10.2	82	5.52	0.80	4.50	3,300	800	
6	7:38	8.0	3.0	9.9	82	2.56			3,300	800	
7	7:15	8.1	2.0	10.5	85	6.81			2,600	1,700	
8	8:16	8.3	0	12.2	93	5.36			2,300	1,300	
9	8:46	8.1	0	11.2	85	5.60	0.90	5.50	4,900	3,300	
10	9:12	8.0	0	10.7	82	5.77			17,200	7,000	
11	8:00	7.9	0	10.1	77	4.47			22,100	10,900	
12	7:46	7.8	0	9.7	74	4.92			49,000	13,000	
Avg.		8.0	0.8	10.6	82	5.2	0.85	5.0	11,866	4,530	
Median						5.4			3,300	*2,000	

* Indicates less than

RAPID CREEK SURVEY
December 1963
Summary of Individual Water Pollution Analysis Results

TABLE NO. 14

Station No. 16 (34.7)

Month Date Year	Sample Time A.M.	pH	Temp. °C.	D.O. mg/l	D.O. % Sat.	B.O.D. mg/l	A.B.S. mg/l	Nitrogen NO_3 mg/l	Coliforms MPN per 100 ml	Fecal MPN per 100 ml	Remarks
12-3-63	8:10	8.4	0	12.5	95	----			---	---	
4	8:14	8.4	0	12.4	95	----			330	230	
5	7:12	8.3	0	12.3	94	----	0.7	3.0	230	80	
6	7:50	8.4	1.0	12.0	94	----			790	40	
7	6:57	8.3	1.0	11.6	91	----			790	220	
8	8:35	8.4	0	12.5	95	----			340	80	
9	8:30	8.4	0	12.7	97	----			1,410	210	
10	9:28	8.2	0	11.9	91	----	0.75	3.0	790	230	
11	7:43	8.1	0	11.8	90	----			1,090	310	
12	8:02	8.0	0	11.6	89	----			1,750	790	
Avg.		8.3	0.2	12.1	93	----	.73	3.0	836	243	
Median						----			790	230	

Station No. 17 (12.6)

12-3-63	8:30	8.4	0	13.0	99	1.4			1,300	80	
4	8:30	8.4	0	12.9	98	---			-----	--	
5	6:50	8.5	0	12.9	98	1.47	0.45	3.0	170	20	
6	8:07	8.4	0	12.8	98	1.40			490	20	
7	6:35	8.4	0	12.6	96	2.17			330	80	
8	8:50	8.5	0	13.1	100	1.97			270	20	
9	8:05	8.3	0	12.7	97	1.68			1,300	20	
10	9:46	8.4	0	12.6	96	1.79	0.6	2.5	790	60	
11	7:23	8.3	0	12.5	95	1.20			490	80	
12	8:17	8.2	0	12.2	93	1.50			790	50	
Avg.		8.4	0	12.7	97	1.6	.53	2.8	659	48	
Median						1.50			490	50	

APPENDIX C

LOADINGS - RAPID CITY WASTE TREATMENT PLANT
December 1963

I. Primary Clarifiers - (1-75' dia.; 1-55'x55') (each 7.0' depth)

Total Surface Area = 7445 sq. ft.

Total Volume = 435,500 gallons

Average 24 hr. Flow = 6.4 million gallons

Detention Time = 1.63 hrs. (2 hrs. minimum recommended)

Surface Overflow Rate = 860 gals. per sq. ft. per day
(600 desirable)

II. Digesters - (1-45' dia.,22' depth; 1-45' dia., 19' depth)

Total Volume = 65,250 cu. ft.

Volume per capita (50,000 connected population) = 1.31 cu. ft.
(4 to 5 cu. ft. per capita recommended)

III. Sludge Beds

Total Area = 10,000 sq. ft.

Area per capita (50,000 connected population) = 0.20 sq. ft. per capita (1.0 sq. ft. per capita recommended)

IV. Trickling Filters - (2 each 150' dia. and 8' depth)

Total Area = 35,300 sq. ft. = 0.81 acres

Total Rock Volume = 283,000 cu. ft.

Hydraulic Loading = 7.9 MGD per acre

B.O.D. Loading @ 6739 pounds per day = 23.8 lbs. per 1000 cu. ft. rock
(exceeds recommendation in 10 State Standards)

V. Final Clarifier - (95' dia., 9' sidewall depth)

Surface Area = 7080 sq. ft.

Volume = 477,500 gallons

Detention Time = 1.79 hrs. @ 6.4 MGD
(2.0 hrs. minimum recommended)

Surface Overflow Rate = 905 gals. per sq. ft. per day
(800 minimum recommended)

RESOLUTIONS
Adopted by
South Dakota Public Health Advisory Committee
and
South Dakota Committee on Water Pollution
May 28-29, 1963
Rapid City, South Dakota

The Following recommendations and resolutions were adopted unanimously by the Joint Committees: (Items 1, 2 and 6 are of particular significance to this report.)

1. That adequate water and sewer systems be provided in the upper Rapid Creek area to prevent stream pollution, to abate public health hazards and assure safe water supplies. It is further recommended that the Pennington County Health Department, cooperating with Rapid City, post this stream at frequent intervals indicating it as a source of water supply for Rapid City and prohibiting pollution.

2. That residents of lower Rapid Valley be commended for providing themselves a safe water supply through the Rapid Valley Water Service Company. They are encouraged to continue their efforts to provide community waste collection and treatment facilities.

3. That the Box Elder residents be encouraged to continue their efforts to obtain a satisfactory source of water supply and to develop a community water works. While planning this improvement, consideration should also be given to the construction of an adequate waste collection and treatment works.

4. That licensed eating and lodging establishments in Keystone be encouraged to continue their efforts to provide a safe water supply, and are advised that compliance with sanitation requirements is mandatory for continued licensing. It appears that considerable progress on water development has been made, and the Committees trust that these preliminary plans can be brought to completion.

5. The Committees in joint session express their appreciation for the cooperation and interest displayed by representatives of legislative, municipal, county, and other governmental agencies and private citizens; and for the information provided to enlighten the members.

6. WHEREAS, the South Dakota Committee on Water Pollution and the South Dakota Public Health Advisory Committee met in joint session May 28-29, 1963, at Rapid City and received information and observed the conditions of the Rapid City waste treatment plant and Rapid Creek, and

   WHEREAS, Rapid City serves as a source of water for irrigation, flows through populated areas, and has a potential for numerous recreational uses, and

   WHEREAS, The Rapid City waste treatment plant is seriously overloaded resulting in the discharge of raw sewage and inadequately treated effluent to Rapid Creek, and

   WHEREAS, such discharges create serious public health hazards and water quality degradation in Rapid Creek,

BE IT THEREFORE RESOLVED, that the City of Rapid City be advised to take immediate action directed toward construction of an adequate waste treatment plant designed in accordance with anticipated future municipal growth and the needs of the area, and

BE IT FURTHER RESOLVED, that a site for the proposed treatment plant be considered at least four miles downstream from the existing plant, and

BE IT FURTHER RESOLVED, that the Pennington County Board of Health take action to warn the public against the use of Rapid Creek below the existing waste treatment plant to include posting of signs designating the water as unsafe for recreation, root crop irrigation, and irrigation of areas used by the public; and that use of such water for farm crop irrigation be carried out with extreme caution.

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3. Anon. Drinking Water Standards 1962, Public Health Service Publ. No. 956, U. S. Government Printing Office, Washington D. C., 1962

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5. Anon. Ground Water Contamination, Sanitary Engineering Center Technical Report W61-5, Cincinnati, Ohio, U. S. Public Health Service, 1961

6. Eldridge, E. F., Return Irrigation Water - Characteristics and Effects, Portland Oregon: Region IX, U. S. Public Health Service, May 1, 1960

7. Anon. Surface Water Records of North Dakota and South Dakota, Pierre, South Dakota: U. S. Geological Survey, 1961

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10. Bell, James G., Study and Report Waste Treatment Facilities, Rapid City, South Dakota, Rapid City, S. D.: Kirkham, Michael and Associates, 1962

*11. Anon. Report on Joint Meeting, S. D. Public Health Advisory Committee and S. D. Committee on Water Pollution, Rapid City, S. D., Pierre, South Dakota: State Department of Health, May 28-29, 1963

12. McGauhey, P. H. and John H. Winneberger, Summary Report on Causes and Prevention of Failure of Septic Tank Percolation Systems, Berkeley, Calif.: Sanitary Engineering Research Laboratory, University of California, Report No. 63-5, May 1963

13. Lubinus, Louis and Don C. Kalda, Rural Sewage Disposal, Joint South Dakota State College and South Dakota State Department of Health Bulletin, Brookings, S. D.: Extension Service Circular 602, State University

14. Kerr, Fay and J. Darrell Bakken, Safe Rural Water Supplies, Joint South Dakota State College and South Dakota State Department of Health Bulletin, Brookings, S. D.: Extension Service Circular 601, State University

* These and other Health Department reports available in files at Pierre, South Dakota or in records of the Pennington County Health Department, Rapid City, South Dakota.