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BASE-FLOW STUDIES

PEDERNALES RIVER, TEXAS

Quantity and Quality, April-May 1962

by

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INTRODUCTION

This investigation was made under the provisions of the 1963 cooperative agreement between the Texas Water Commission and the U. S. Geological Survey, Water Resources Division, for the investigation of the water resources of Texas.

The purpose of this investigation was to evaluate the quality of water and the interchange of surface and ground waters in the Pedernales River drainage area during a period when evaporation and transpiration losses were significant and to compare the results with those of an investigation made in January 1956 when evaporation and transpiration were near minimum (Holland and Lee, 1956). The reach studied extends 103 miles from a point 2 miles southwest of Harper in Gillespie County to below Cypress Creek in Travis County. (See Plate 1.)

Supporting data not given in the text, tables, and figures are available in the files of the U. S. Geological Survey in Austin, Texas

SUMMARY AND CONCLUSIONS

The Pedernales River generally gained in flow throughout the reach investigated, from zero flow at the initial point to 30.3 cubic feet per second at mile 103. (See Figure 1.) Small quantities of water that are lost in areas of faulting, jointing, and solution channeling probably do not leave the river valley. Other small losses are attributable to evaporation and transpiration. These findings agree with the results of the investigation made in 1956.

The chemical analyses indicate that the water of the basin generally meets limits set by the U. S. Public Health Service "Drinking Water Standards," with the dissolved-solids content of the water of the Pedernales River ranging from 268 to 524 parts per million. Principal chemical constituents are calcium, magnesium, and bicarbonate, except that relatively high concentrations of chloride are found in tributaries which drain areas underlain by the Hensell Member of the Travis Peak Formation. Under the U. S. Salinity Laboratory Staff standards for irrigation waters, the water of the Pedernales River would be classified as "medium-salinity" and "low-sodium." In this area, where the annual average rainfall ranges from 25 to 30 inches per year, the water should be entirely satisfactory for irrigation.

GENERAL GEOLOGY

The Pedernales River watershed is near the eastern edge of the Edwards Plateau where much of the original plateau surface has been dissected by the streams in the river system. Rocks ranging in age from Precambrian to Recent crop out along the main river channel. (See Plate 1.)

The Edwards and associated limestones of Early Cretaceous age underlie the upper part of the drainage area, cap the divides, and form the undissected surface of the Edwards Plateau between the major tributaries. These rocks consist of limestone, dolomite, and chert and are broken by interconnected joints, fissures, and solution channels. Rainfall absorbed on the Edwards outcrop is lost mostly by evapotranspiration but some water penetrates to the water table and eventually appears in springs and seeps at the base of the formation. The Edwards Limestone is a part of the Fredericksburg Group, which also includes the underlying Comanche Peak Limestone and the Walnut Clay. The Comanche Peak is an impure limestone containing much clay and an abundance of fossils. Neither the Comanche Peak nor the Walnut Clay has the physical qualities or characteristics to absorb, transmit, or store appreciable quantities of water. Also, the area of outcrops of these two formations is confined to a narrow band along the dissected edge of the surface of the Edwards Plateau.

Underlying the Edwards and associated limestones is the Glen Rose Limestone of Early Cretaceous age. This formation is composed of thin-bedded limestone, dolomite, and marl. The Glen Rose overlies the Hensell Member of the Travis Peak Formation, which is mostly sandstone. The Glen Rose is relatively impermeable, but the Hensell Member is permeable and captures a high percentage of the precipitation that falls on its comparatively large area of outcrop. (See Plate 1.)

Outcrops of rocks of Mississippian and Pennsylvanian age occupy small areas in the lower part of the watershed. These rocks are limestone, shale, and chert breccia.

The Ellenburger Group of Early Ordovician age is stratigraphically below the Hensell Member. However, the area of outcrop of these formations, which are mostly limestone and dolomite, is small.

Below the Ellenburger Group is the Wilberns Formation of Late Cambrian age. Underlying the Wilberns is the Riley Formation, which is also of Late Cambrian age. The Wilberns Formation consists of dolomite, limestone, and sandstone. The Riley Formation is made up of beds of sandstone and limestone.

The oldest rock in the area drained by the Pedernales River is a granite of Precambrian age that crops out in a few small areas in the lower part of the watershed.

RELATION OF BASE FLOW AND CHEMICAL QUALITY TO GEOLOGY

This investigation was started on April 3, 1962, when the flow of the Pedernales River was sustained entirely by ground water. During the night of April 4 a thunderstorm in the upper part of the watershed produced surface runoff. The investigation was discontinued and was resumed on May 15 after surface runoff had ceased. Records for the gaging station on the Pedernales River near Johnson City show that during the investigation, May 15 to 21, the discharge slowly declined from 19 to 13 cfs (cubic feet per second). This is a normal base-flow recession for this stream; periods of uniform base flow occur only as the flow approaches zero.

During the 1962 investigation, discharge was measured or estimated at 52 sites and water samples were collected for chemical analysis at 50 sites. The results of discharge measurements are given in Table 1 and the chemical analyses are given in Table 2. These data, which are also shown graphically on Figure 1, indicate changes in chemical quality and the amount of flow. Although small amounts of water were lost, no area was found where significant amounts of water were seeping into ground-water aquifers, and in general the river was gaining flow throughout the reach.

Analyses of three samples collected from the river and of three samples from tributary streams are presented graphically in Figure 2. The total height of each vertical bar graph is proportional to the total concentration of anions (negatively charged constituents) or cations (positively charged constituents) expressed in equivalents per million. The bar is divided into segments to show the concentrations of individual cations and anions.

At low flow the waters of the watershed are saturated or nearly saturated with calcium and magnesium bicarbonates, which are dissolved from the limestones and dolomites that crop out over much of the drainage area. The presence of sodium chloride in water increases the solubility of calcium and magnesium; consequently, those waters that contain more sodium and chloride also contain more calcium and magnesium.

Both the amount of flow and the chemical quality of water are closely related to geology. In the following discussion the study reach has been subdivided where significant changes in geology occur, as those changes affect quantity and quality of flow.

Reach From Mile 0 to Mile 18

In the upper 18 miles of the area investigated, the riverflow ranged from 0 to 2.22 cfs. Initial flow begins a quarter of a mile downstream from mile 0, with a discharge of 0.85 cfs from springs at the base of the Edwards and associated limestones. Through the upper part of the study reach the flood plain of the Pedernales River contains extensive deposits of alluvium (gravel, sand, and silt), which can absorb and store a considerable quantity of water. A limestone member of the Riley Formation crops out in the river channel at mile 17, and the heavy rock ledge formed by this outcrop forms a temporary base level and effectively dams up the alluvium upstream. The outflow from the reach from mile 0 to mile 18 is about 25 percent less than the accumulated inflow. Transpiration from trees and other vegetation on the alluvial terraces account for much of this loss.

At mile 0.5 the water of the Pedernales River contained 395 ppm (parts per million) dissolved solids. Inflow through the next 18 miles contained lower concentrations of dissolved solids, and the dissolved-solids content of the river ranged from 268 to 335 ppm. Tributaries in this reach drain areas underlain by the Edwards and associated limestones, as well as smaller areas underlain by the Hensell Member of the Travis Peak Formation. The chemical analysis for the Pedernales River at mile 14.3 (site 9), shown graphically in Figure 2, is representative of the waters in the first 18 miles of the study reach. The principal dissolved constituent is bicarbonate. Calcium and magnesium are present in approximately equivalent amounts, and together they are equivalent to the bicarbonate. Principal remaining constituents are sodium and chloride, which make up about 20 percent of the total. This chemical composition is typical of water from a terrane of impure limestone and dolomite, such as the area underlain by the Glen Rose Limestone.

Reach From Mile 18 to Mile 53

Investigation of this reach was begun on May 15, when the discharge at mile 18 (site 11) was 0.73 cfs, compared with 2.22 cfs on April 4. Through the next 35 miles the river discharge increased to 13.7 cfs and the dissolved-solids concentration increased about 60 percent.

From mile 18 to mile 34 the river flows in an alluvial channel through the southern edge of a large area of outcrop of the Hensell Member of the Travis Peak Formation, and receives tributary inflow from several creeks that drain the Hensell Member outcrop. Below mile 34 the channel is cut in rocks of the Ellenburger Group and all flow is brought to the surface. Thus, the 6.88 cfs measured at mile 38.4 (site 24) represents the total outflow from the area above this point.

From a fault line at mile 41.5, where a series of seeps and springs contribute small quantities of water, to mile 48 at Stonewall, the river again flows through alluvium associated with the Hensell Member. At mile 48 the flow had increased to 14.6 cfs, but 0.9 cfs apparently was lost between mile 48 and mile 53.

Tributary inflow from Live Oak, Barrons, Palo Alto, Cave, and Three Mile Creeks had dissolved-solids concentrations as high as 731 ppm and increased the concentrations of the river water to more than 500 ppm at mile 34.4. Analyses for the river at mile 34.4 (site 23) and for Three Mile Creek show increases in the concentrations of all constituents (Figure 2). The increased mineralization apparently is caused by water from the Hensell Member of the Travis Peak Formation. Barrons Creek, which carries sewage effluent from the city of Fredericksburg, contained 87 ppm nitrate. However, excessive nitrate was not found in samples collected from the river downstream from Barrons Creek.

Reach From Mile 53 to Mile 103

Through the final 50 miles of the study reach, the flow of the Pedernales River increased from 13.7 to 30.3 cfs and the river decreased in dissolved-solids concentrations. The Glen Rose Limestone and rocks of Ordovician and Cambrian age crop out over much of the drainage area in the lower part of the basin.

The river channel from mile 53 to mile 88 is wide, is composed mostly of rock, and has a steep gradient. Evaporation losses are probably significant in the reaches of wide, flat, rock streambed. The many faults in the reach affect the quantity of streamflow, because water is being lost from the stream in zones of fractured and faulted rock near mile 58, and at faults near miles 66 and 69. Two faultline springs at mile 56 contributed 0.5 cfs of flow, and there are many springs and seeps along a series of faults from mile 70 to mile 88. Inflow from these sources, plus contributions from Rocky, North Grape, Flat, and Miller Creeks increased the flow of the river to 23.8 cfs at mile 90.7, below Pedernales Falls.

From mile 90 to mile 103 the river flows through a narrow, deep canyon which is floored with alluvium. Principal sources of inflow are Flat and Cypress Creeks, with lesser quantities of water entering the stream from small springs and seeps along the alluvial banks. At the lowermost measuring site, which is near the head of backwater from Lake Travis when the lake is at maximum conservation storage, the flow was 30.3 cfs.

Below mile 53, the concentrations of dissolved minerals in the water of tributary streams were lower than in the main stem, as smaller quantities of sodium chloride apparently are dissolved from the Glen Rose Limestone and the Ordovician and Cambrian rocks than from the Hensell Member of the Travis Peak Formation. Analyses for Rocky and Miller Creeks, shown in Figure 2, are representative of the chemical character of waters from the lower part of the watershed, where dissolved solids ranged from 226 to 335 ppm. An analysis for the river at mile 103 (site 52) is also shown on Figure 2, and indicates that the principal chemical constituents had once more become bicarbonate, calcium, and magnesium. The analyses show that the water in the lower part of the watershed and the water near the upper end (site 9, mile 14.3) were very similar.

RELATION OF QUALITY OF WATER TO USE

Standards published by the U. S. Public Health Service (1962) list limits of concentrations of dissolved constituents which should not be exceeded in drinking water used on interstate common carriers. These standards, which are generally accepted as a basis for determining the suitability of a water for domestic or municipal use, require that chloride or sulfate concentrations not exceed 250 ppm and that total dissolved solids not exceed 500 ppm.

None of the sources sampled in the Pedernales River drainage area contained more than 250 ppm chloride or sulfate, although three tributaries and the river at one point contained more than 500 ppm dissolved solids. The analyses indicate that the water of the drainage area generally meets limits set by the "Drinking Water Standards." The water is very hard and should be softened for domestic or municipal use. The hardness ranged from 178 to 488 ppm.

According to the U. S. Salinity Laboratory Staff (1954, p. 69), the characteristics of an irrigation water that appear most important in determining its quality include: (1) total concentration of soluble salts, and (2) relative proportion of sodium to other cations. Under the Salinity Staff standards, which were established for arid areas, water of the Pedernales River would be classified as "medium-salinity" and "low-sodium." In the Pedernales River drainage area, where the annual average rainfall ranges from 25 to 30 inches per year, the water should be entirely satisfactory for irrigation.

This investigation was made during a period of low flow, when all the stream waters were derived from springs and seeps. Ground water is generally more concentrated than surface runoff as it remains in contact with the rocks and soils for much longer periods. The chemical-quality data discussed in this report, therefore, probably represent about the maximum concentrations of dissolved solids likely to occur in the Pedernales River and its tributaries. Flood runoff will have much lower concentrations.

COMPARISON OF 1956 INVESTIGATION WITH 1962 INVESTIGATION

The 1956 investigation was made during a drought and in January when evaporation and transpiration were near a minimum. Although base flow was very low, ranging from 0 to 3.95 cfs, there was in general an increase in base flow in the 70 miles investigated, as there was in the 1962 investigation. The discharge profile for both investigations is shown on Figure 1. Flow originated from the same sources and there were minor losses in areas of faulting, jointing, and solution channeling. Water samples for chemical-quality analyses were not collected in 1956.

REFERENCES

Holland, P. H., and Lee, F. C., 1956, Low flow investigation of the Pedernales River, Texas, January 1956: U. S. Geol. Survey open-file rept., 24 p., 3 figs.

U. S. Public Health Service, 1962, Public Health Service drinking water standards: Public Health Service Pub. 956, 61 p.

U. S. Salinity Laboratory Staff, 1954, Diagnosis and improvement of saline and alkali soils: U. S. Dept. Agriculture Handb. 60, 160 p.

Table 1.--Discharge measurements of the Pedernales River and tributaries, April-May, 1962

Site No.	Date (1962)	Stream	Location	River miles	Water temp. (°F)	Discharge, in cfs		Remarks
						Main stream	Tributary	
1	April 3	Pedernales River	2 mi. downstream from Harper	0	--	0.0	--	Rock streambed
2	3	do	1/2 mi. below Pantry Creek--1/4 mi. below springs	.5	56	.85	--	Rock streambed--all flow from spring in river channel
3	3	Pecan Draw Creek	At mouth	2.1	--	--	[a] 0.15	Rock streambed
4	3	Pedernales River	0.3 mi. below Pecan Draw	2.4	55	1.27	--	Gravel and boulder streambed
5	4	do	County road crossing	5.2	55	.99	--	Rock streambed
6	3	Scott Creek	About 1 mi. above mouth	[b] 5.7	56	--	.72	Gravel streambed
	3	Flag Creek	At mouth	7.3	--	--	0	Do.
7	4	Pedernales River	1 mi. below Flag Creek	8.3	57	2.32	--	Do.
8	4	do	At county road crossing	10.4	57	2.10	--	Do.
9	4	do	do	14.3	57	1.92	--	Do.
10	4	Whiteoak Creek	1/4 mi. above mouth	[b] 14.8	58	--	.89	Gravel and clay streambed
11	4	Pedernales River	1/4 mi. above Spring Creek--at crossing	18.0	57	2.22	--	Rock streambed
12	4	Spring Creek	At mouth	18.2	--	--	[a] .2	Clay streambed
		Investigation interrupted by rain and resulting surface runoff during night of April 4. Investigation resumed on May 15.						
9	May 15	Pedernales River	At county road crossing	14.3	79	.37	--	Gravel streambed
11	15	do	1/4 mi. above Spring Creek--at crossing	18.0	77	.73	--	Rock streambed
12	15	Spring Creek	At mouth	18.2	--	--	[a] .10	Clay streambed
13	15	Pedernales River	1 mi. above State Highway 16	20.6	82	.46	--	Gravel streambed
14	15	Wolf Creek	At Henke Ranch, 11 mi. above mouth	[b] 21.7	77	--	.81	Flow from springs on Henke Ranch
15	15	do	At mouth	21.7	78	--	.71	Sand and clay streambed
16	16	Pedernales River	0.8 mi. above Bear Creek	23.0	72	1.66	--	Gravel streambed
17	16	Bear Creek	1,000 ft. above mouth	[b] 23.8	71	--	.16	Gravel and sand streambed
18	16	Masse Creek	At mouth	25.1	71	--	[a] .03	Do.
19	16	Live Oak Creek	0.5 mi. above mouth	[b] 27.0	71	--	1.67	Gravel streambed
20	16	Pedernales River	0.7 mi. below Live Oak Creek	27.7	73	4.75	--	Do.
	16	Muesebach Creek	At mouth	31.2	--	--	0	Sand streambed
21	16	Pedernales River	0.2 mi. below Muesebach Creek	31.4	75	4.87	--	Gravel streambed
22	16	Barrons Creek	About 1 mi. above mouth	[b] 32.0	75	--	1.0	Do.
23	16	Pedernales River	At U. S. Highway 290	34.4	77	5.36	--	Do.
24	16	do	County road crossing	38.4	76	6.88	--	Rock streambed
25	16	Palo Alto Creek	At mouth	39.4	76	--	[a] .1	Sand streambed
26	16	Pedernales River	0.3 mi. above South Grape Creek	43.1	78	7.70	--	Do.
27	17	South Grape Creek	400 ft. below U. S. Highway 290	[b] 43.4	72	--	1.52	Gravel streambed
28	17	Cave Creek	400 ft. above mouth	[b] 45.4	72	--	[a] .1	Sand streambed
29	17	Pedernales River	0.3 mi. below Cave Creek	45.7	74	12.0	--	Gravel streambed
30	17	Three Mile Creek	At U. S. Highway 290	[b] 46.9	74	--	[a] .3	Do.
31	17	Pedernales River	0.5 mi. above county road	49.4	77	14.6	--	Rough rock streambed
32	17	do	At crossing 0.4 mi. above county line	53.2	78	13.7	--	Rock streambed
33	17	Two Springs	1 mi. above McDougals Crossing	56.0	76	--	.5	On Gilbert A. Schmidt Ranch
34	17	Pedernales River	At McDougals Crossing--F.M.1320	57.0	79	14.9	--	Gravel on rock streambed
35	17	Rocky Creek	At mouth	57.6	78	--	1.47	Gravel streambed
36	18	Pedernales River	2.4 mi. below Rocky Creek	60.0	75	15.2	--	Rough rock streambed
37	18	North Grape Creek	0.5 mi. above mouth	[b] 63.1	79	--	1.78	Sand streambed
38	18	Pedernales River	100 ft. below North Grape Creek	63.1	79	17.4	--	Do.
39	18	do	0.2 mi. above Hickory Creek	65.2	82	16.0	--	Rock and sand streambed
40	18	Hickory Creek	At mouth	65.4	80	--	[a] .1	Sand streambed
41	19	Pedernales River	1.9 mi. above Flat Creek	67.8	77	16.4	--	Rock streambed
42	19	Flat Creek	0.3 mi. above mouth	[b] 69.7	78	--	.77	Do.
43	19	Pedernales River	At gaging station near Johnson City	70.0	86	15.3	--	Gravel streambed
44	19	do	3.7 mi. below gage near Johnson City	73.7	85	15.6	--	Sand on rock streambed
45	20	do	0.5 mi. above Miller Creek	83.1	81	16.9	--	Rock stream
46	20	Miller Creek	0.8 mi. above mouth	[b] 83.6	81	--	2.75	Gravel streambed
47	21	Pedernales River	3.3 mi. below Pedernales Falls	90.7	77	23.8	--	Small gravel streambed
48	21	Flat Creek	4 mi. above mouth	[b] 94.0	73	--	2.40	Sand streambed
49	21	Pedernales River	2.5 mi. below Flat Creek	96.5	76	27.4	--	Gravel streambed
50	21	Basin Creek	200 ft. above mouth	[b] 102.6	80	--	.51	Do.
51	21	Cypress Creek	0.2 mi. above mouth	[b] 102.8	80	--	1.55	Do.
52	21	Pedernales River	0.2 mi. below Cypress Creek	103	82	30.3	--	Do.

[a] Estimated.
[b] River mile on Pedernales River at mouth of tributary.

Table 2.--Chemical analyses of the Pedernales River and tributaries, April to May 1962

(Results in parts per million except as indicated)

Site No.	Stream	Date (1962)	Discharge (cfs)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (calculated)[1]		Hardness as $CaCO_3$		Percent sodium	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
														Parts per million	Tons per acre-foot	Calcium, magnesium	Noncarbonate				
2	Pedernales River----------	April 3	0.85	13	82	22	32		314	17	50	--	25	a395	0.54	295	38	19	0.8	688	7.2
3	Pecan Draw---------------	do.	.15	--	--	--	--		256	13	36	--	--	285	.39	222	12	--	--	506	7.7
4	Pedernales River----------	do.	1.27	--	--	--	--		232	17	50	--	--	310	.42	220	30	--	--	555	7.7
5	Do---------------------	April 4	.99	--	--	--	--		214	19	52	--	--	290	.39	198	22	--	--	517	7.5
6	Scott Creek--------------	April 3	.72	--	--	--	--		248	12	27	--	--	265	.36	214	11	--	--	469	7.6
7	Pedernales River----------	April 4	2.32	4.2	36	27	29		224	19	42	--	.4	a268	.36	201	18	24	.9	491	7.5
8	Do---------------------	do.	2.10	--	--	--	--		232	19	42	--	--	285	.39	208	18	--	--	508	7.5
9	Do---------------------	do.	1.92	--	--	--	--		254	19	44	--	--	300	.41	224	16	--	--	540	7.6
9	Do---------------------	May 15	.37	4.4	44	30	32		280	16	40	0.4	.2	a305	.41	234	4	23	.9	550	7.8
10	White Oak Creek-----------	April 4	.89	--	--	--	--		280	26	40	--	--	320	.44	246	16	--	--	569	7.7
11	Pedernales River----------	do.	2.22	--	--	--	--		274	24	49	--	--	335	.46	244	20	--	--	599	7.4
11	Do---------------------	April 5	10.4	--	--	--	--		248	23	46	--	--	305	.41	224	21	--	--	547	7.4
11	Do---------------------	May 15	.73	--	--	--	--		262	--	40	--	--	295	.40	226	12	--	--	530	7.6
12	Spring Creek-------------	April 4	.2	--	--	--	--		292	23	75	--	--	390	.53	280	40	--	--	699	7.5
13	Pedernales River----------	May 15	.46	--	--	--	--		280	--	44	--	--	315	.43	244	14	--	--	562	7.9
14	Wolf Creek---------------	do.	.81	--	--	--	--		286	--	15	--	--	260	.35	240	6	--	--	465	7.6
15	Do---------------------	do.	.71	11	46	31	25		232	17	34	.3	.2	b305	.41	242	12	18	.7	538	7.6
16	Pedernales River----------	May 16	1.66	--	--	--	--		308	--	50	--	--	350	.48	272	20	--	--	623	7.6
17	Bear Creek---------------	do.	.16	--	--	--	--		276	--	28	--	--	285	.39	238	12	--	--	513	7.6
19	Liveoak Creek------------	do.	1.67	7.6	47	48	62		330	30	105	.4	.2	b472	.64	315	44	30	1.5	839	7.9
20	Pedernales River----------	do.	4.75	--	--	--	--		322	--	92	--	--	440	.60	306	42	--	--	782	7.8
21	Do---------------------	do.	4.87	--	--	--	--		308	--	118	--	--	485	.66	320	68	--	--	870	7.6
22	Barrons Creek------------	do.	1.0	19	79	47	121		380	28	182	.7	67	a731	.99	390	79	40	2.7	1,280	7.3
23	Pedernales River----------	do.	5.36	8.6	58	45	70		334	37	119	.4	1.0	b524	.71	330	56	32	1.7	908	7.7
24	Do---------------------	do.	6.88	--	--	--	--		312	--	124	--	--	500	.68	320	64	--	--	895	7.4
25	Palo Alto Creek-----------	do.	.1	14	58	60	54		418	27	95	.5	2.5	b534	.73	392	49	23	1.2	922	7.5
26	Pedernales River----------	do.	7.70	--	--	--	--		290	--	124	--	--	480	.65	296	58	--	--	854	7.9
27	South Grape Creek---------	May 17	1.52	5.5	52	38	43		308	27	69	.4	1.5	b395	.54	286	34	25	1.1	694	7.8
28	Cave Creek---------------	do.	.1	--	--	--	--		430	--	68	--	--	460	.63	380	28	--	--	823	7.6
29	Pedernales River----------	do.	12.0	--	--	--	--		304	--	117	--	--	475	.64	304	55	--	--	847	7.8
30	Three Mile Creek----------	do.	.3	15	90	64	70		364	32	215	.6	3.2	a669	.91	488	189	24	1.4	1,310	7.6
31	Pedernales River----------	do.	14.6	--	--	--	--		306	--	120	--	--	490	.67	314	63	--	--	876	7.6
32	Do---------------------	do.	13.7	--	--	--	--		292	--	120	--	--	480	.65	302	62	--	--	860	7.7
33	Two Springs--------------	do.	.5	--	--	--	--		348	--	30	--	--	365	.50	328	43	--	--	656	7.5
34	Pedernales River----------	do.	14.9	3.3	38	46	58		266	40	106	.4	.0	a423	.58	284	66	31	1.5	800	7.4
35	Rocky Creek--------------	do.	1.47	13	53	34	18		240	64	31	.5	3.2	a335	.46	272	76	12	.5	591	7.6
36	Pedernales River----------	May 18	15.2	--	--	--	--		264	--	100	--	--	420	.57	280	64	--	--	779	7.3
37	North Grape Creek---------	do.	1.78	6.8	34	32	29		230	17	51	.3	.0	b286	.39	216	28	22	.9	525	7.7
38	Pedernales River----------	do.	17.4	--	--	--	--		252	--	87	--	--	395	.54	260	54	--	--	707	7.6
39	Do---------------------	do.	16.0	--	--	--	--		246	--	91	--	--	400	.54	258	56	--	--	718	7.7
40	Hickory Creek------------	do.	.1	--	--	--	--		144	--	78	--	--	295	.40	194	76	--	--	526	7.6
41	Pedernales River----------	May 19	16.4	--	--	--	--		252	--	89	--	--	400	.54	262	56	--	--	719	7.7
42	Flat Creek---------------	do.	.77	--	--	--	--		302	--	32	--	--	335	.46	288	40	--	--	600	7.6
43	Pedernales River----------	do.	15.3	5.9	34	40	50		248	35	83	.4	.2	a370	.50	250	46	30	1.4	695	7.6
44	Do---------------------	do.	15.6	--	--	--	--		244	--	82	--	--	365	.50	254	54	--	--	683	7.7
45	Do---------------------	May 20	16.9	--	--	--	--		252	--	70	--	--	350	.48	256	50	--	--	653	7.6
46	Miller Creek-------------	do.	2.75	7.4	43	17	11		182	24	18	.3	.2	b226	.31	177	28	12	.4	381	7.4
47	Pedernales River----------	May 21	23.8	--	--	--	--		240	--	53	--	--	320	.44	238	42	--	--	572	7.5
48	Flat Creek---------------	do.	2.40	--	--	--	--		206	--	14	--	--	230	.31	192	23	--	--	394	7.6
49	Pedernales River----------	do.	27.4	--	--	--	--		226	--	48	--	--	300	.41	222	37	--	--	538	7.6
50	Basin Creek--------------	do.	.51	9.2	56	17	6.8	.7	224	24	12	.3	.2	b239	.33	210	26	7	.2	412	7.6
51	Cypress Creek------------	do.	1.55	12	52	35	17		306	14	32	.4	.2	b319	.43	274	22	12	.4	571	7.6
52	Pedernales River----------	do.	30.3	7.7	38	29	25		222	25	43	.3	.2	b288	.39	214	32	20	.7	515	7.6

1 Calculated from specific conductance.
a Calculated from determined constituents.
b Residue at 180°C.

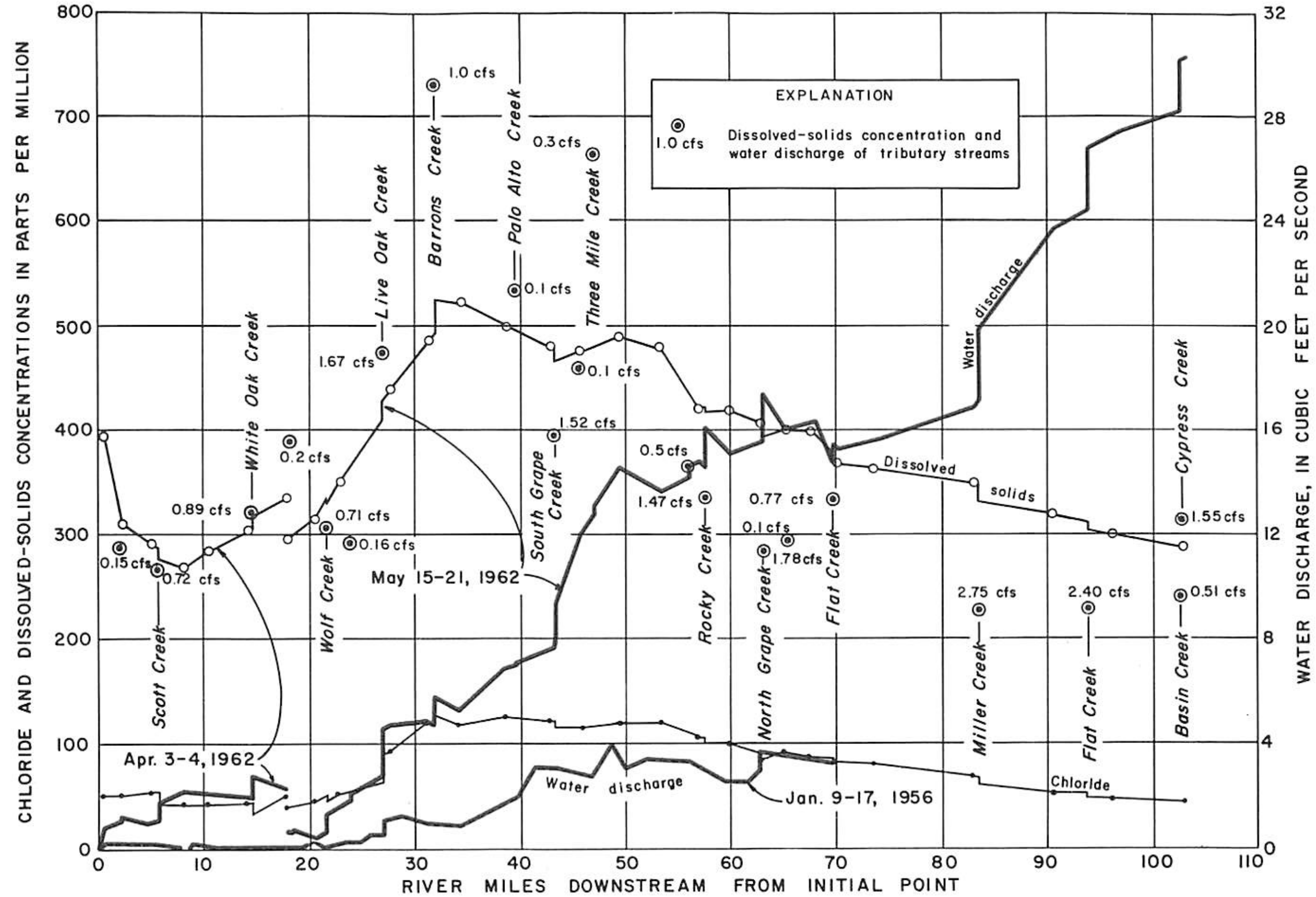

Figure I

Profile of Chloride and Dissolved-Solids Concentrations and Water Discharge, Pedernales River, April 3-4 and May 15-21, 1962, with Dissolved-Solids Concentrations and Discharge of Tributary Streams, and with Discharge Profile for January 9-17, 1956

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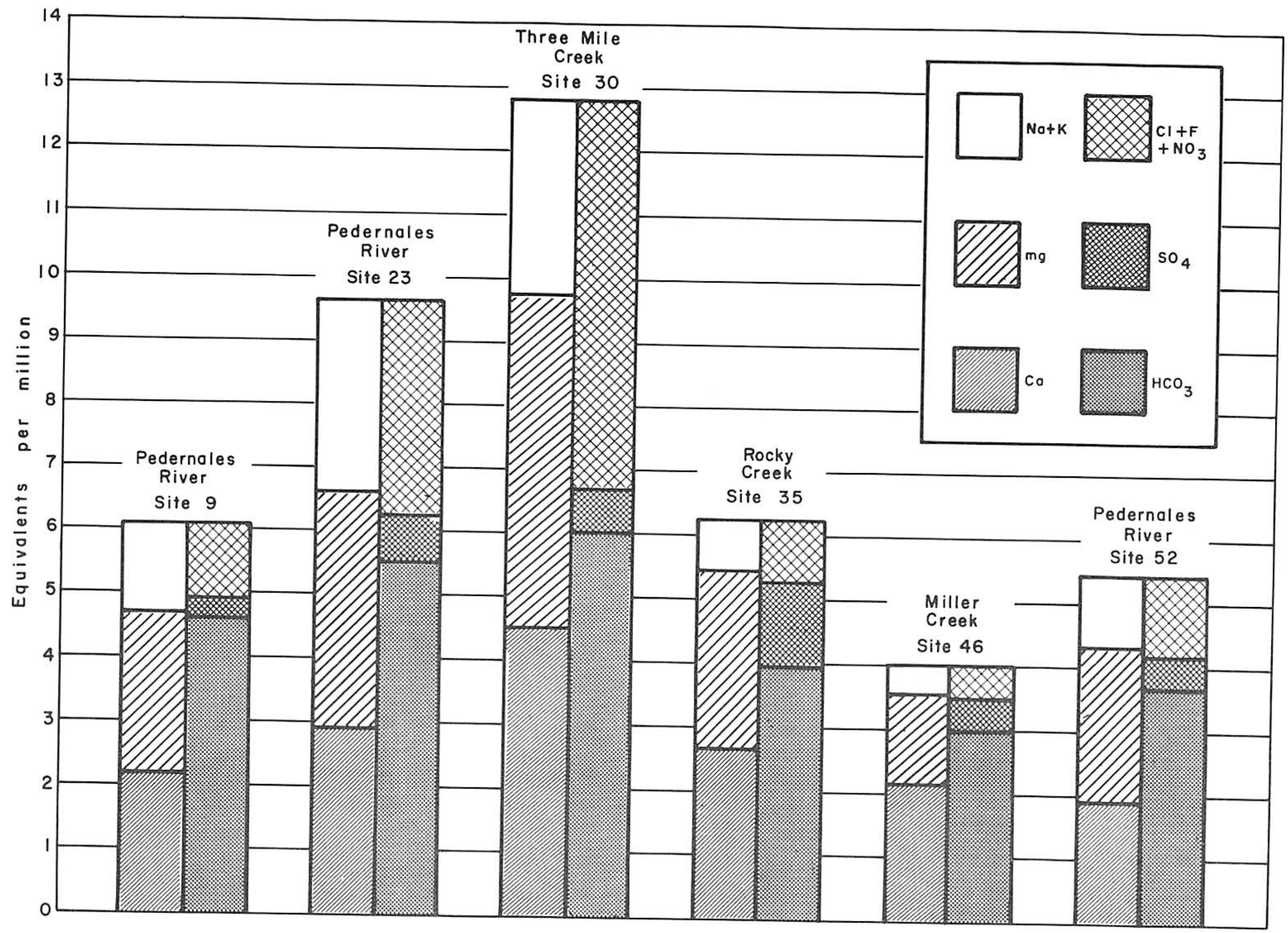

Figure 2

Chemical Analyses of Water from the Pedernales River and Tributaries

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Plate I

Geologic Map Showing Water Quality and Discharge at Measurement Sites, and Location of Springs, Pedernales River and Vicinity, Texas

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Base adapted from geologic maps of Gillespie and Blanco Counties, Texas, prepared by University of Texas Bureau of Economic Geology

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