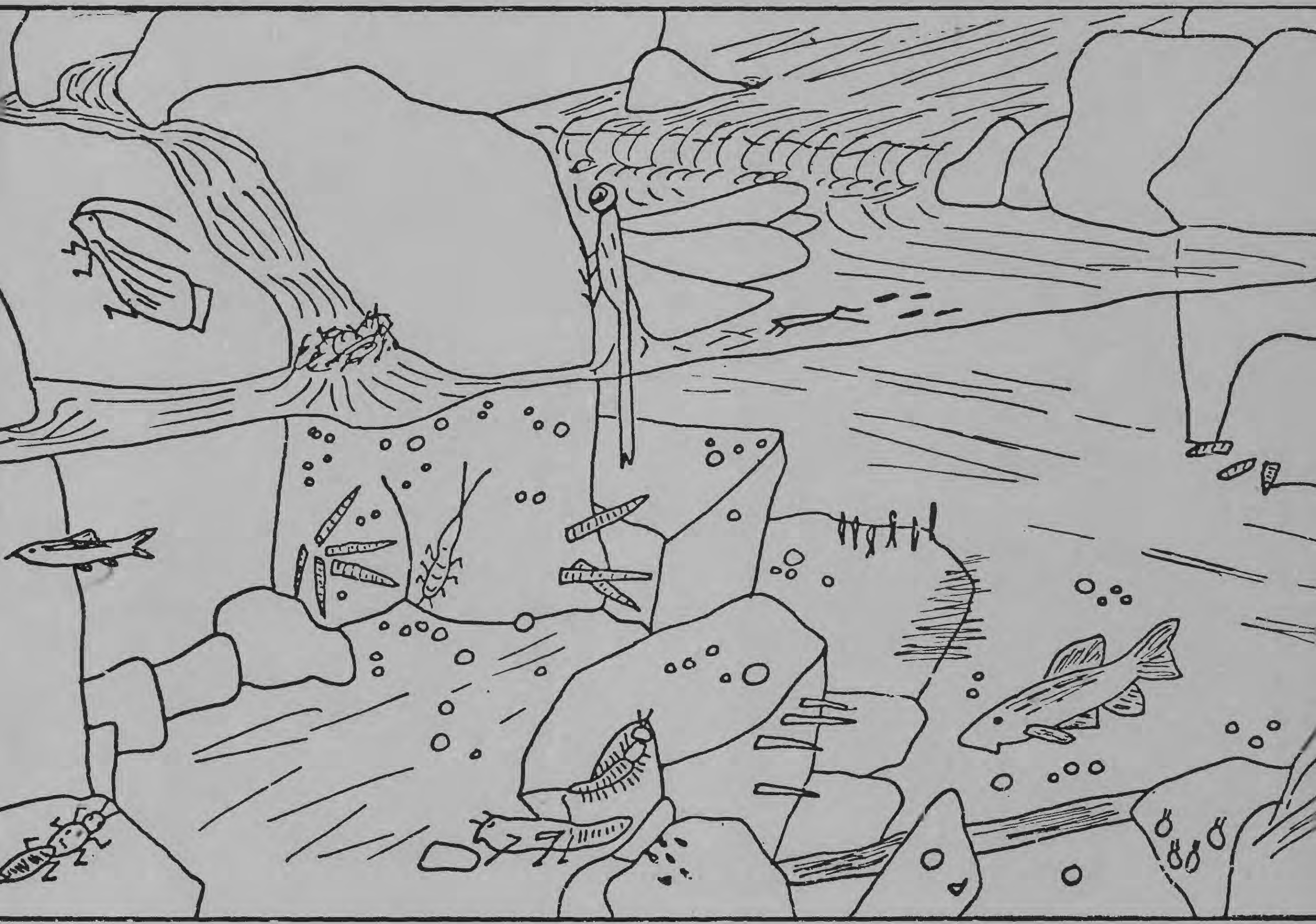
THE BIOLOGY OF SALT WELLS CREEK AND ITS TRIBUTARIES, SOUTHWESTERN WYOMING



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A description of aquatic organisms and biological communities is presented for Salt Wells Creek, a plains stream in the Green River Basin. The description includes seasonal population fluctuations of benthic organisms and algae, the food pyramid, and nutrient relations between various types of plants and animals. The algae and stream invertebrates were studied to determine baseline data and biological indicators of water quality.

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*Plains stream, *aquatic habitats, *aquatic populations, *biological communities, *aquatic environments, phytoplankton, periphyton, stream invertebrates, fish populations, edge effect, food chains, food web, food pyramid, succession, trophic level, conceptual model, nutrients, trace elements, conductivity, salinity, water temperature, hydrogen ion concentration, suspended-sediment concentration, Wyoming.

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1978

UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, Secretary

GEOLOGICAL SURVEY

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Cheyenne, Wyoming 82001

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CONVERSION FACTORS

Multiply metric units	By	To obtain Inch-pound units
meter (m)	3.281	foot
kilometer (km)	.6214	mile
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)
liter (L)	0.03531	cubic foot (ft^3)

STATION IDENTIFICATION

As a means of identification, the U.S. Geological Survey assigns an eight-digit station number (such as 09216565) to most sites where data are collected from streams. Where assigned, station numbers are used in this report. The station numbers increase in downstream order. Stations on tributaries are assigned numbers between upstream and downstream stations on main stems. Gaps are left in the numbering system to allow for new stations that may be established. The first two digits of the station number denote the drainage basin. Station numbers beginning with "09" are in the Green River drainage.

Sites that have station numbers in the Salt Wells Creek drainage are gaging stations. Additional sites where hydrologic data were collected during this study are designated Sites A, B, C, and X (fig. 1).

GLOSSARY

Algae are chlorophyll-bearing plants with relatively undifferentiated tissues that lack true roots, stems, and leaves (Wilson and Loomis, 1957, p. 310).

Algivorous refers to plants and insects that eat only algae (Wilson and Loomis, 1957, p. 84).

Alkiphilous, as used in this report, refers to aquatic organisms that live in water having a pH around seven with best development over seven (Hustedt, 1937-38, p. 187).

Aquatic populations are groups or individuals of any one kind living in water (Odum, 1971, p. 4).

Benthic invertebrates are animals without backbones inhabiting the bottoms of lakes, streams, and other bodies of water that are retained on a U.S. Standard Sieve No. 70 or a 210-um mesh opening (Greeson and others, 1977, p. 145).

Beta-mesohalobous, as used in this report, refers to aquatic organisms that live in water having salt concentrations of 500 to 10,000 mg/L (Kolbe, 1927, p. 1-146).

Biological community is any assemblage of populations living in a prescribed area or physical habitat (Odum, 1971, p. 140).

Climax community refers to a stable community that is established at a point where both plant and animal succession stops; a kind of community that grows in succession until it becomes stable, self-regenerating, and persists without major change (Reid and Wood, 1976, p. 288-289).

Collectors are aquatic insects that feed on microbially colonized fine particulate organic matter (Cummins, 1975, p. 291).

Dendrogram is a diagrammatic representation showing the taxonomic similarity among organisms in samples.

Diversity index is a mathematical measure of community structure variety. The formula used is:

$$\text{Diversity index} = \bar{d} = -\sum_{i=1}^{s} \frac{n_i}{n} \log_2 \frac{n_i}{n}$$

where n_i = number of individuals in each taxon,

n = total number of individuals, and

s = total number of the taxa in each sample.

High values (sometimes given as >3) indicate well-balanced communities (clean water types); low values (<1) indicate organically enriched communities (Wilhm and Dorris, 1968, p. 477-481).

Ecotone is a transition zone between two or more biological communities (Odum, 1971, p. 157).

Edge effect is an enrichment of the numbers, kinds, and types of organisms caused by the overlapping of two communities (Odum, 1971, p. 157).

Ephemeral stream is a stream that usually flows only in direct response to precipitation. Such a stream receives no water from springs and no long continued supply from melting snow or other surface resource. Its channel is above the water table (Lowham, 1976, p. ix).

Euplanktonic, as used in this report, refers to specific habitat or microhabitat in which aquatic organisms are normally suspended in water; distribution is dependent on current (Lowe, 1974, p. 9).

Eurythermal, as used in this report, refers to aquatic organisms that live where the temperature is 15°C or greater (Lowe, 1974, p. 9).

Flow diagram is a graphical representation for the definition, analysis, or solutions of a problem, in which symbols are used to represent data and flow (Sanders, 1968, p. 373).

Food chain is the transfer of food energy from the primary source in plants through a series of organisms with repeated eating and being eaten (Odum, 1971, p. 63).

Grazers, as used in this report, are insects that eat plants as a food energy source, occupy the second trophic level, and are primary consumers in an aquatic food chain.

Habitat is the place where an organism lives, or the place where one would go to find it (Odum, 1971, p. 234).

Habitat preference is the preference of an organism to live in a given place or habitat.

Intermittent stream is a stream or reach of a stream that flows only part of the year when it receives water from springs or from surface flows during wet weather or from melting snow (Lowham, 1976, p. ix).

Nektonic refers to aquatic animal forms that have the ability to swim effectively against, or independently of, the current.

Nektonic predators are aquatic animal forms that feed upon benthic predators, occupy the fourth trophic level, and are the tertiary consumers of the aquatic food chain.

Oligothermal, as used in this report, refers to aquatic organisms living in a temperature range between 0° and 15°C (Lowe, 1974, p. 9).

Oligotrophic, as used in this report, refers to an aquatic habitat having low nutrient concentrations (Lowe, 1974, p. 5).

Omnivorous refers to animals which feed upon both plant and animal food (Wilson and Loomis, 1957, p. 512).

Periphyton are plants growing around (upon) solid surfaces (Greeson and others, 1977, p. 127).

Phytoplankton are the plant part of the plankton assemblage that drift passively with the currents (Greeson and others, 1977, p. 91).

Pondlike refers to anything occurring in or on a pond or pondlike place.

Pondlike community is a community that is composed of organisms that have pond habitat preferences and similarities.

Primary producers are green plants.

Primary consumers are animals that feed upon plants as a food energy source and occupy the second trophic level in an aquatic food chain.

Primary productivity is the rate at which radiant energy is stored by photosynthetic and chemosynthetic activity of producer organisms (chiefly green plants) in the form of organic substances which can be used as food material (Odum, 1971, p. 43).

Population distribution pattern is a distribution pattern of plants and animals found at a given location and at a given time.

Pyramid of numbers shows diagrammatically, by number of individual organisms, the trophic structure and function of the food chain phenomena. In the pyramid of numbers, the producer level forms the base of the pyramid and the successive levels form the tier and apex (Odum, 1971, p. 79).

Riffle community is a community that is composed of organisms that have riffle habitat preferences.

Seasonal periodicity refers to the recurrence of events, activities, and changes in the component species population which, in turn, are ultimately felt in the nature of the community (Reid and Wood, 1975, p. 416-418).

Seasonal succession is an orderly process of community development that involves changes in species structure and community processes with time (Odum, 1971, p. 251).

Secondary consumers are the benthic invertebrate predators that feed upon other animals as a food energy source and occupy the third trophic level in an aquatic food chain.

Shredders are insects that feed upon nondissolved organic materials such as leaves and twigs, occupy the second trophic level, and are primary consumers of an aquatic food chain.

Tertiary consumers are fish that feed upon aquatic insects as a food energy source and occupy the fourth trophic level of an aquatic food chain.

Tolerance levels are the ranges of chemical and physical conditions which plants and animals can survive (Odum, 1971, p. 107).

Trophic levels are food levels that supply food energy sources for organisms in an aquatic food chain (Odum, 1971, p. 63).

THE BIOLOGY OF SALT WELLS CREEK AND ITS TRIBUTARIES, SOUTHWESTERN WYOMING

by Morris J. Engelke, Jr.

ABSTRACT

A description of biological communities in Salt Wells Creek, a plains stream in the Green River Basin of Wyoming, is presented. The description includes population distribution patterns, community edge effects, the food pyramid, and nutrition (trophic) levels between various types of plants and animals. Both algae and stream invertebrates were studied.

Salt Wells Creek is a low-nutrient concentration system in the plains of southwestern Wyoming. The observed sources of phytoplankton were springs, stock ponds, and the periphytic algae dislodged from the substrate. During high flows, green and blue-green algae were dominant. During low flows, the streams became pondlike with intermittent flow, and were dominated by diatoms. Principle diatom genera were *Navicula*, *Nitzschia*, *Surirella*, and *Gomphonema*. Seasonal succession of community development occurred in periphyton and benthic invertebrates. The amphipod, *Gammarus* (scud), is the principal benthic organism found in the basin. Trichoptera were the second most abundant benthic invertebrate. A conceptual model of the aquatic biology and its relations to water chemistry in a plains stream is presented.

INTRODUCTION

Streams in the plains region of the west have received little attention from a biological standpoint. With the onset of strip mining for coal, plains streams will become an important source of water and, in many instances, will be greatly affected by mining activities. Because of recent environmental concern about the effects of strip mining, an intense study of plains streams was initiated. In 1975 the U.S. Geological Survey began a comprehensive water-quality and quantity study in the Green River and Great Divide Basins in southwestern Wyoming. Part of this study was concerned with biological populations in the streams of the area. This report presents the results of the biological study. The study was directed toward defining interrelations of the physical, chemical, and biological factors that affect the biological populations of Salt Wells Creek in southwestern Wyoming. Phytoplankton, periphyton, and benthic invertebrate populations were studied to determine food chains, habitat preferences, and interbiological relations. The water chemistry of the stream was defined to help describe the biological environment.

Streams in the Salt Wells Creek drainage are either ephemeral or intermittent. Salt Wells Creek flows 129 kilometers northward from its headwaters near Pine Mountain through a plains area into Bitter Creek, which is a tributary to the Green River. Coal deposits are located in the area and mining is an expected event. Figure 1 is a map of the drainage area showing sampling sites. Figures 2 and 3 illustrate views of the study area.

METHODS

Physical, chemical, and biological data were collected from Salt Wells Creek and its tributary, Gap Creek. The most frequently sampled stations were 09216565, Salt Wells Creek near South Baxter, Wyo., and 09216576, Gap Creek below Beans Spring Creek near South Baxter, Wyo. The chemical and biological measurements were made following the methods approved by the U.S. Geological Survey (Brown and others, 1970, p. 1-160; Greeson and others, 1977, p. 93, 130, 151, and 200). Data collection for the study was done in cooperation with the U.S. Bureau of Land Management. The ideas for the conceptual model of the biological community in the streams were derived from a number of references and discussions, of which Elton (1946, p. 54-68) and Odum (1971, p. 293) were principle sources.

The stream channel and bank stability were evaluated by using a qualitative method developed by the U.S. Bureau of Land Management (Duff and Cooper, 1976, p. 47). This procedure evaluates the resistive capacity of stream channels to the detachment of bed and bank materials; the lower the ratings the more stable the stream channels. The field form used for this survey is shown in table 1.

A qualitative fish survey was made with the aid of Bob Wiley, Fishery Biologist, Wyoming Game and Fish Department. Seines and electrofishing gear were used to capture the fish.

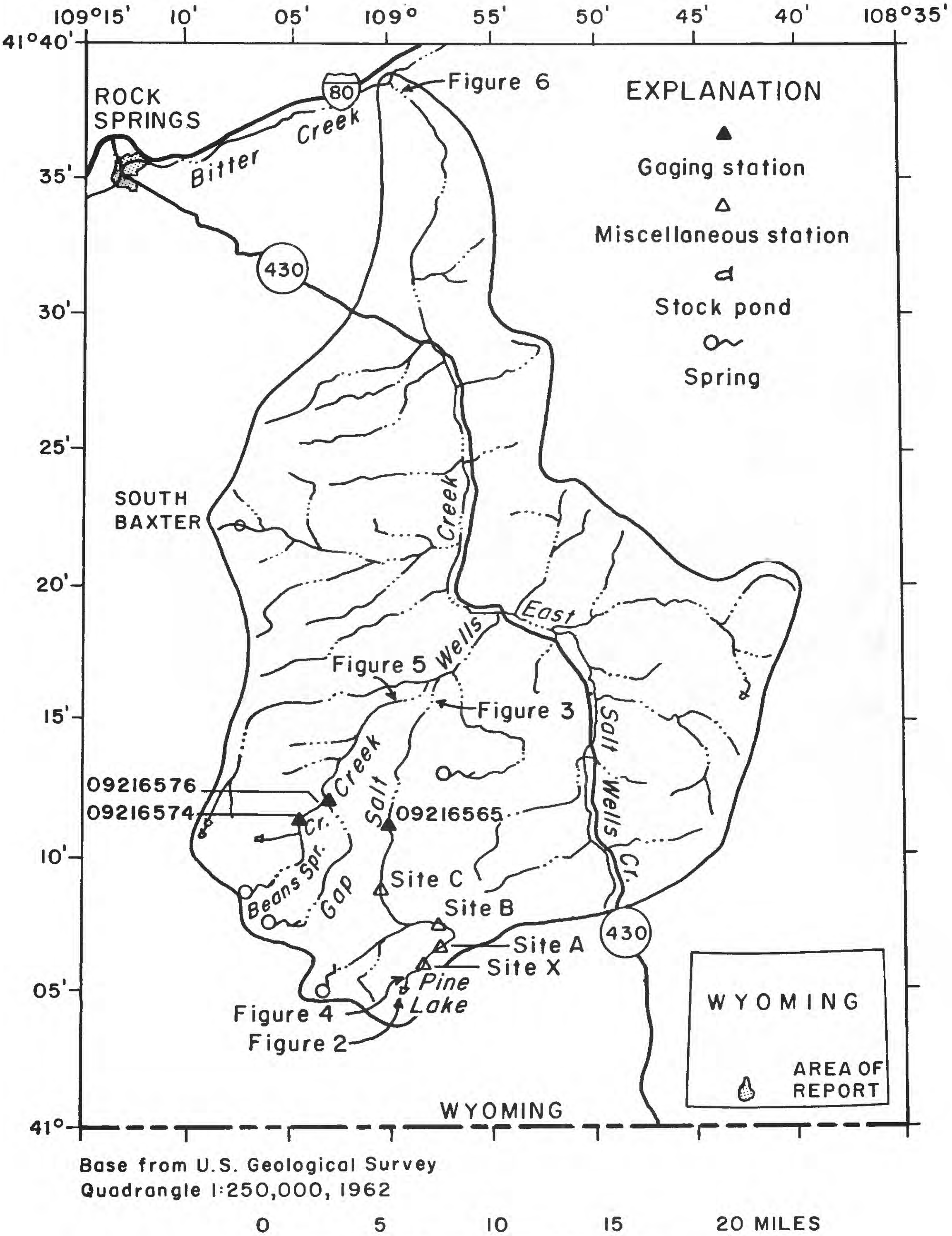


Figure 1.--Location of sampling stations in study area.

Figure 2.--Pine Lake in the headwaters of Salt Wells Creek.
(The photograph shows the subalpine character and
high mountain topography of Pine Mountain.)

Figure 3.--General view upstream (south) of Salt Wells Creek. (The hills are vegetated with junipers and the lowlands with sagebrush.)

Table 1.--Stream channel and bank stability field-evaluation form (Duff and Cooper, 1976, p. 47)

Item Rated	Stability Indicators by Classes							
	EXCELLENT		GOOD		FAIR		POOR	
UPPER BANKS								
Landform Slope	Bank slope gradient <30%	2	Bank slope gradient 30-40%	4	Bank slope gradient 40-60%	6	Bank slope gradient 60%+	8
Mass Wasting Existing or Potential	No evidence of past or potential for future mass wasting into channels.	3	Infrequent and/or very small. Mostly healed over. Low future potential.	6	Moderate frequency & size, with some raw spots eroded by water during high flows.	9	Frequent or large, causing sediment nearly yearlong or imminent danger of same.	12
Debris Jam Potential Floatable Objects	Essentially absent from immediate channel area.	2	Present but mostly small twigs and limbs.	4	Present, volume and size are both increasing.	6	Moderate to heavy amounts, predominantly larger sizes.	8
Bank Protection from Vegetation	90% + plant density. Vigor and variety suggests a deep, dense root mass.	3	70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.	6	50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.	9	<50% density plus fewer species & less vigor indicate poor, discontinuous, and shallow root mass.	12
LOWER BANKS								
Channel Capacity	Ample for present plus some increases. Peak flows contained. W/D ratio<7.	1	Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8-15.	2	Barely contains present peaks. Occasional overbank floods. W/D ratio 15-25.	3	Inadequate. Overbank flows common. W/D ratio 25.	4
Bank Rock Content	65%+ with large, angular boulders 12"+ numerous	2	40-65%, mostly small boulders to cobble 6-12".	4	20-40%, with most in the 3-6"diameter class.	6	<20% rock fragments of gravel sizes, 1-3" or less.	8
Obstructions Flow Deflectors Sediment Traps	Rocks, old logs firmly embedded. Flow pattern of pool & riffles stable without cutting or deposition.	2	Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.	4	Moderately frequent, moderately unstable obstructions & deflectors move with high water causing bank cutting and filling of pools.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sed. traps full, channel migration occuring.	8
Cutting	Little or none evident. Infrequent raw banks less than 6" high generally.	4	Some, intermittently at outcurves & constrictions. Raw banks may be up to 12".	8	Significant. Cuts 12-24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
Deposition	Little or no enlargement of channel or point bars.	4	Some new increases in bar formation, mostly from coarse gravels.	8	Moderate deposition of new gravel & coarse sand on old and some new bars.	12	Extensive deposits of predominately fine particles. Accelerated bar development.	16
BOTTOM								
Rock Angularity	Sharp edges and corners, plane surfaces roughened.	1	Rounded corners & edges, surfaces smooth & flat	2	Corners & edges well rounded in two dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
Brightness	Surfaces dull, darkened, or stained. Gen. not "bright".	1	Mostly dull but may have up to 35% bright surfaces.	2	Mixture, 50-50% dull and bright, ± 15%; i.e., 35-65%.	3	Predominately bright, 65%+ exposed or scoured surfaces.	4
Consolidation or Particle Packing	Assorted sizes tightly packed and/or overlapping.	2	Moderately packed with some overlapping.	4	Mostly a loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	8
Bottom Size Distribution Percent Stable Material	No change in sizes evident. Stable materials 80-100%	4	Distribution shift slight. Stable materials 50-80%.	8	Moderate change in sizes. Stable materials 20-50%.	12	Marked distribution change. Stable materials 0-20%.	16
Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition.	6	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30-50% affected. Deposits & scour at obstructions, constrictions, and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
Clinging Aquatic Vegetation Moss & Algae	Abundant. Growth largely moss like, dark green, perennial. In swift water too.	1	Common. Algal forms in low velocity & pool areas. Moss here too and swifter waters.	2	Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.	3	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	4
COLUMN TOTALS								

Record the values in each column for a total reach score. (E.___+ G.___+ F.___+ P.___ = ___)

Reach score of: 38 = Excellent, 39-76 = Good, 77-114 = Fair, 115+ = Poor.

Circle only one of the numbers in parenthesis for each indicator rated. If condition falls between the conditions described, cross out the given number and write in the intermediate value. The above Form is to be completed each time Form 6671-2 is completed (see Part II, Recording Field Data). The above Form was developed by Hydrologists in the Northern Region of the United States Forest Service.

RESULTS

The environmental requirement for stream organisms is controlled by such habitat factors as streambed materials, dissolved substances, water temperature, streamflow, and suspended-sediment concentrations. High streamflows usually have a decreased dissolved-solids concentration (DeLong, 1977, p. 6) and an increased suspended-sediment concentration. In the Salt Wells Creek drainage, high streamflow results from spring snowmelt and high-intensity summer rainstorms.

Gap Creek and the main stem of Salt Wells Creek are intermittent streams. The headwaters of these two streams flow continuously and have more stable watersheds, streambank vegetation, and streambed materials. Figures 4, 5, and 6 illustrate the change in streambank vegetation along Salt Wells Creek.

Chemical Characteristics

Dissolved oxygen is an important gas in the stream environment as a regulator of metabolic processes of organisms. Both study streams had dissolved-oxygen concentrations near or above saturation when measured (fig. 7). The daytime concentration range of dissolved oxygen, as measured during the study, was 7.9 to 11.6 mg/L (milligrams per liter).

Bicarbonate, carbon dioxide, and the pH system in plains streams are determined by the chemical nature of rocks of the drainage basin, the streambed materials, water temperature, and biological processes such as photosynthesis and respiration. The ranges of bicarbonate and carbon dioxide for stations 09216565, Salt Wells Creek, and 09216576, Gap Creek, are shown in table 2.

The dissolved-solids concentration determines, in part, the variety and abundance of aquatic plants and animals in the plains streams. A source of dissolved solids is the quantity of available dissolved matter washed into the stream from the drainage basin. Other sources are decaying plant and animal materials. Springs and marshes may also contribute to the dissolved-solids concentration in Salt Wells Creek drainage. The biology and its relations to water chemistry are shown in figures 8-14. Concentration ranges for several nitrogen and phosphorus types are given in tables 3 and 4.

Sulfate is necessary for plant growth. Sulfur depletion can inhibit growth and reduce productivity in algal populations. Sources of sulfate in plains streams are precipitation, runoff, and the weathering of geologic formations.

At station 09216565, the sulfate-distribution range was 290 to 600 mg/L. The lowest measurement was recorded during late July and the highest during snowmelt and high-intensity summer rainstorms. At station 09216576, the sulfate range was 120 to 610 mg/L. The lowest measurements were recorded in August and the highest in April when snowmelt was occurring.

Figure 4.--Vegetative growth in headwaters of Salt Wells Creek near South Baxter.

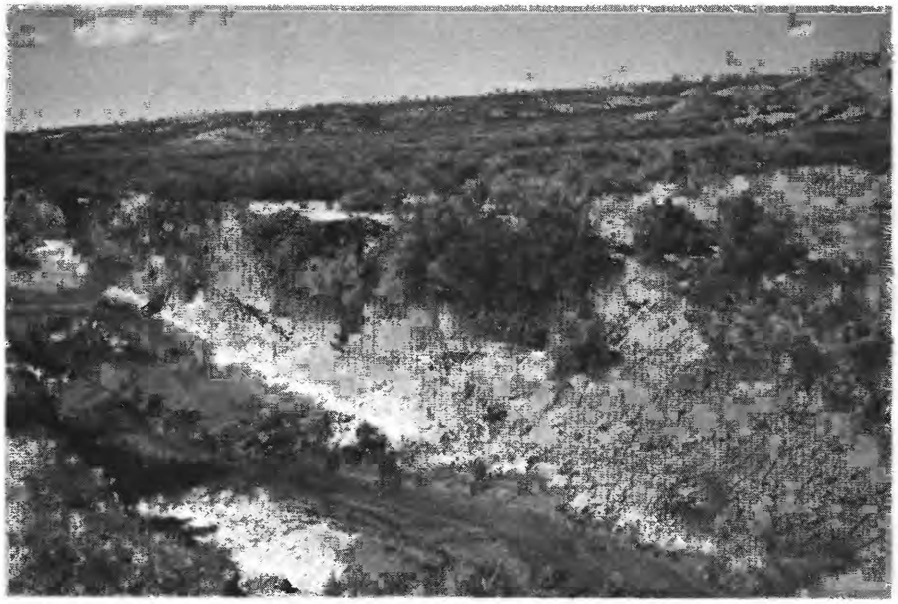


Figure 5.--View upstream of Gap Creek near mouth. (Note the channel has downcut, and bank vegetation is sparse.)

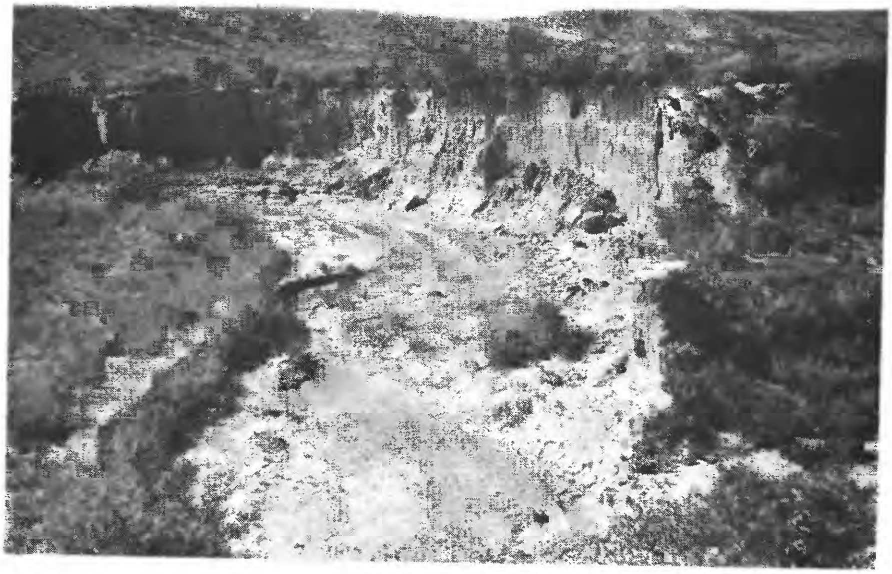


Figure 6.--View upstream of Salt Wells Creek near station 09216750.

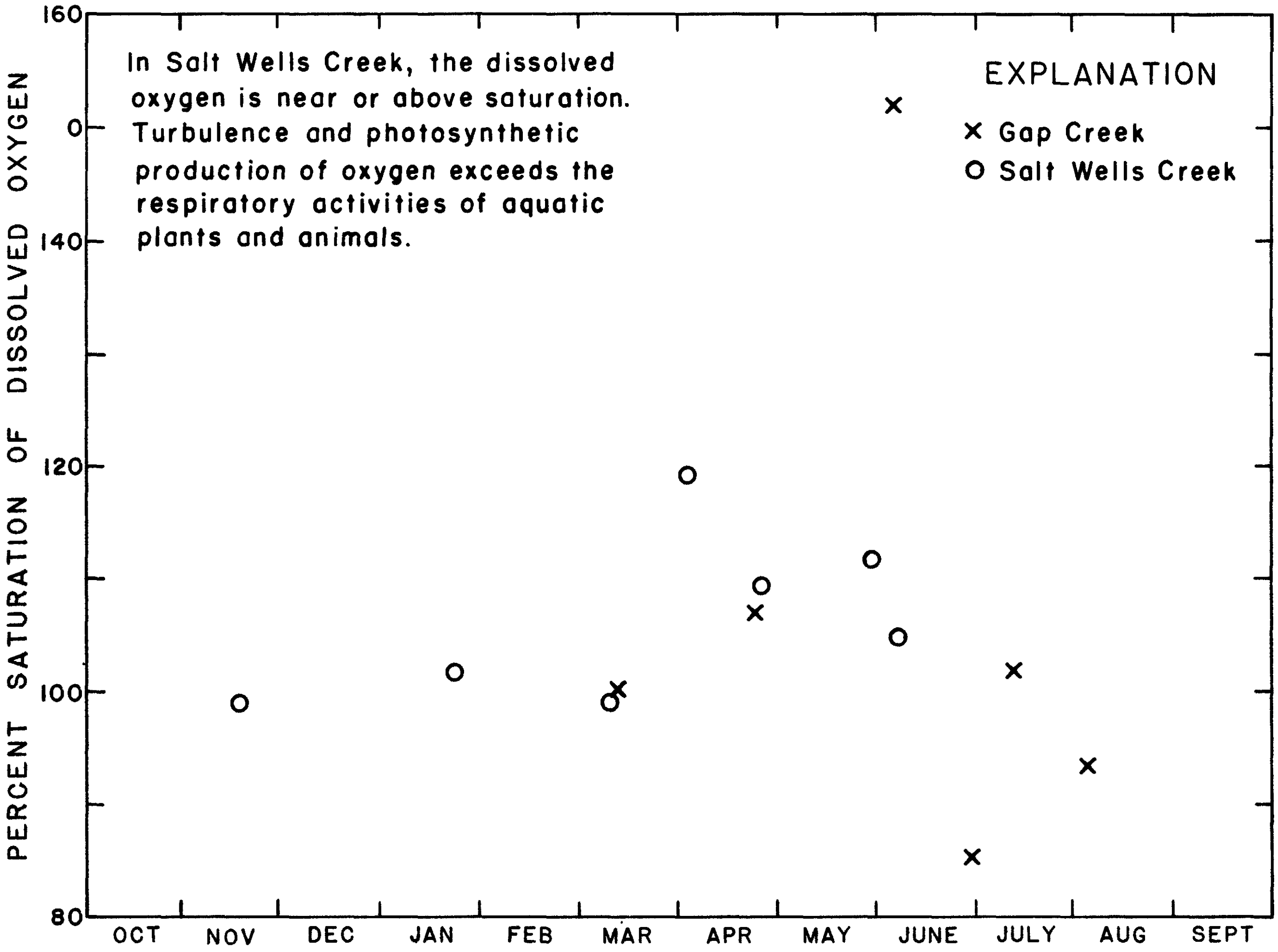


Figure 7.--Observed percent saturation of dissolved oxygen for stations 09216576, Gap Creek below Beans Spring Creek near South Baxter, Wyoming and 09216565, Salt Wells Creek near South Baxter, Wyoming (1976 water year). Dissolved oxygen was measured during the daytime.

Table 2.--The concentration and range of bicarbonate and carbon dioxide for stations 09216576, Gap Creek below Beans Spring Creek near South Baxter, and 09216565, Salt Wells Creek near South Baxter

Date	Bicarbonate	Carbon dioxide
	09216565, Salt Wells Creek near South Baxter	
Mar 31, 1976	329 mg/L	1.1 mg/L
Apr 20, 1976	359 mg/L	1.4 mg/L
July 10, 1976	225 mg/L	1.0 mg/L
Aug 1, 1976	271 mg/L	1.4 mg/L
RANGE	225 to 359 mg/L	1.0 to 1.4 mg/L
	09216576, Gap Creek below Beans Spring Creek near South Baxter	
Nov 17, 1975	339 mg/L	3.4 mg/L
Dec 17, 1975	352 mg/L	4.5 mg/L
Jan 19, 1976	304 mg/L	4.9 mg/L
Mar 9, 1976	303 mg/L	3.1 mg/L
Mar 20, 1976	265 mg/L	5.3 mg/L
Apr 6, 1976	305 mg/L	2.4 mg/L
Apr 21, 1976	444 mg/L	3.6 mg/L
RANGE	265 to 444 mg/L	2.4 to 5.3 mg/L

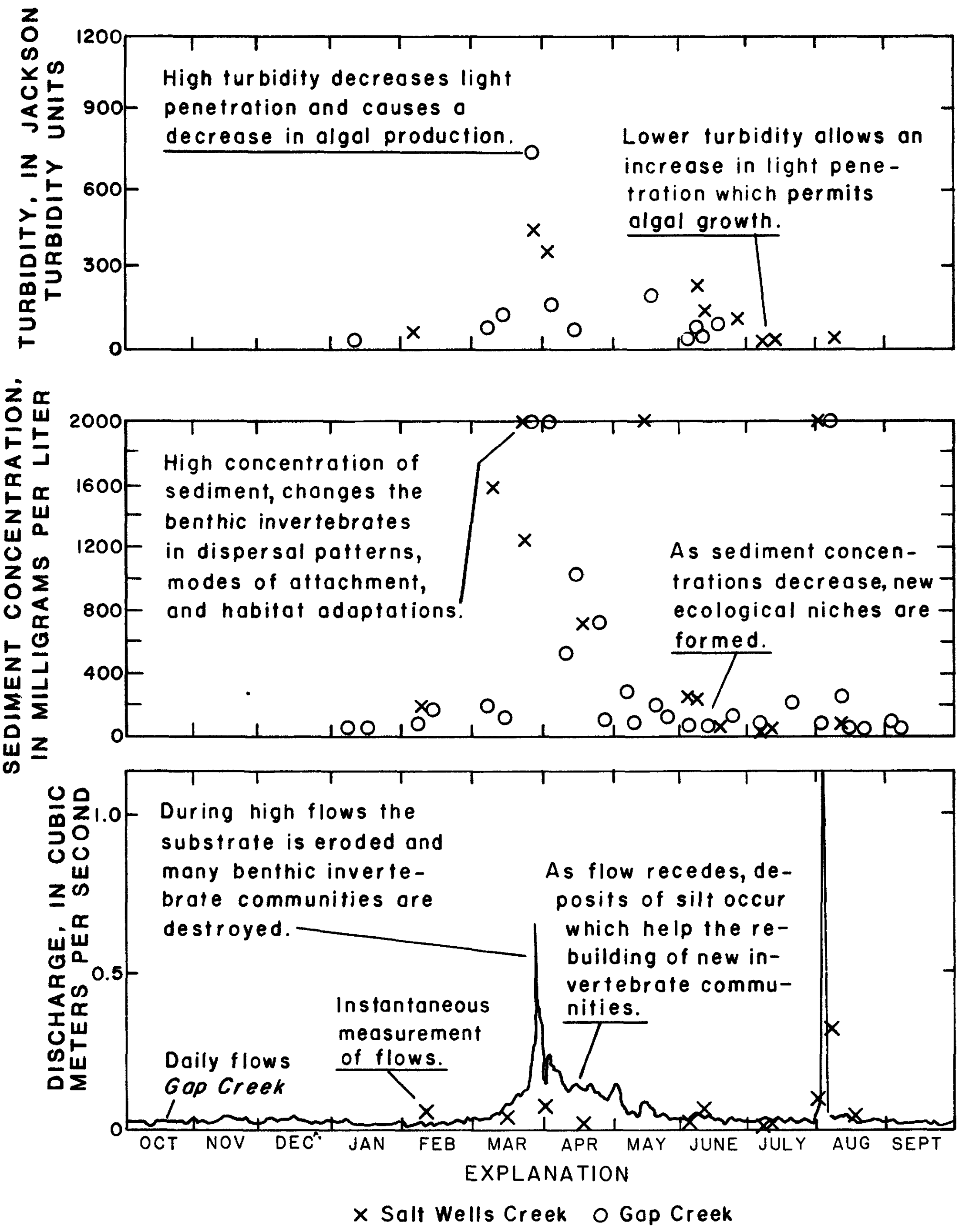


Figure 8.--Discharge, suspended-sediment concentration, and turbidity at streamflow stations 09216576, Gap Creek and 09216565, Salt Wells Creek (1976 water year).

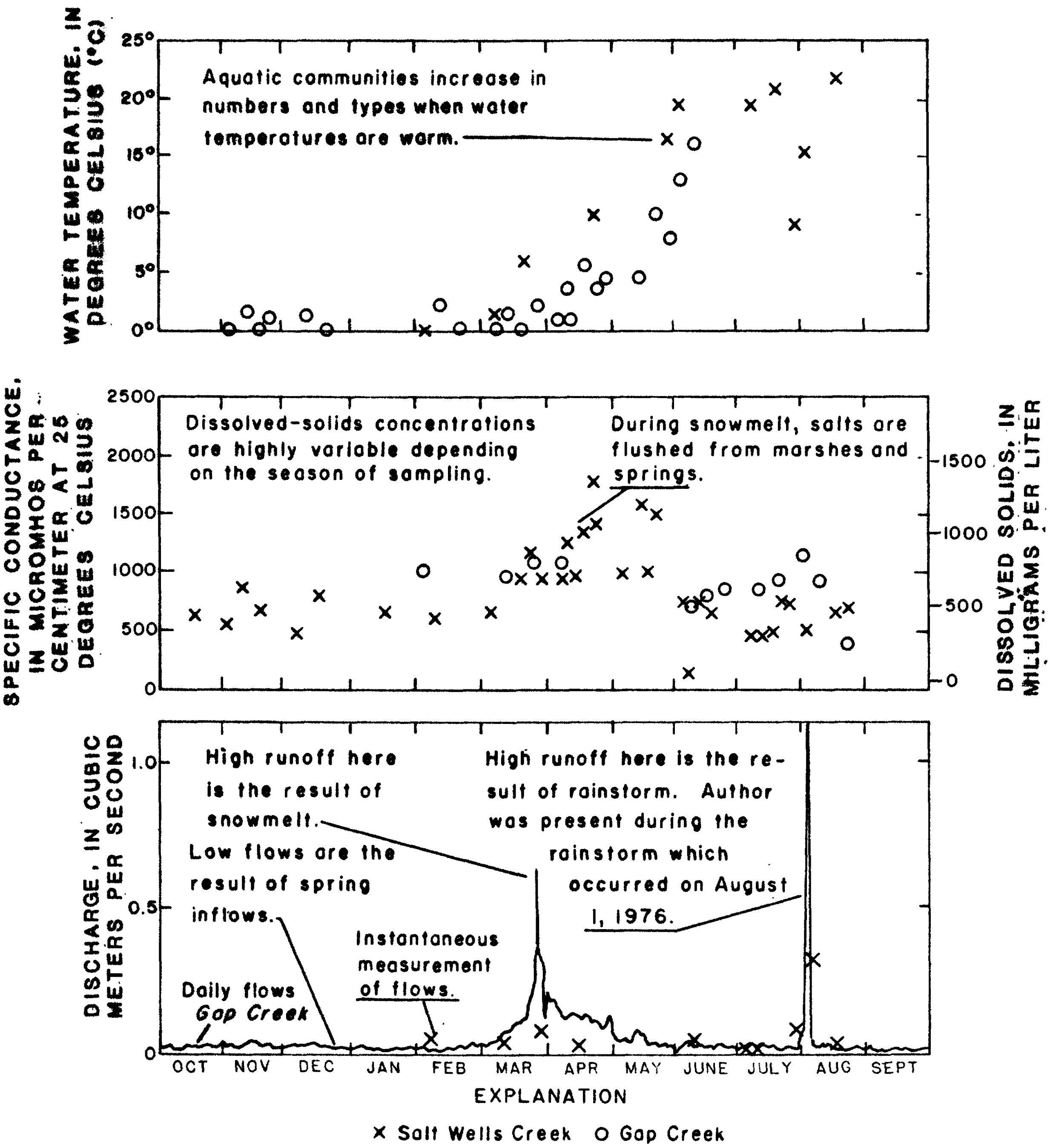


Figure 9.--Specific conductance, dissolved-solids concentration, water temperature, and discharge at streamflow stations 09216576, Gap Creek and 09216565, Salt Wells Creek (1976 water year).

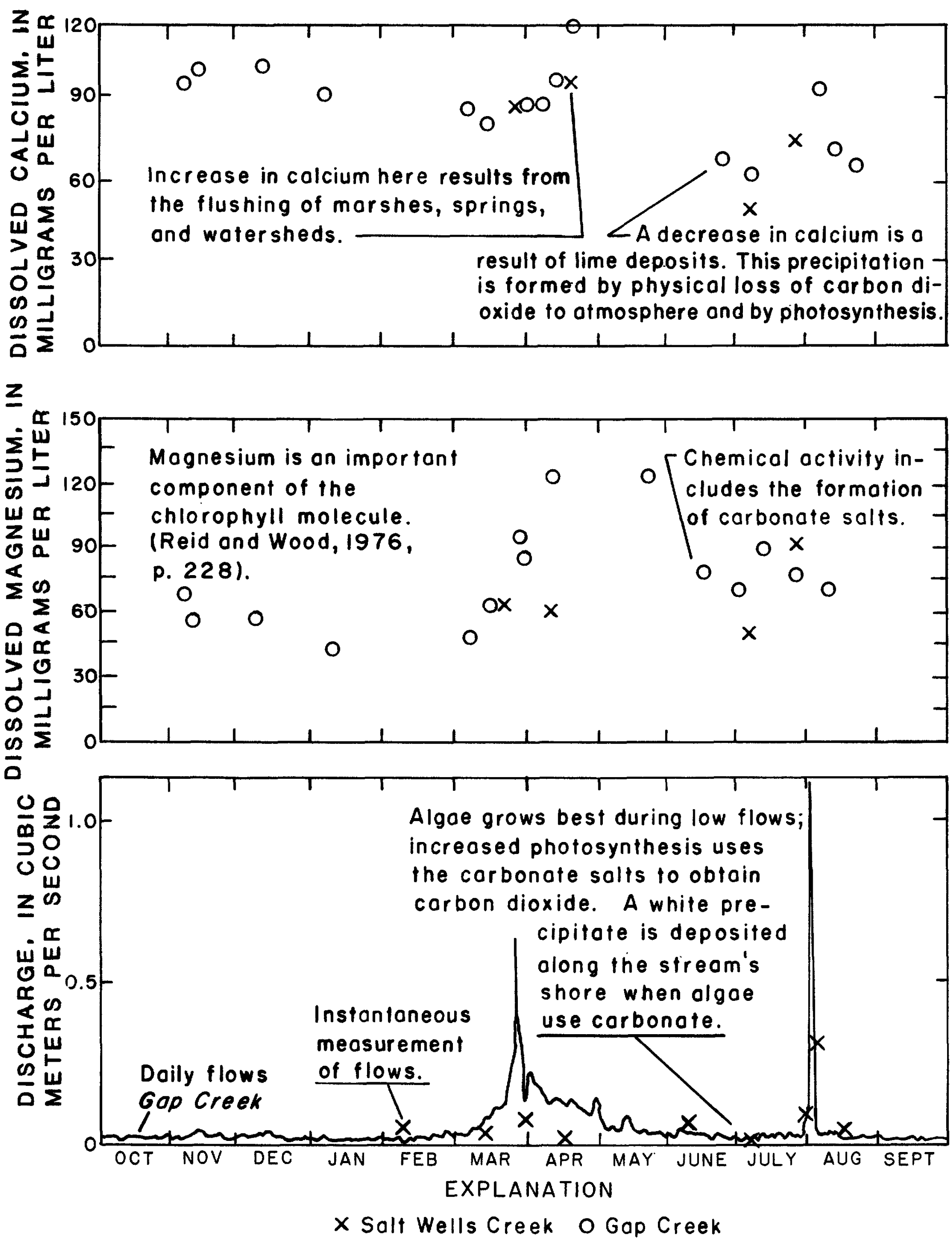


Figure 10.--Seasonal variation of dissolved calcium, dissolved magnesium, and discharge at stations 09216576, Gap Creek and 09216565, Salt Wells Creek (1976 water year).

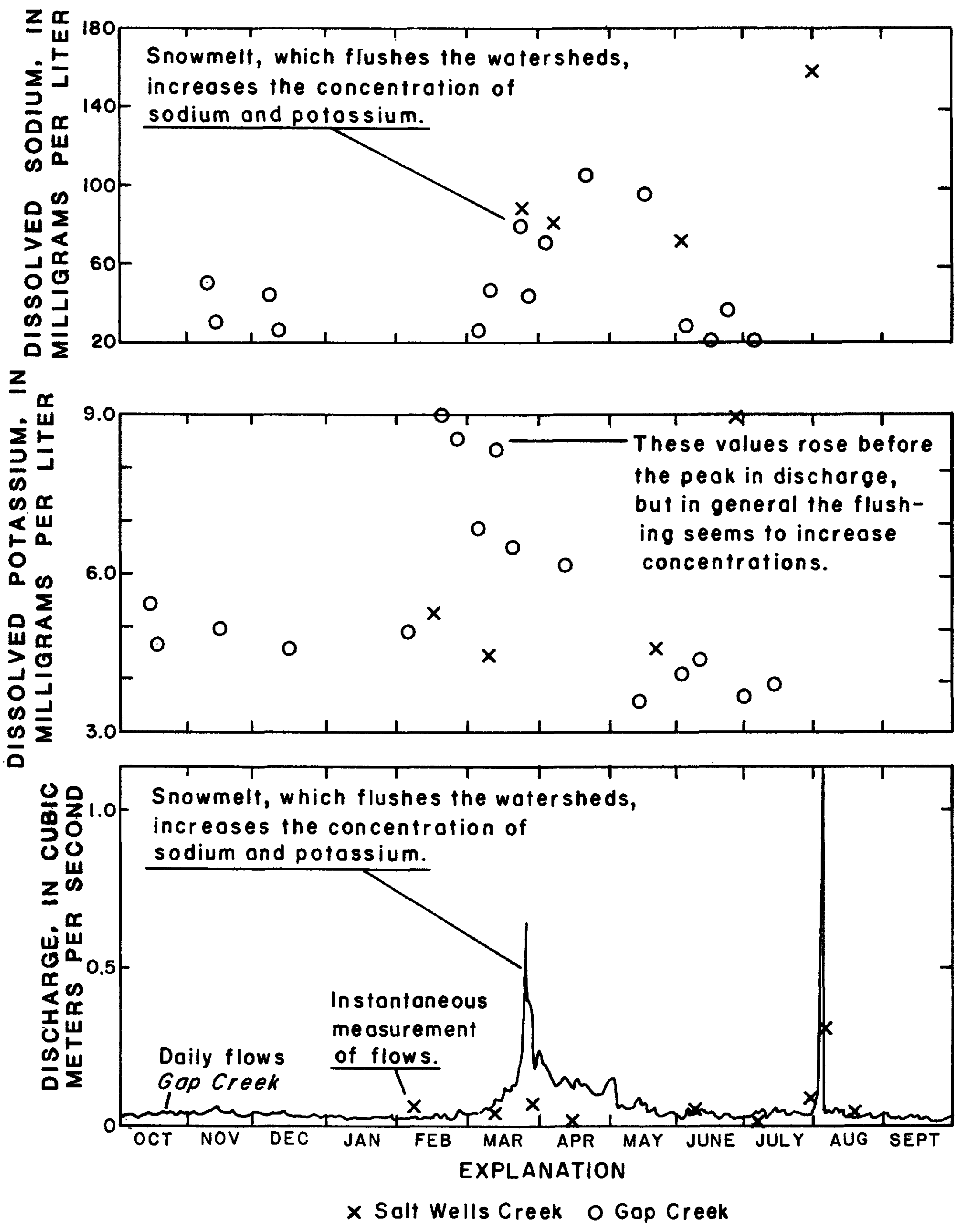


Figure 11.--Seasonal variation of dissolved sodium, dissolved potassium, and discharge for stations 09216576, Gap Creek and 09216565, Salt Wells Creek (1976 water year).

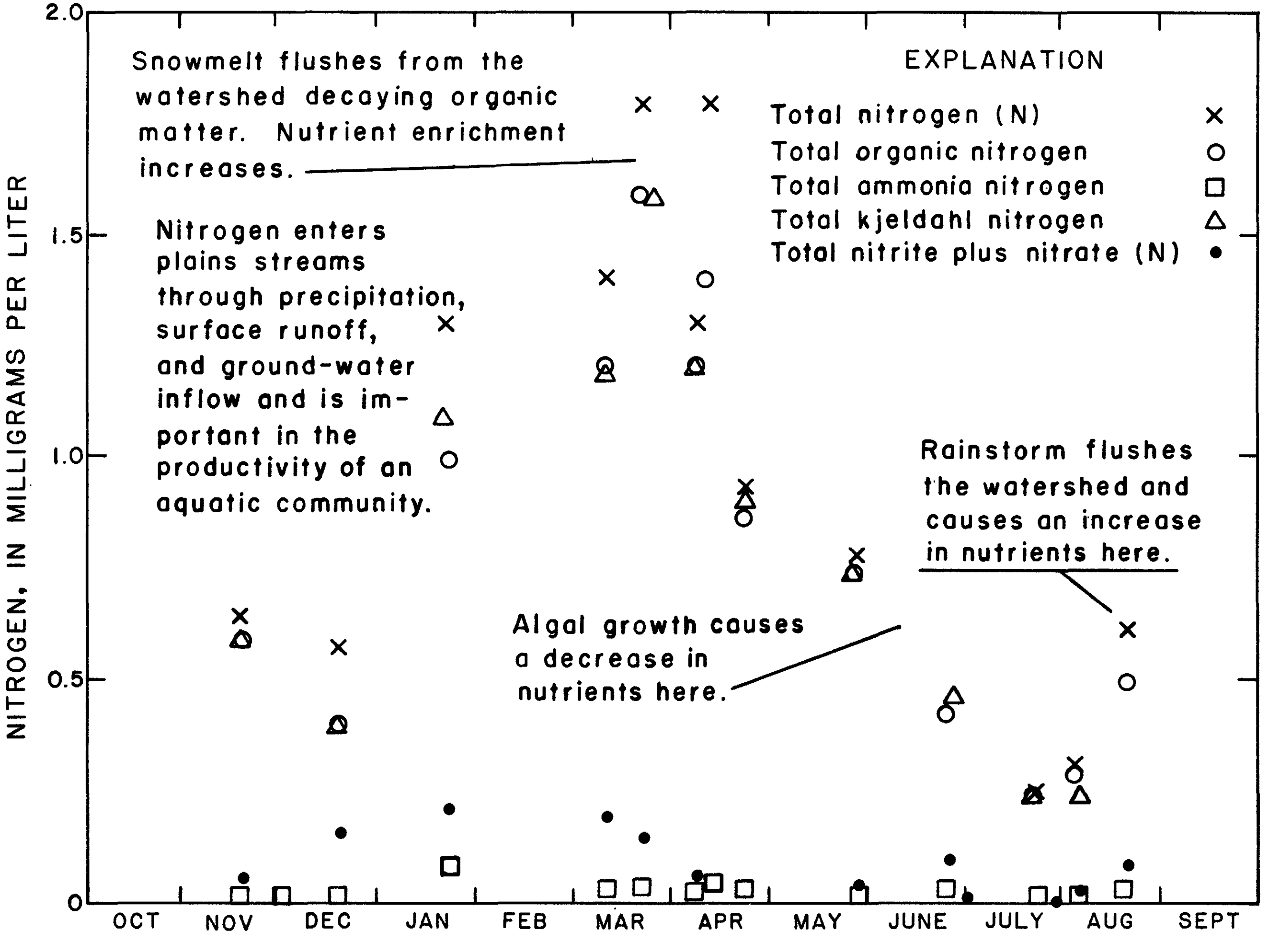


Figure 12.--Seasonal variation in concentration of various forms of nitrogen at station 09216576, Gap Creek (1976 water year).

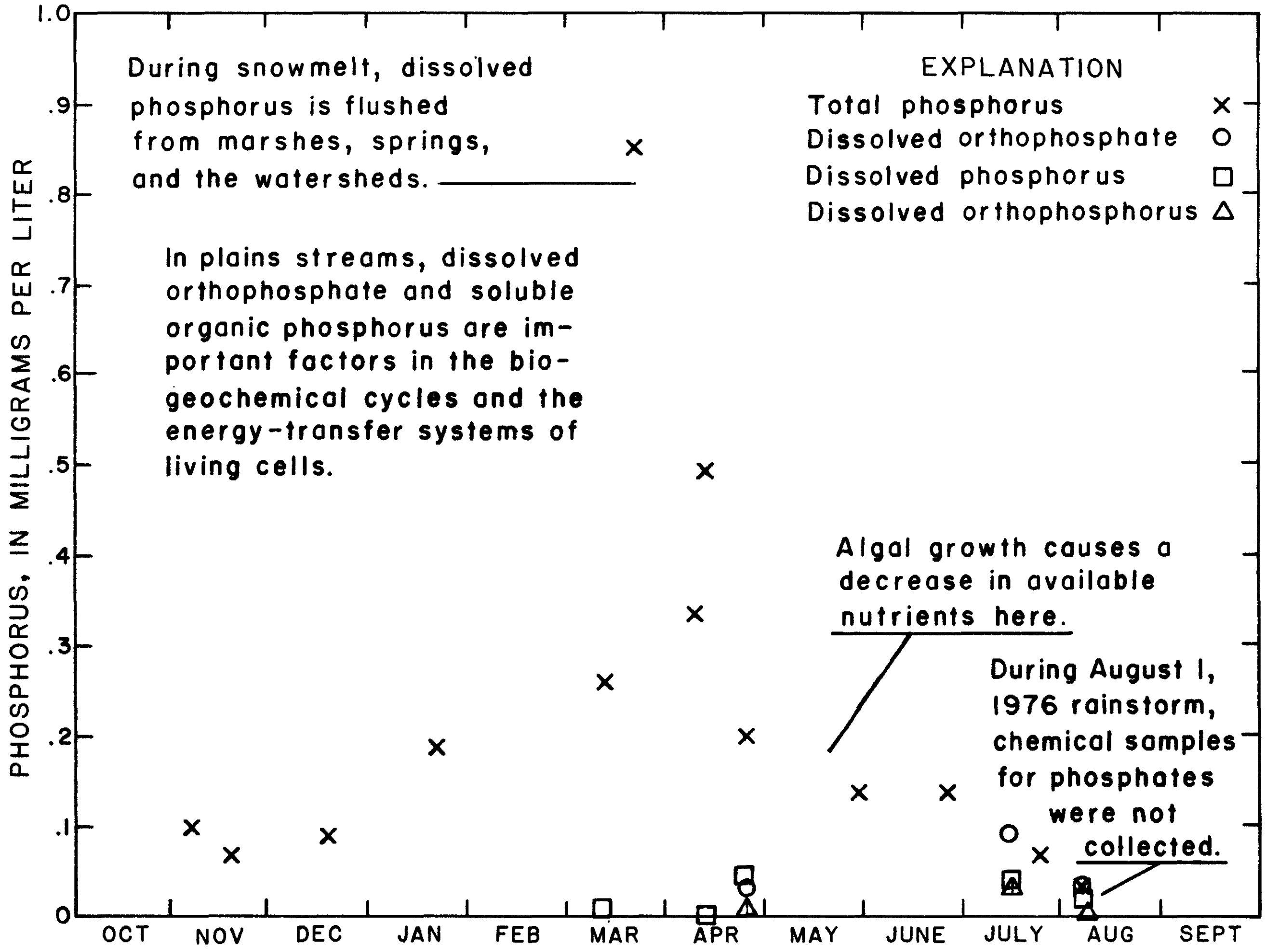


Figure 13.--Seasonal variation of several forms of phosphorus at station 09216576, Gap Creek (1976 water year).

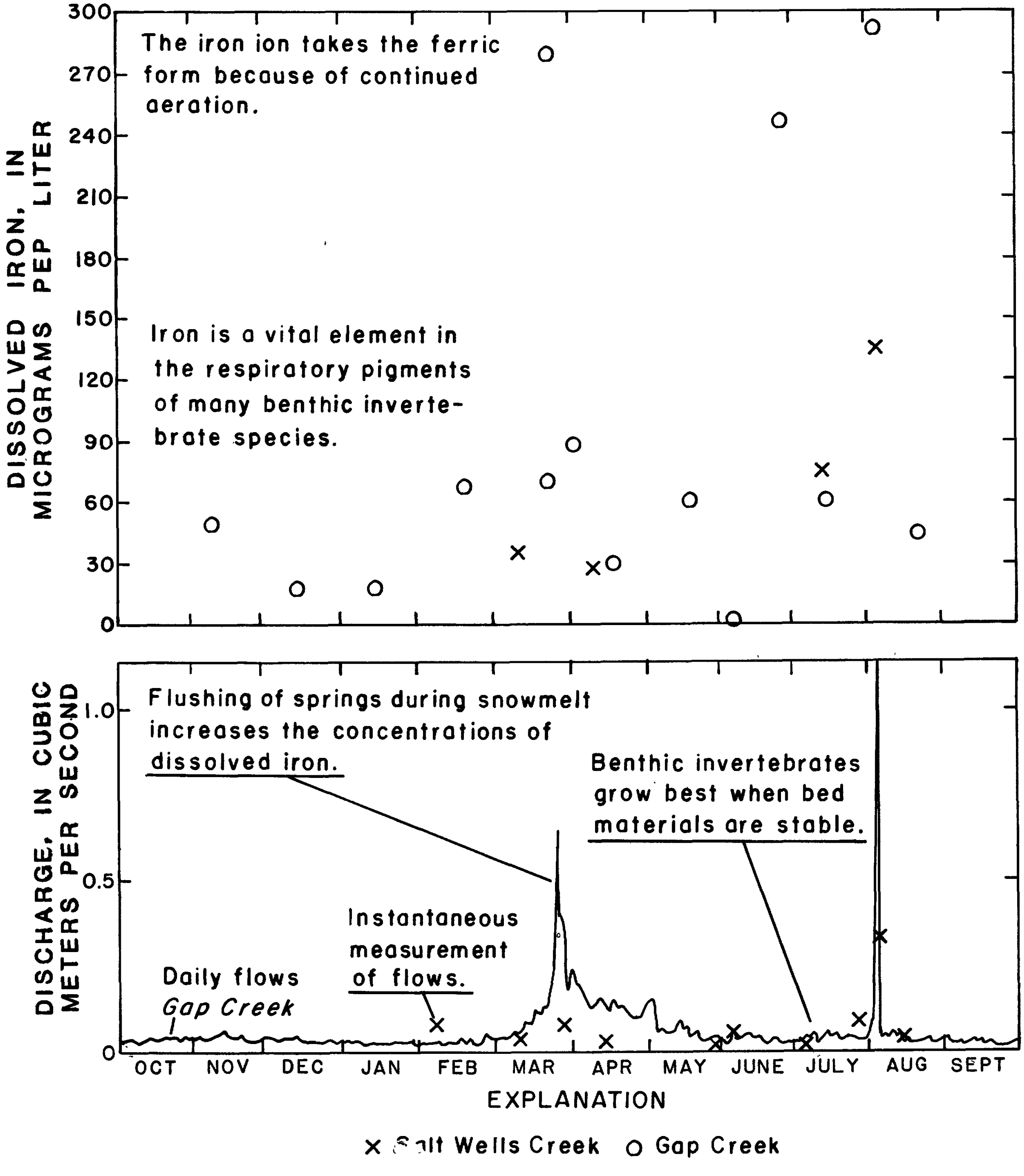


Figure 14.--Seasonal variation of discharge and dissolved iron at stations 09216576, Gap Creek and 09216565, Salt Wells Creek (1976 water year).

Table 3.--Concentration range of nitrogen types at stations 09216576, Gap Creek below Beans Spring Creek near South Baxter, and 09216565, Salt Wells Creek near South Baxter, 1976 water year

Nitrogen Types	Range
09216576, Gap Creek below Beans Spring Creek near South Baxter	
Total nitrogen	0.24 to 1.8 mg/L
Total organic nitrogen	.24 to 1.6 mg/L
Total ammonia nitrogen	.00 to .9 mg/L
Total Kjeldahl nitrogen	.24 to 1.8 mg/L
Total nitrite plus nitrate nitrogen	.00 to .19 mg/L
09216565, Salt Wells Creek near South Baxter[1]	
Total nitrogen	2.0 to 2.1 mg/L
Total organic nitrogen	1.8 to 2.0 mg/L
Total ammonia nitrogen	.00 to .03 mg/L
Total Kjeldahl nitrogen	1.8 to 2.0 mg/L
Total nitrite plus nitrate nitrogen	.06 to .22 mg/L

[1] Only two samples were collected at station 09216565.

Table 4.--Concentration range of several phosphorus types at stations 09216576, Gap Creek below Beans Spring Creek near South Baxter, and 09216565, Salt Wells Creek near South Baxter, 1976 water year

Phosphorus types	Range
09216576, Gap Creek below Beans Spring Creek near South Baxter	
Dissolved orthophosphate as phosphorus	0.03 to 0.09 mg/L
Total phosphorus as phosphorus	.10 to .85 mg/L
Dissolved phosphorus as phosphorus	.00 to .03 mg/L
09216565, Salt Wells Creek near South Baxter[1]	
Dissolved orthophosphate as phosphorus	0.00 to 0.09 mg/L
Total phosphorus as phosphorus	.48 to 1.50 mg/L
Dissolved phosphorus as phosphorus	.01 to .03 mg/L

[1] Only two samples were collected at station 09216565.

Biological Characteristics

Phytoplankton and periphyton are the primary producers in the aquatic food chain of plains streams. The suspended and attached algae are controlled by the chemical and physical factors of the water environment. These chemical and physical properties are dissolved oxygen, pH, water temperature, turbidity, the reservoir of nutrients, organic matter from terrestrial plants, the substrate, the duration of water in the channel, and the velocity of the channel waters.

The kinds of algae, dates of samples, and other included information for stations 09216565 and 09216576 are shown in tables 5 and 6 and figures 15 and 16.

Benthic invertebrates are important in the food chain of plains streams as well as serving as indicators of environmental quality. The orders or families, the relative abundance, the diversity indices, and the dates of sample collection at stations 09216565 and 09216576 are shown in tables 7 and 8.

The caddisflies Hydropsyche and Brachycentrus were associated with fast water and riffles. Hydropsyche was found on twigs and larger rocks. Brachycentrus was found mainly on cobblestones. The caddisfly, Leptocella, was found in moderately smooth water and usually on trailing root masses. The caddisflies Ptilostomis and Limnephilus were found on submerged vegetation in pondlike conditions.

The mayfly, Baetidae, is associated with slow streams and is usually found under rocks. The stonefly, Dsoperla, was found usually clinging to rocks on the stream bottom. The hellgrammite, Sialis, was found in soft mud or under stones in moderate to fast water. Other mud burrowers were the dragonflies, Gomphidae.

Most of the slow-water forms were the water boatmen, Gerridae, and the midge, Chironomidae. The most common beetle was the riffle beetle, Elmidae. Its habitat appeared to be restricted to flowing water and riffles.

On June 2, 1976, the U.S. Geological Survey and the Wyoming Game and Fish Department conducted a fish survey of streams in the study area. Two species, the mountain sucker, Catostoma platyrhynchus (Cope), and the speckled dace, Rhinichthys osculus (Girard), were collected from Salt Wells Creek, figures 17 and 18. Only the mountain sucker was collected from Gap Creek and Beans Spring Creek.

The mountain sucker is almost entirely algivorous (Simon, 1951, p. 61) although Baxter and Simon (1970, p. 111) reported some animal predation on primarily midge larvae and caddisflies. The speckled dace is omnivorous with some preference for vegetative matter (Baxter and Simon, 1970, p. 75).

Table 5.--Number and percent of genera, date of collection, and diversity indices for phytoplankton at station 09216565, Salt Wells Creek near South Baxter

Date / Genera	03-09-76 Num-ber	03-09-76 Per-cent	04-20-76 Num-ber	04-20-76 Per-cent	06-03-76 Num-ber	06-03-76 Per-cent	06-25-76 Num-ber	06-25-76 Per-cent	08-01-76 Num-ber	08-01-76 Per-cent	11-02-76 Num-ber	11-02-76 Per-cent	Organism range per genus (cells per mL)
Ankistrodemus	77	5											([1])
Achnanthes	77	5			52	2	220	8	5,700	5			52- 5,700
Rhoicosphenia	77	5			52	2	---	0	2,800	2			0- 2,800
Cymbella	77	5							2,800	2			77- 2,800
Epithemia	77	5					---	0					0- 77
Synedra	230	16			160	6			2,800	2	---	0	160- 2,800
Gomphonema	---	0	290	33	730	26	150	5	8,500	7			150- 8,500
Amphipleura	77	5											([1])
Gyrosigma	77	5			---	0							0- 77
Navicula	310	22	580	67	880	32	580	21	17,000	15	37	3	37-17,000
Pinnularia	---	0											([1])
Nitzschia	150	11			680	25	1,500	53	62,000	55	1,400	94	150-62,000
Surirella	230	16			210	7	360	13	11,000	10	37	3	37-11,000
Rhopalodia									2,800	2			([1])
TOTALS[2]	1,459	100	870	100	2,764	100	2,810	100	115,400	100	1,474	100	
DIVERSITY INDEX		3.22		0.92		2.26		1.86		2.23		0.34	

[1] Genera appeared only once during sampling and range is undetermined.
[2] Range is 870 to 115,400 cells per milliliter.

Table 6.--Number and percent of genera, date of collection, and diversity indices for phytoplankton at station 09216576, Gap Creek below Beans Spring Creek near South Baxter

Date / Genera	08-04-75 Number	08-04-75 Percent	08-27-75 Number	08-27-75 Percent	11-05-75 Number	11-05-75 Percent	04-01-76 Number	04-01-76 Percent	06-03-76 Number	06-03-76 Percent	06-26-76 Number	06-26-76 Percent	08-01-76 Number	08-01-76 Percent	Organism range per genus (cells/per mL)
Ankistrodemus	---	0							16	1					0- 16
Achnanthes	---	0	14	6	18	3									0- 18
Cocconeis	---	0	---	0											(1)
Cymbella	19	4	---	0	18	3									0- 19
Epithemia	---	0	14	6											0- 14
Syndera	---	0			36	7	28	1			2	19	260	6	0- 260
Gomphonema	19	4	7	3					16	1	---	3	65	1	7- 65
Caloneis	19	4							---	0					0- 19
Gyrosigma	19	4											---	0	0- 19
Navicula	95	21	21	9	200	38	250	10	460	31	3	32	320	7	3- 460
Nitzschia	270	59	140	62	200	38	85	3	320	21	3	29	3,800	34	3-3,800
Surirella	19	4			36	8			160	11	2	16			2- 160
Pinnularia			---	0									65	1	0- 65
Lyngbya			28	14											(1)
Rhoicosphenia					18	3	28	1	16	1	---	1			0- 28
Chlamydomonas							28	1							(1)
Cymatopleura							28	1							(1)
Oscillatoria							2,200	83	510	34					510-2,200
Anabaena													65	1	(1)
TOTALS[2]	460	100	224	100	526	100	2,647	100	1,498	100	11	100	4,576	100	
DIVERSITY INDEX	1.88		1.78		2.10		0.99		2.08		2.14		0.99		

1 Genera appeared only once during sampling and range is undetermined.
2 Range is 11 to 4,576 cells per milliliter.

GENERA	1976 March 9	April 20	June 3	June 25	Aug. 1	Nov. 2
Achnanthes	X					X
Cocconeis	X					
Rhoicosphenia	X				X	
Cymbella	X	X		X	X	X
Epithemia	X	X			X	X
Synedra	X			X		X
Gomphonema	X	X	X	X	X	X
Gyrosigma	X	X			X	X
Navicula	X	X	X	X	X	X
Pinnularia	X	X			X	X
Nitzschia	X	X	X	X	X	X
Surirella	X	X		X		X
Oscillatoria	X	X		X		
Cladophora		X				
Rhopalodia		X			X	X
Caloneis		X			X	X
Lyngbya			X	X	X	X
Oedogonium				X	X	X
Stigeollonium				X	X	X
Cladophora					X	
Anabaena					X	
Calothrix					X	X
Spirogyra						X
Anomoeoneis						X
Cylindrotheca						X
Tribonema						X
Number of orders	2	3	2	4	5	6
Number of families	8	7	4	9	11	13
Number of genera	13	12	4	10	16	20

Figure 15.--Genera and date of collection for periphyton at station 09216565, Salt Wells Creek, 1976.

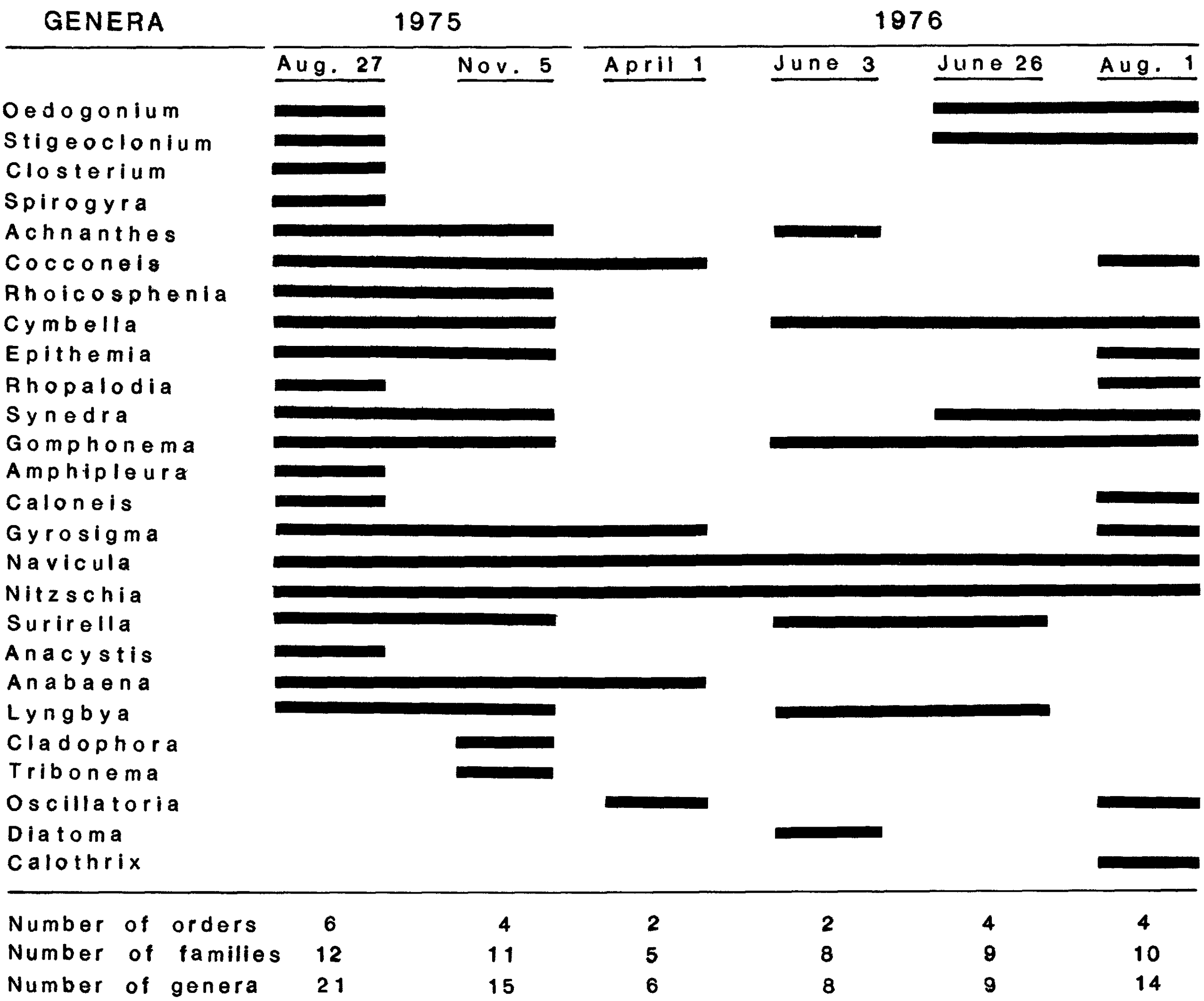


Figure 16.--Genera and date of collection for periphyton at station 09216576, Gap Creek, 1975-76.

Table 7.--Number and percent, dates of collection, and diversity indices for benthic invertebrates at station 09216565, Salt Wells near South Baxter

Date / Organisms	04-20-76		06-03-76		11-02-76	
	Number	Percent	Number	Percent	Number	Percent
Hydracarina-water mites	4	1	17	38		
Elmidae-riffle beetles	16	5	1	2	1	4
Dryopidae-riffle beetles	5	1			4	15
Chironomidae-midges	6	2			11	39
Tipulidae-crane flies	7	2	2	4	6	21
Ephemeroptera-mayflies	129	38	2	4		
Odonata-dragonflies	2	1	3	7		
Plecoptera-stoneflies	42	12	4	9		
Hydropsychidae-caddis flies	125	36	10	23	6	21
Limnephilidae-caddis flies	6	2				
Gastropoda-snails	1	--	1	2		
Gerridae-water striders			4	9		
Hydrophilidae-water scavengers			1	2		
Gammarus-scud	([1])		([1])		([1])	
TOTAL	343	100	45	100	28	100
DIVERSITY INDEX		2.20		2.66		2.57

[1] Benthic samples were taken in riffles above ponds. The ponds supported a high population of *Gammarus* (scuds). The riffle community is represented.

Table 8.--Number and percent, dates of collection, and diversity indices for benthic invertebrates at station 09216576, Gap Creek below Beans Spring Creek near South Baxter

Date / Organism	08-27-75		11-05-75		06-06-76	
	Number	Percent	Number	Percent	Number	Percent
Elmidae-riffle beetles	23	5				
Chironomidae-midges	329	78				
Simulidae-black flies	36	8				
Ephemeroptera-mayflies	11	3	9	3	25	25
Plecoptera-stoneflies	3	1	26	10	41	40
Trichoptera-caddis flies	21	5	31	12	23	23
Oligochaeta-aquatic earthworm			35	14		
Hydracarina-water mites			13	5		
Helichus-riffle beetles			3	1		
Dubiraphia-riffle beetles			6	2		
Optioservus-riffle beetles			19	7	2	2
Brychius-crawling water beetle			1	.6		
Helophorus-water scavenger			1	.6	2	2
Ceratopogonidae-biting midges			1	.6		
Chironomus-midges			3	1		
Pentaneura-midges			31	12		
Procladius-midges			1	.6		
Rheotanytarsus-midges			2	1		
Stictochironomus			2	1		
Tabanus-horseflies			2	1		
Eriocera-crane flies			1	.6		
Tipula-crane flies			1	.6	3	3
Corixidae-water boatmen			64	25		
Megaloptera-alderflies			1	.6		
Odonata-dragonflies			1	.8		
Annelida-leeches						
Amphipoda-scuds	([1])		([1])		([1])	
Nuculoidea-fingernail clams						
Basommatophora-pond snails			5	2		
Dytiscidae-predaceous diving beetles					4	4
Stratiomyiidae-soldier flies					1	1
TOTAL	423	100	259	100	101	100
DIVERSITY INDEX		0.82		2.46		1.99

[1] Benthic samples were taken in riffles above ponds. The ponds supported a high population of *Gammarus* (scuds). The riffle community is represented.

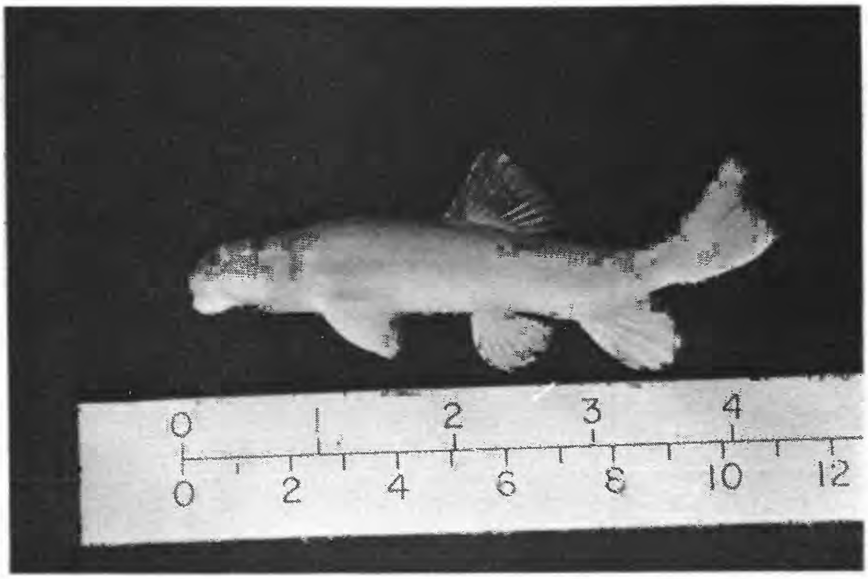


Figure 17.--Mountain sucker, Catostoma platyrhynchus (Cope), collected below Titsworth Spring on Gap Creek near South Baxter.

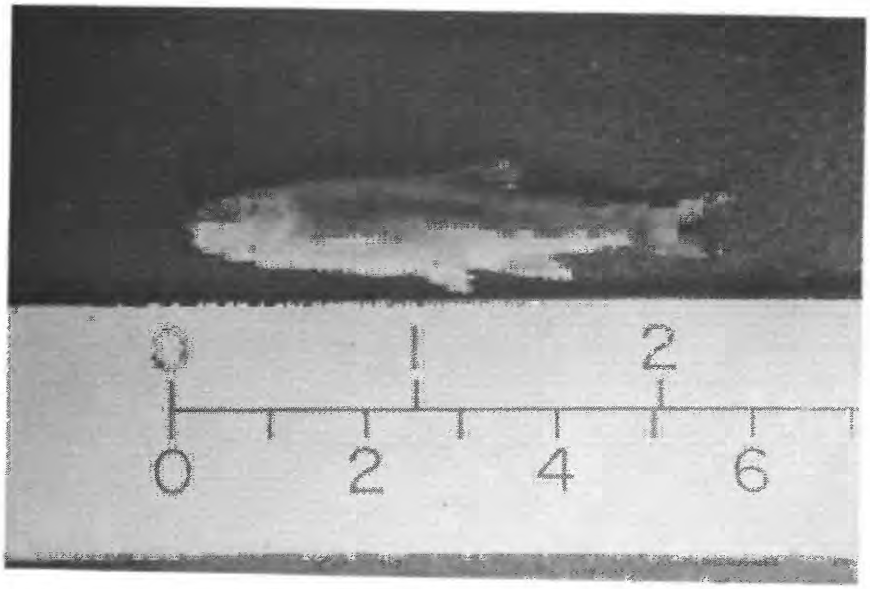


Figure 18.--Speckled dace, <u>Rhinichthys osculus</u> (Girard), collected at station 09216565, Salt Wells Creek near South Baxter.

DISCUSSION

Biophysical Aspects

The stability of Salt Wells Creek is determined by the rate of inflow of waters and materials from the watershed. The watershed was evaluated by rating the stability of the streambank and of bed materials (Duff and Cooper, 1976, p. 47). A stability curve was drawn (fig. 19) showing the relation of elevation to the stability rating of the bank and bed materials. Photographs (fig. 19) show the difference in bank structure from site X to the confluence with Bitter Creek, approximately 129 kilometers downstream. The difference in upper and lower bank vegetation and the bed materials are shown for stations located on the headwaters and lower reach of Salt Wells Creek.

Figure 20 shows the stream profile of Salt Wells Creek and its tributaries. Pine Lake, located on the headwaters of Salt Wells Creek, is fed by springs and surface runoff. The springs are on the southwestern shore of the lake. Water flows over an earth-filled dam on the northern shore of the lake. Flow becomes intermittent during late June to late September. The bed material below the dam consists of firmly embedded rocks and logs. The stream consists of pools and riffles. There is relatively little bank cutting or deposition in this area.

Site X, 0.6 kilometer downstream from Pine Lake, is a spring and is a source of flow for Salt Wells Creek during the summer months. The bed material at this site is composed of rocks, cobblestones, and sand with some embedded twigs and logs. At site A, which is 1.0 kilometer downstream from site X, the bed material consists of cobblestones, sand, and silt. The stream consists of riffles with some minor pools. Bank erosion is evident.

Site B, which is located just downstream from an old beaver pond, is 12.9 kilometers downstream from Pine Lake. At this site the bed material and aquatic habitat change. The pond area above the dam is backfilled with sediment and the area is now a livestock pasture. Streamflow is discontinuous from the southern boundary of the pasture to site B, and the subsurface flow is from pool to pool. Scouring, deposition, and bank erosion are common during spring runoff and high-intensity rainstorms.

At site C, about 16.6 kilometers below Pine Lake, the bed material consists of small cobblestones, sand, and silt.

At station 09216565, the bed material consists of gravel, sand, and silt. Heavy silt deposits occur in the pool areas. Figure 21 shows a photograph of gaging station 09216565 after the high-intensity rainstorm on August 1, 1976. Note the deposition of new gravel and coarse sand on the old sand bar. Bank erosion is also evident. During snowmelt and high-intensity rainstorms, the entire reach of Salt Wells Creek is wet. During late June 1976, the stream was dry about 1.6 kilometers downstream from station 09216565.

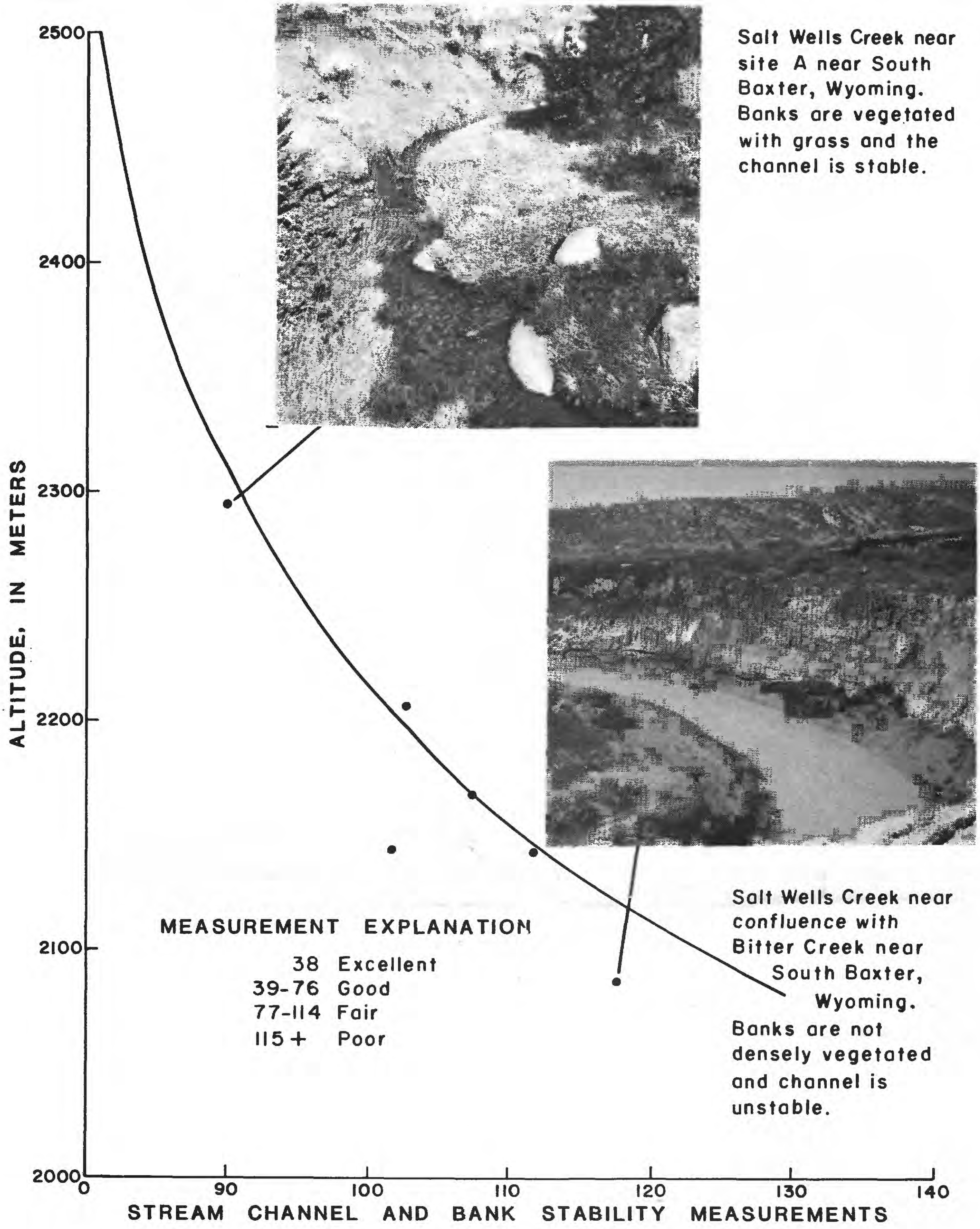


Figure 19.--Stream channel and bank stability curve.

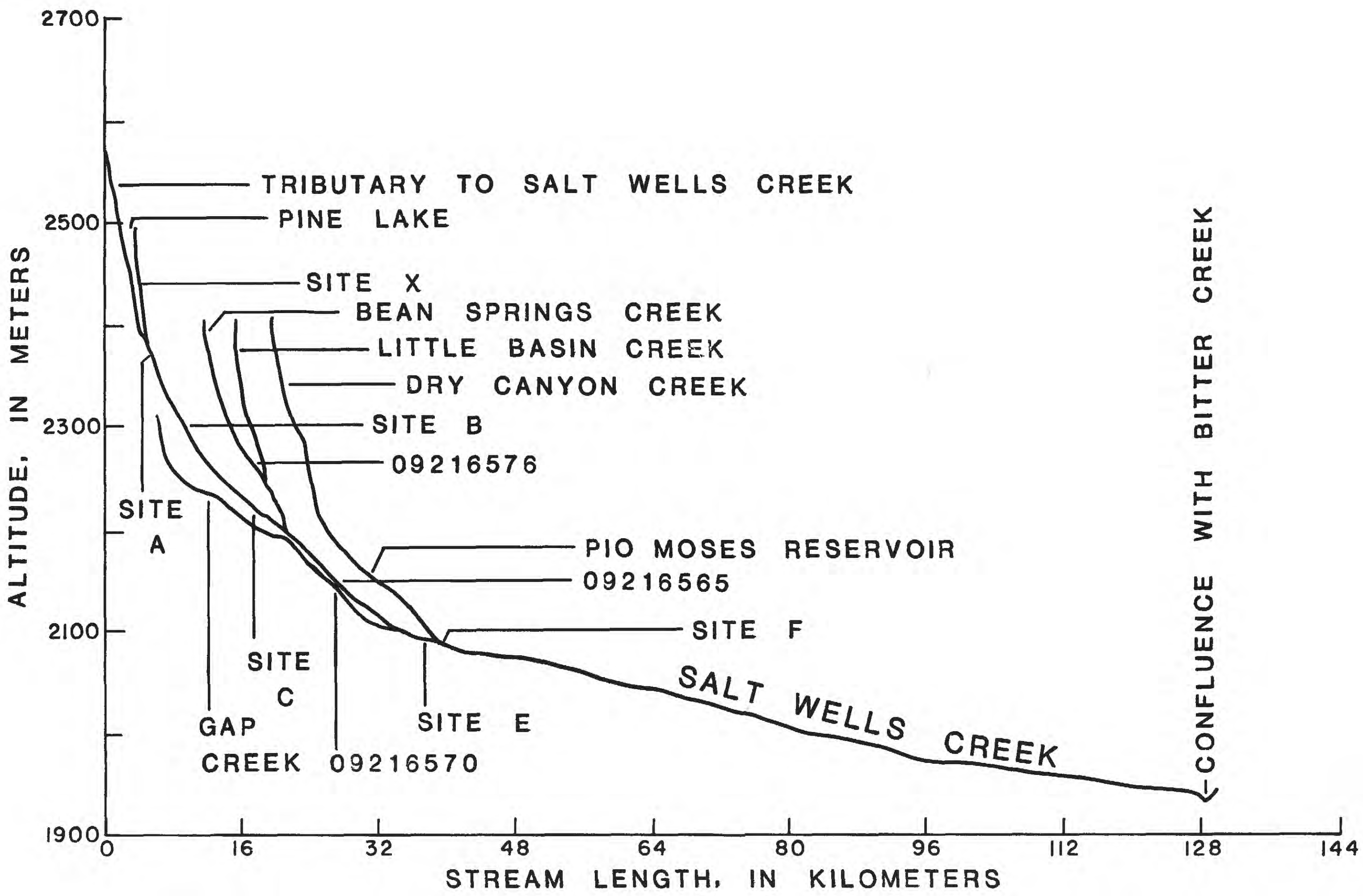


Figure 20.--Stream profile of Salt Wells Creek and its tributaries.

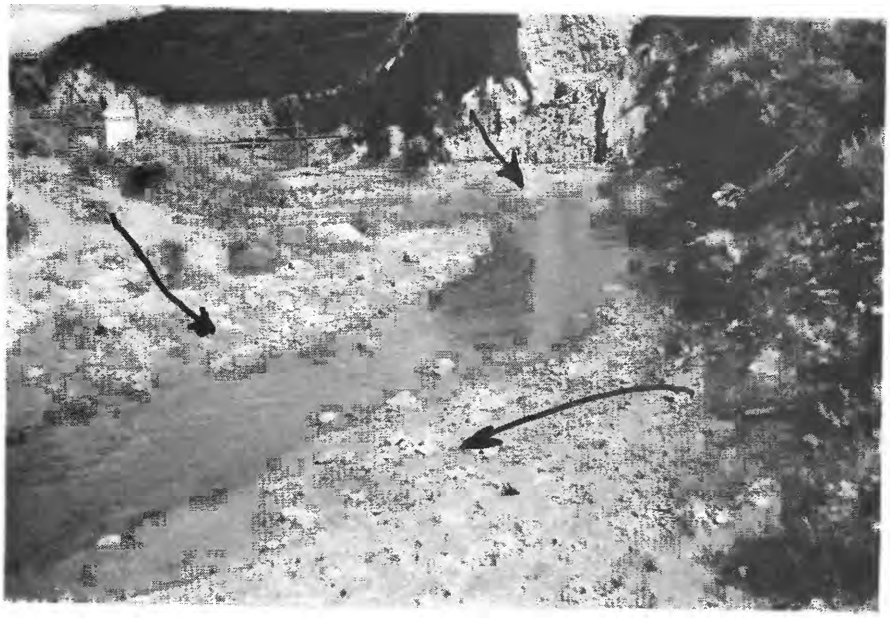


Figure 21.--Station 09216565, Salt Wells Creek, view downstream of unstable stream channel and banks. (Arrows show the unstable sand bars.)

The aquatic habitats along Salt Wells Creek and its tributary, Gap Creek, change during spring runoff. Increasing stream velocity disturbs the substrate. When the streamflow subsides, new bed materials are deposited in place of the old. These events change the aquatic habitats. The factors that help restore the aquatic habitat after it has been destroyed are numerous. Light, flowing water, and stable bed materials are the more important physical parameters needed. During the summer when low streamflow occurs, plains streams become pondlike. It is important to note that the aquatic habitat is stable at higher altitudes, and that this habitat degrades due to changing basin characteristics in a downstream direction (table 9).

The seasonal variation, Jaccard Coefficient of Association and Cluster Analysis (Southwood, 1966, p. 342-344), and the diversity index are useful in illustrating the seasonal periodicity of phytoplanktonic development (Odum, 1971, p. 251).

There are three sources of phytoplankton in the Salt Wells Creek drainage. One is the springs, in which diatoms dominate. The second is stock ponds, in which green and blue-green algae dominate. The third source is the dislodged periphytic algae from the streambed. The successional stages of phytoplanktonic growth during spring, summer, and fall are shown in figures 22-27. The circular diagrams (fig. 22) show blue-green algae to be dominant during the spring months. This is due to the scrubbing and scouring of the stock ponds during high streamflows from snowmelt. The circular diagrams (figs. 24 and 26) show diatoms are dominant during the summer and early autumn when low streamflows exist and springs are the main source of water.

During the summer and early autumn, streams are slow flowing and often ponded. Both the pondlike character and the assemblage of phytoplanktonic taxa are used in establishing water quality and baseline data. The seasonal cycle of the codominant genera for both gaging stations, 09216576 and 09216565, are shown in figure 28. Two genera, Nitzschia and Navicula, were plotted on this graph to show the increase or decrease of numbers during a growing season. Although three genera, Nitzschia, Navicula, and Surirella, appear consistently throughout the growing season, Nitzschia and Navicula are the largest in abundance of the codominant genera.

Another genus, Gomphonema, also appears frequently. The increase of this genus occurs during high streamflows and is related to water sources other than springs. During high streamflows, the stock ponds are flushed, and all four of these diatoms (Navicula, Nitzschia, Surirella, and Gomphonema) and the green and blue-green algae increase. During low streamflows, the green and blue-green algae and the diatom Gomphonema decrease relative to other diatoms.

Water quality has a direct effect on species compositions of diatom communities. Changes in the diatom community in turn produce changes in all higher trophic levels of the aquatic food chain.

Table 9.--Description of physical features of Salt Wells Creek near South Baxter

	Streamflow (seasonal)	Vegetation	Bank and bed material	Aquatic habitat	Stability ratio[1]
Upper reach, headwaters to gaging station 09216565 0 - 16.1 km	Perennial	Mixed conifers with short grass	Uniformly stable in all flows	Stable in all flows	Less than 86, good to excellent
Middle reach, gaging station to confluence of Pretty Water Creek, 16.1 to 45.1 km	Intermittent	Sagebrush with short grass	Stable--low flows; unstable--high flows	Stable--low flows; unstable--high flows	86 to 114, fair to good
Lower reach, Pretty Water Creek to confluence of Bitter Creek 45.1 to 128.7 km	Intermittent	Saltbrush, hop sage, bud sage with short grass	Unstable all flows	Unstable all flows	Greater than 114, poor

1 Duff and Cooper (1976, p. 47).

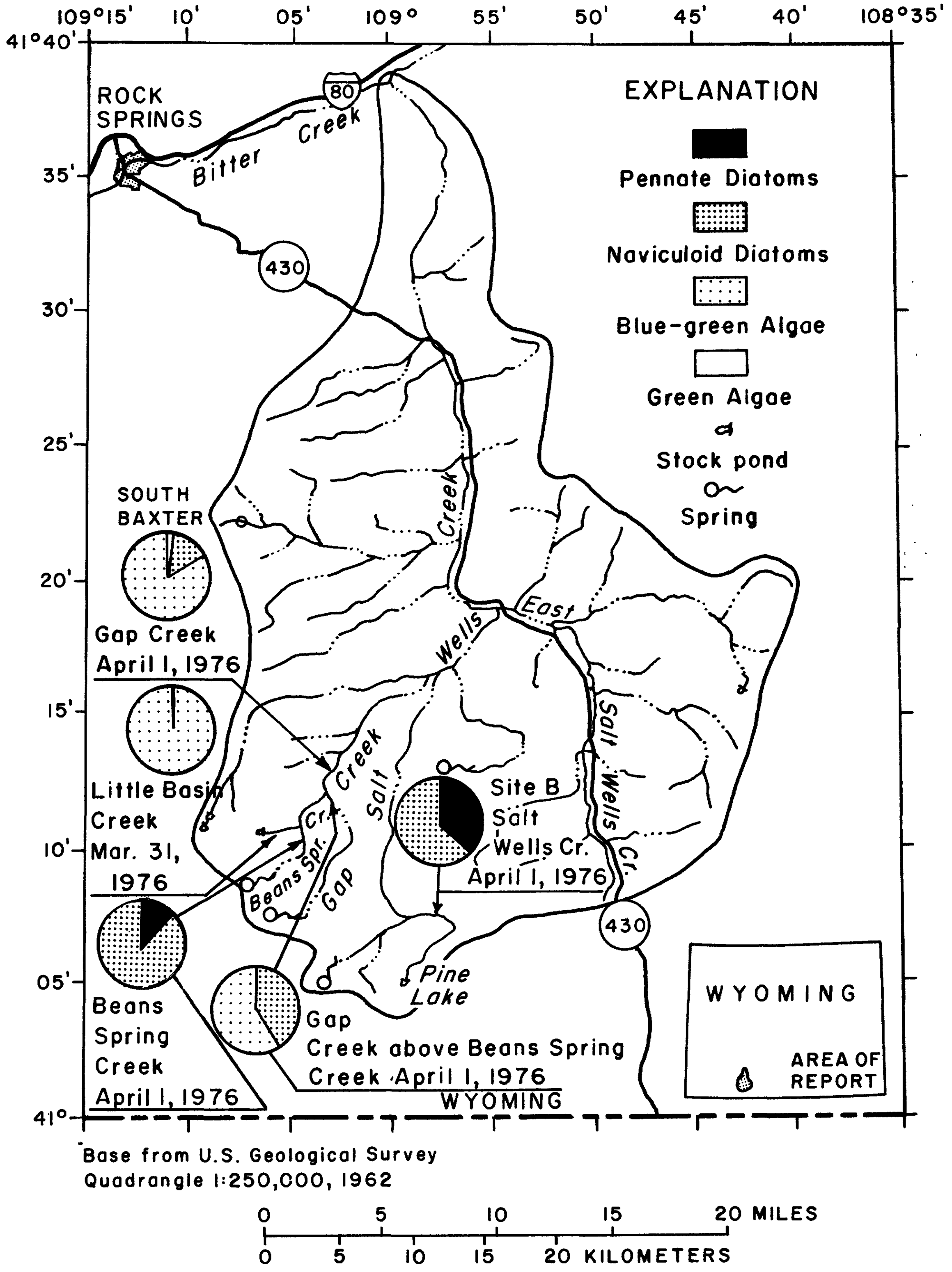


Figure 22.--Percentage population for phytoplankton on upper reach of Salt Wells Creek drainage during spring runoff, 1976.

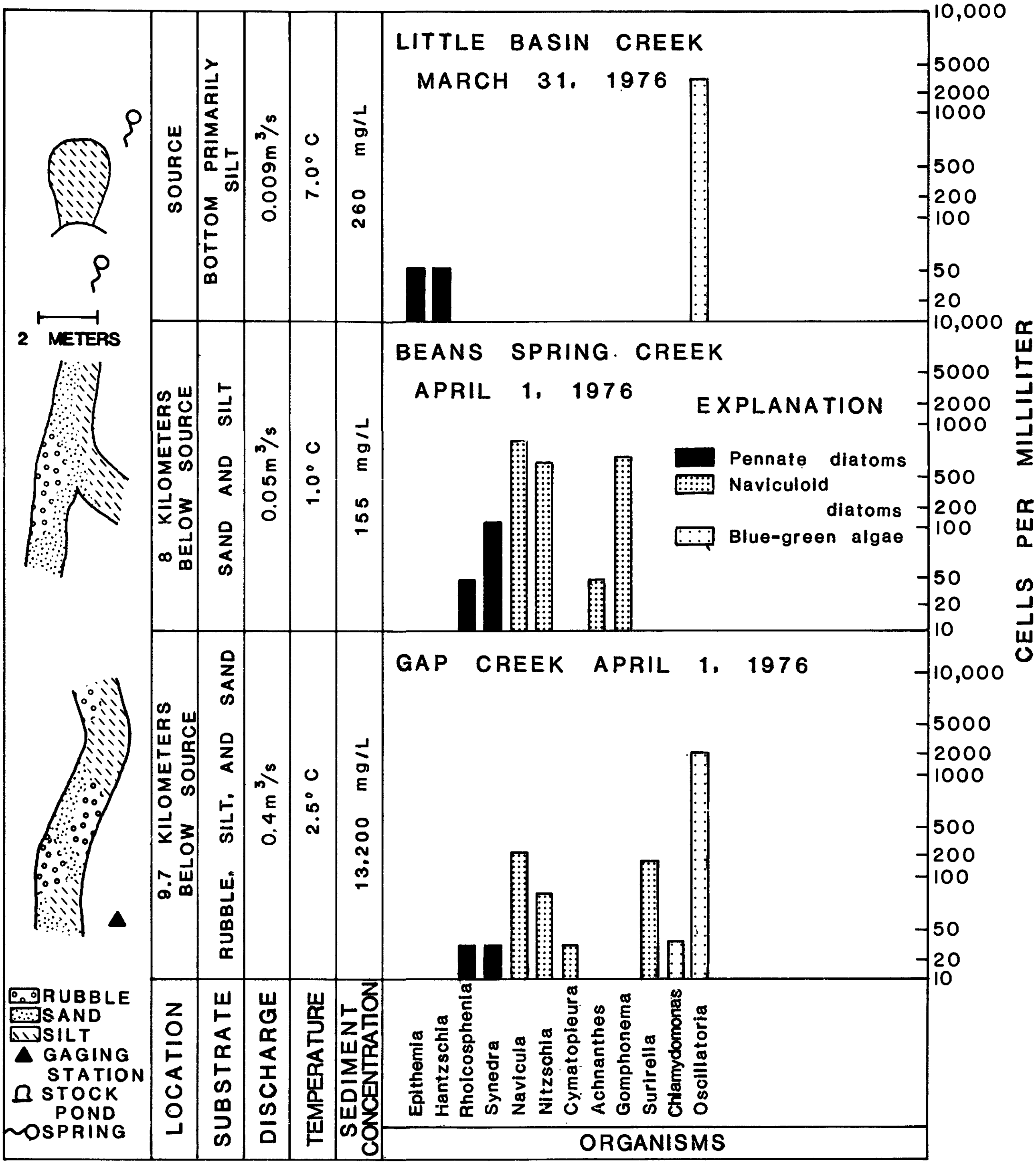


Figure 23.--Habitat characteristics and spring population for phytoplankton in Salt Wells Creek drainage, 1976. (Modified from Noel, 1954).

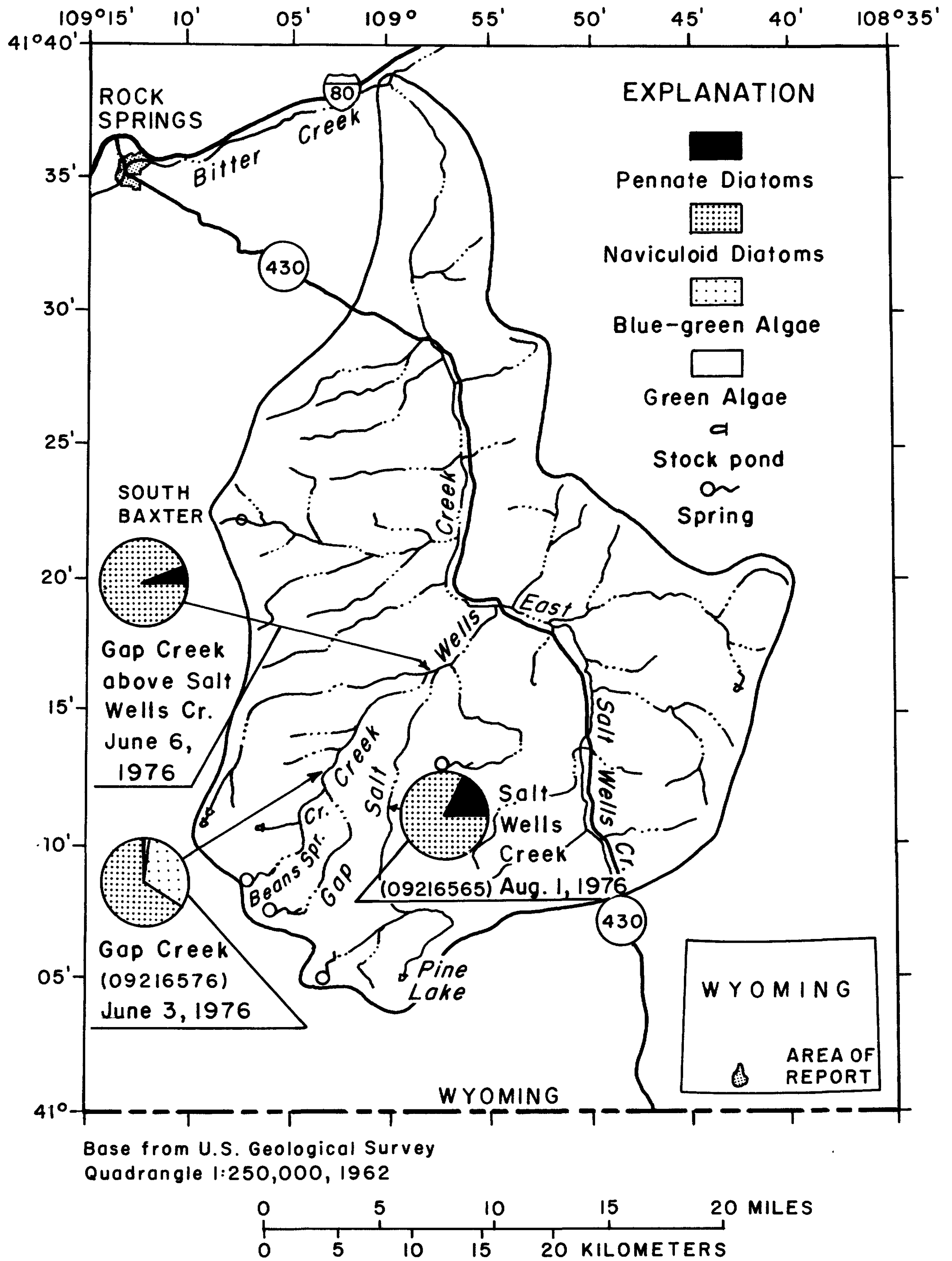


Figure 24.--Percentage population for phytoplankton on upper reach of Salt Wells Creek drainage during summer streamflow, 1976.

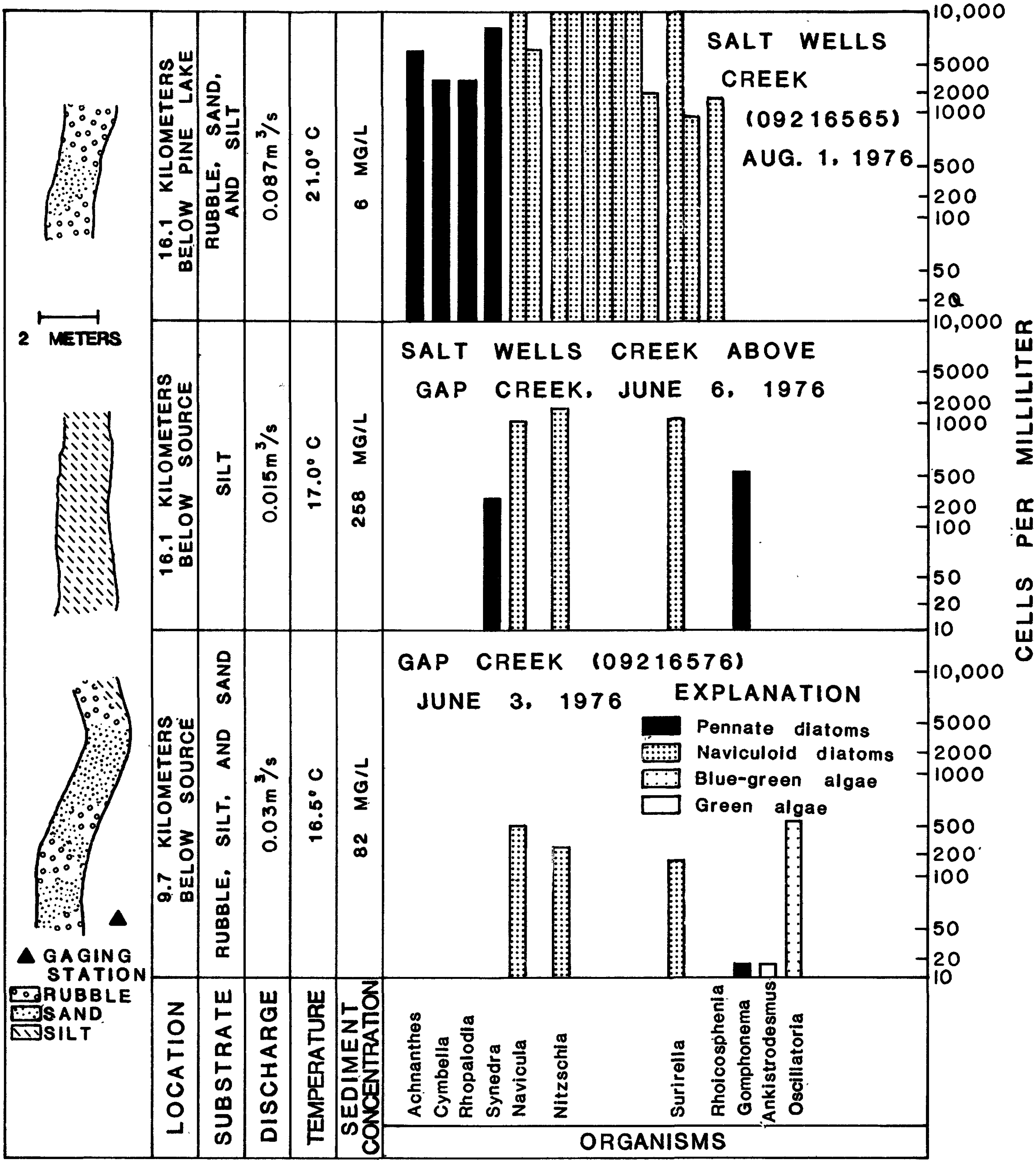


Figure 25.--Habitat characteristics and summer population for phytoplankton in Salt Wells Creek drainage, 1976. (Modified from Noel, 1954).

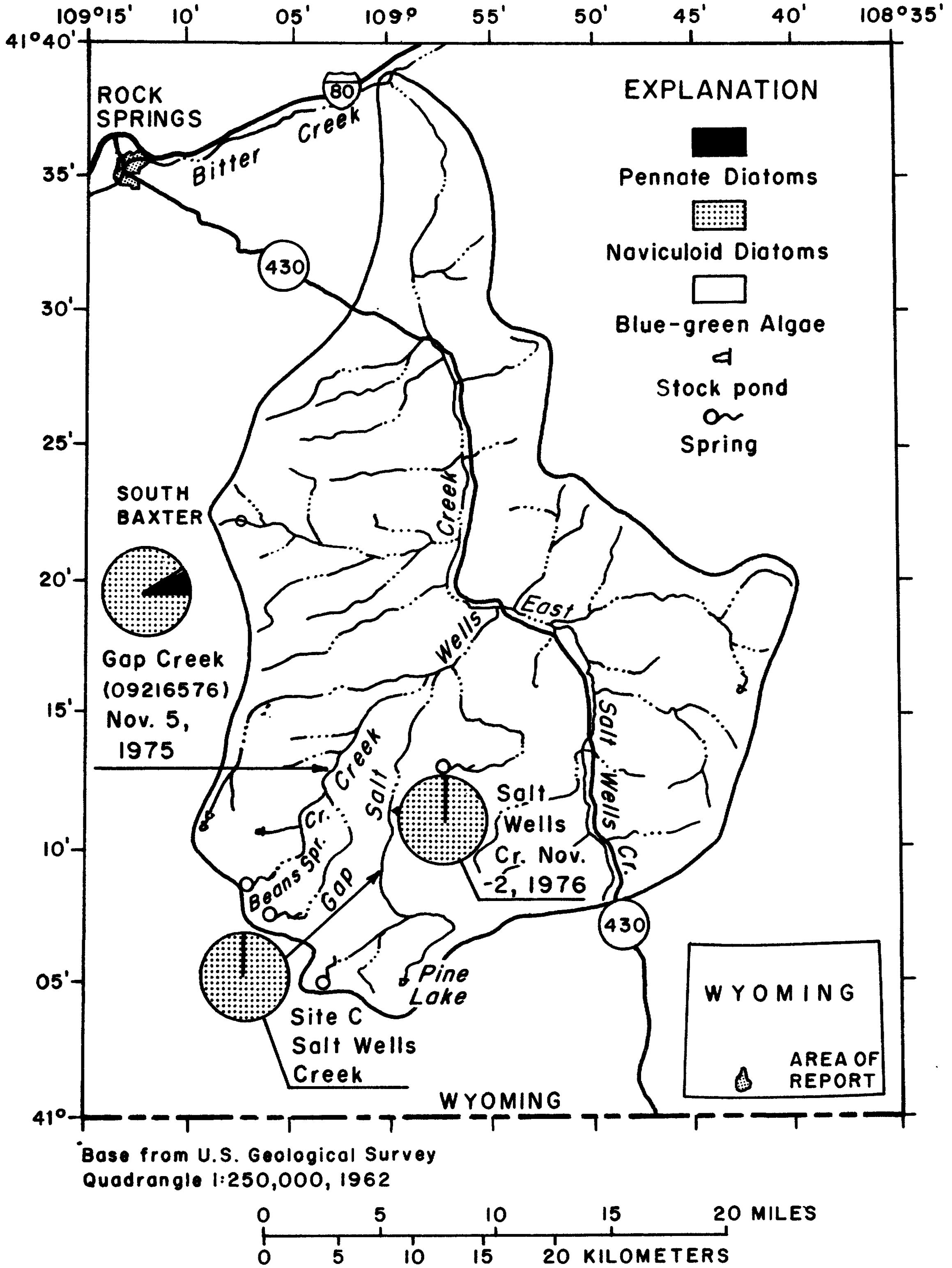


Figure 26.--Percentage population for phytoplankton on upper reach of Salt Wells Creek drainage during fall streamflow, 1976.

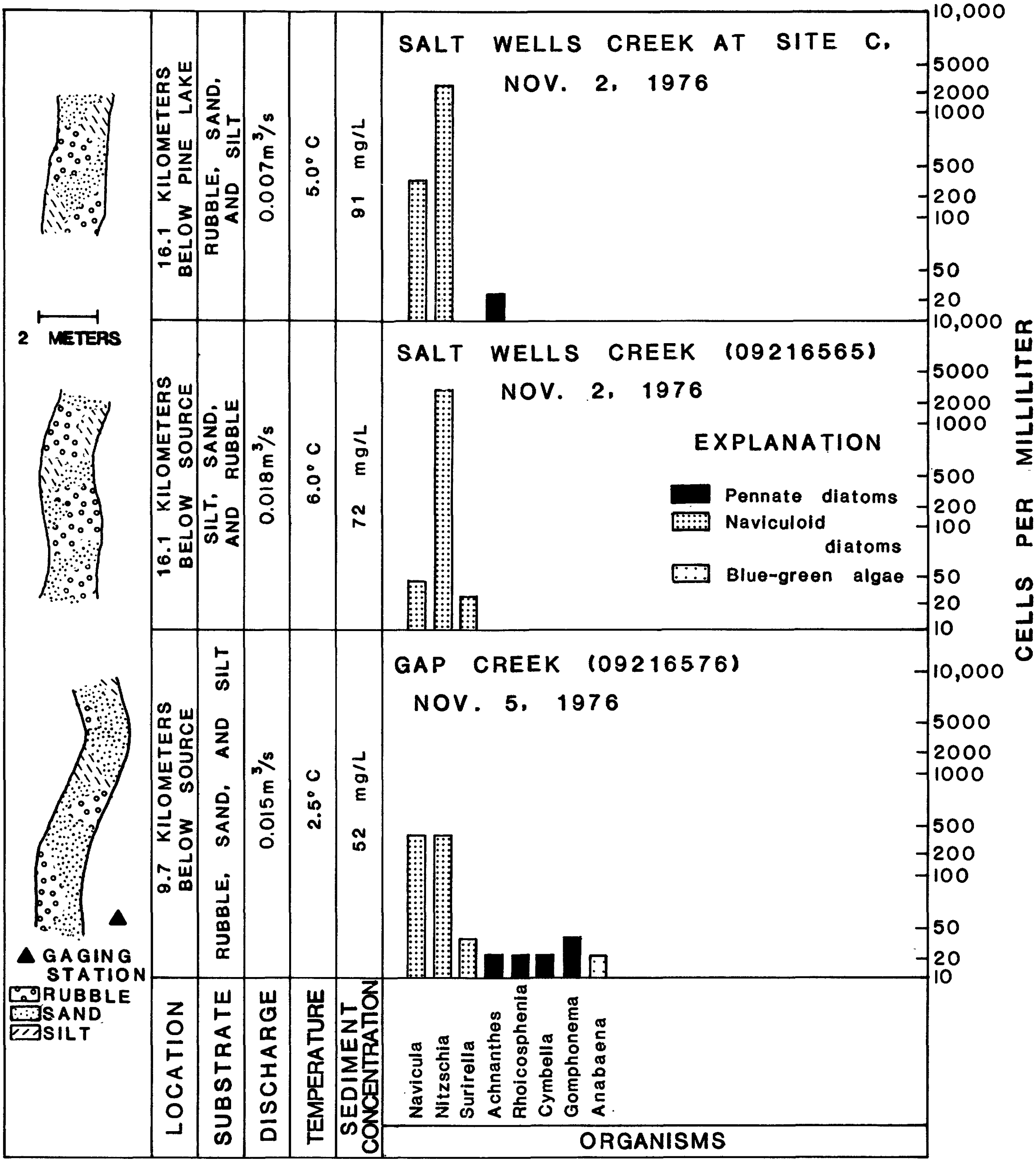


Figure 27.--Habitat characteristics and fall population for phytoplankton in Salt Wells Creek drainage, 1976. (Modified from Noel, 1954).

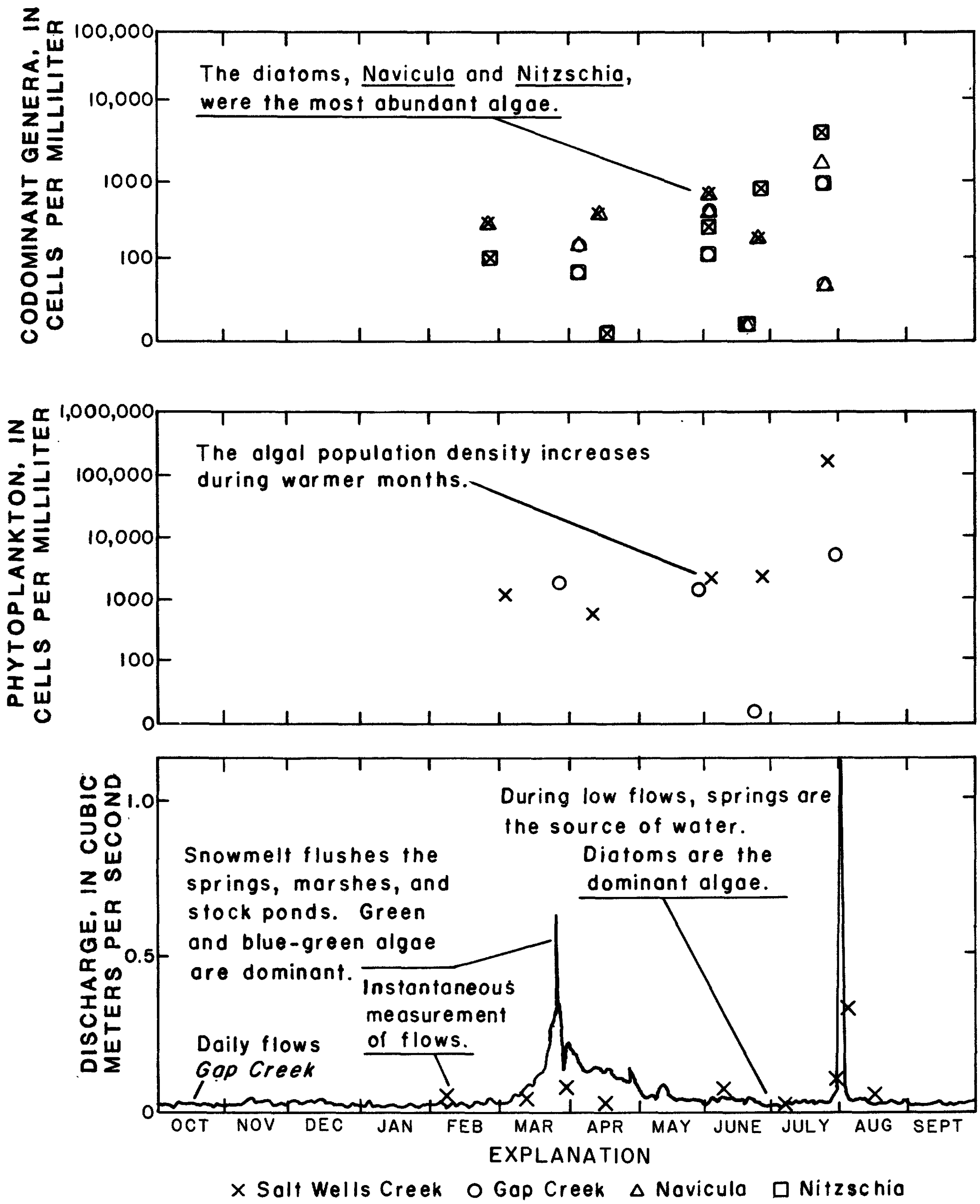


Figure 28.--Seasonal variation of phytoplankton, discharge, and codominant genera at stations 09216576, Gap Creek, and 09216565, Salt Wells Creek (1976 water year).

Lowe (1974, p. 4) lists the tolerance levels for the codominant genera, Nitzschia and Navicula. Both genera are present because of their cosmopolitan distribution and extremely wide environmental tolerance range (figs. 29 and 30).

The Jaccard Coefficient of Association and Cluster Analysis (Southwood, 1966, p. 342-344) for phytoplankton at Salt Wells Creek and Gap Creek are shown in figures 31 and 32. The dendrograms show that phytoplanktonic taxa are more similar during various seasons of the growing year. In Salt Wells Creek, the dendrogram shows a similarity between the June and August samples, D, C, and E. In Gap Creek, the dendrogram shows a similarity between the August samples A, C, and E and between samples B and D. In both streams, the summer samples form a cluster which shows that they share many taxa in common. The dendrograms for both streams show three different phytoplankton assemblages. These algal assemblages occur in a seasonal succession of community development.

The seasonal variation of the diversity index for phytoplankton is shown in figure 33. The diversity indices range was from 0.9, a low value, to 3.3. The low diversity sample was taken during the spring when high streamflows occurred. The high diversity sample was taken during the summer when low streamflows occurred. Physical characteristics that affect phytoplankton in plains streams are shown in table 10.

The seasonal variation of periphyton was compared by using a bar graph (fig. 34). This method expresses the season and rate of growth by comparing the number of occurrences between the families and orders. In addition, dendrograms were used to show the similarity among samples and the seasonal algal successions between stations 09216576 and 09216565 (figs. 35 and 36). The periphyton samples tend to be more similar during spring, summer, and fall. During the spring, the periphyton community is disturbed or destroyed by high streamflows. When the water subsides in late spring, a new periphyton community begins to reestablish. During late summer and early fall, the periphyton tend to attain maximum development and composition.

Three sites were sampled for benthic invertebrates. Lists of benthic invertebrates at stations 09216565, 09216572, and 09216576 are shown in figures 37-39. Physical characteristics that affect benthic invertebrates in plains streams are shown in table 11.

Biochemical Aspects

The ecosystem ecology of aquatic communities in Salt Wells Creek and Gap Creek is described by the development of the trophic levels, the food chain, the pyramid of numbers, the conceptual model, the ranges of chemical properties, and the flow diagram.

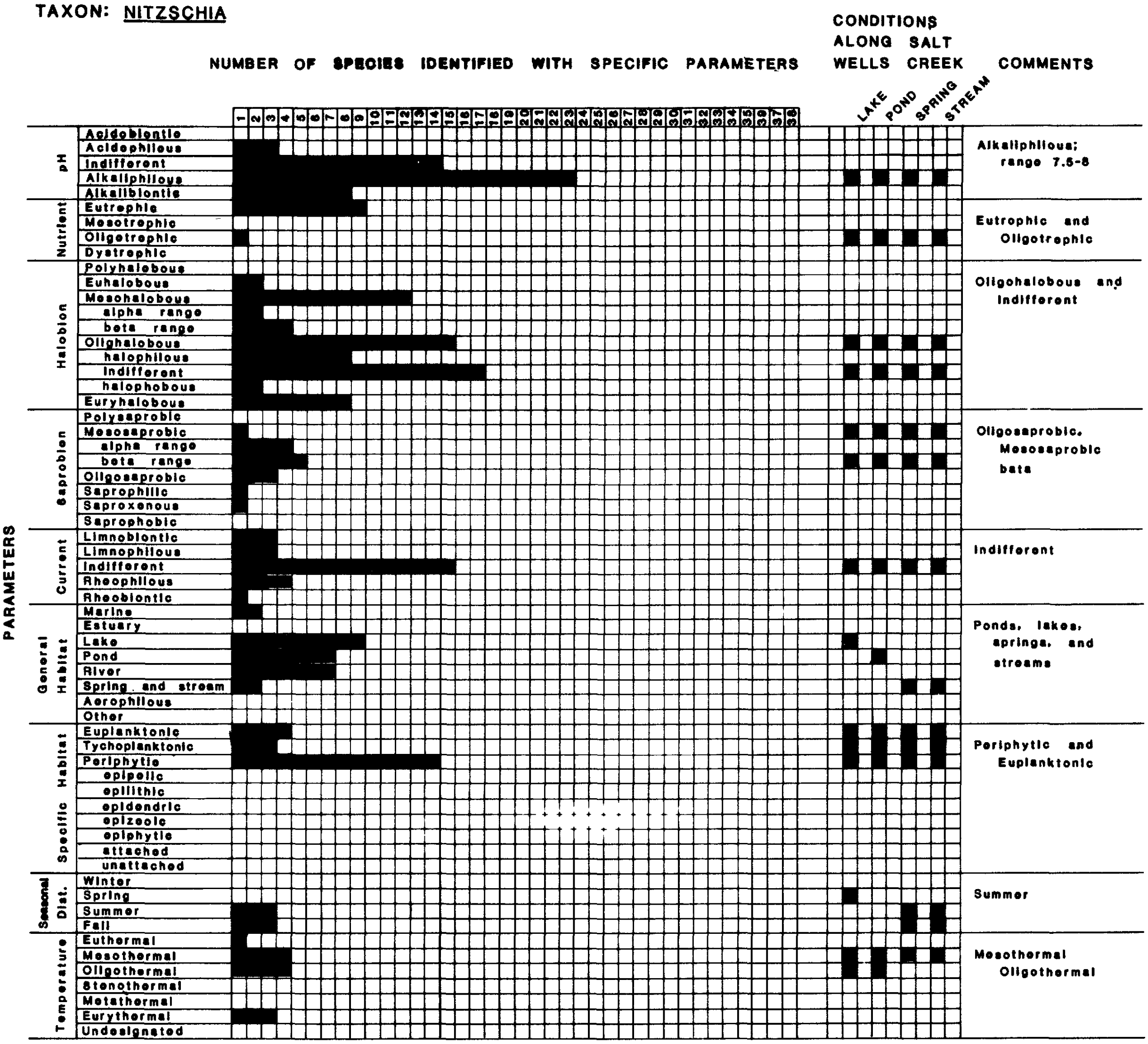


Figure 29.--Tolerance range of select parameters for genus Nitzschia. This is an ecological profile sheet which considered various species parameters for the genus Nitzschia (from Lowe, 1974).

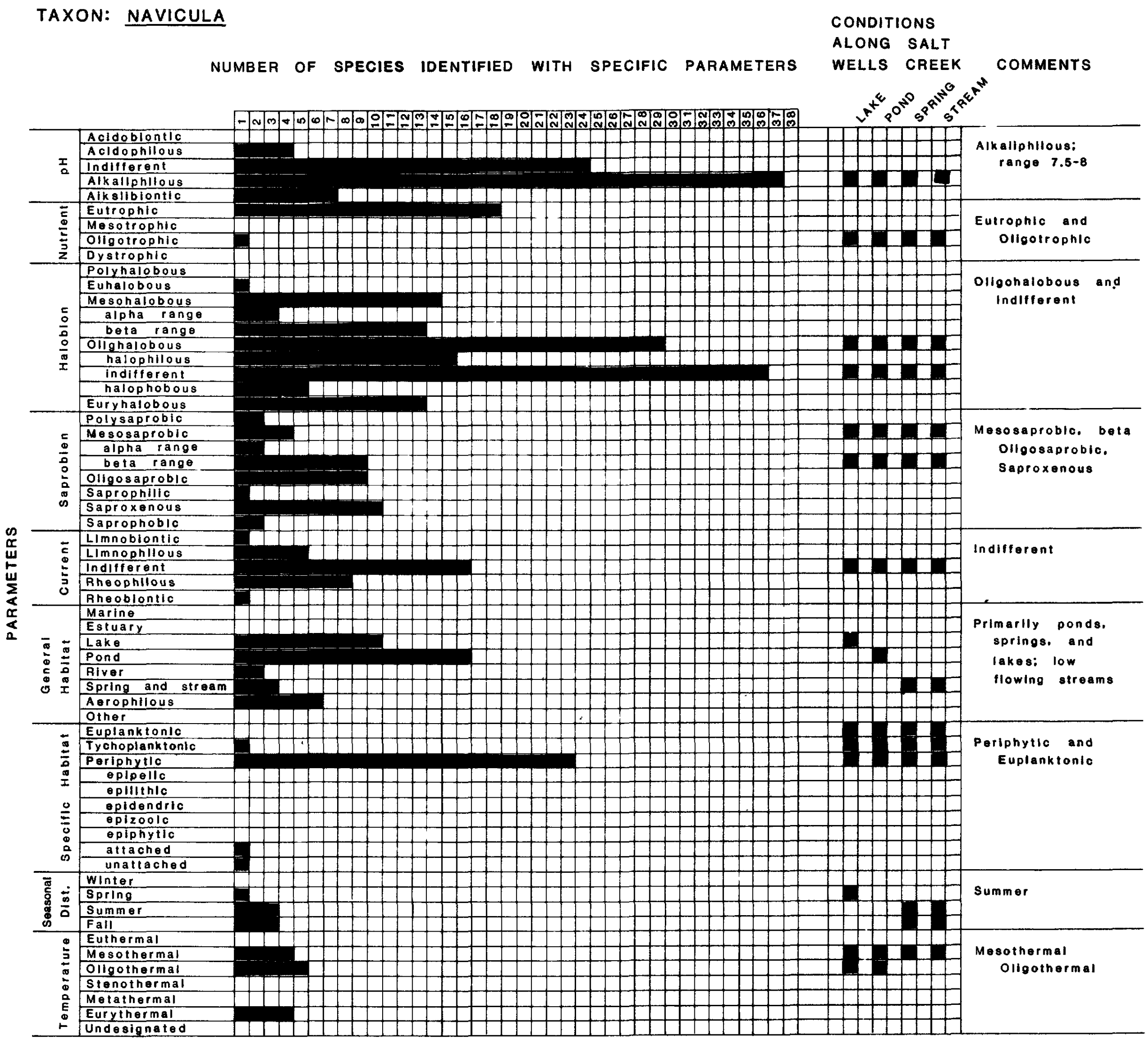


Figure 30.--Tolerance range of select parameters for genus Navicula. This is an ecological profile sheet which considered various species parameters for the genus Navicula (from Lowe, 1974).

GENUS	A March 9, 1976	B April 2, 1976	C June 3, 1976	D June 25, 1976	E Aug. 1, 1976	F Nov. 2, 1976	G
Ankistrodesmus	X	O	O	O	O	O	
Achnanthes	X	O	X	X	X	O	
Cymbella	X	O	O	O	X	O	
Epithemia	X	O	O	X	O	O	
Synedra	X	O	X	O	X	X	
Gomphonema	X	X	X	X	X	O	
Amphipleura	X	O	O	O	O	O	
Gyrosigma	X	O	X	O	O	O	
Navicula	X	X	X	X	X	X	
Pinnularia	X	O	O	O	O	O	
Nitzschia	X	O	X	X	X	X	
Surirella	X	O	X	X	X	X	
Rhoicosphenia	X	O	X	X	X	X	
Rhopalodia	O	O	O	O	X	O	
	13	2	8	9	4	7	

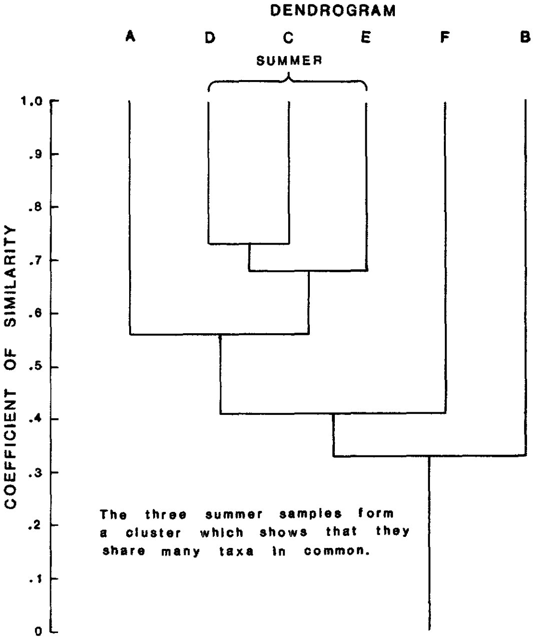
PAIRS

AB =	2/13 =	.15 =	.2	BF =	2/7 =	.29 =	.3
AC =	3/13 =	.62 =	.6	CD =	7/10 =	.70 =	.7
AD =	8/14 =	.57 =	.6	CE =	4/S =	.50 =	.5
AE =	4/13 =	.31 =	.3	CF =	6/9 =	.67 =	.7
AF =	7/13 =	.54 =	.5	DE =	4/9 =	.44 =	.4
BC =	2/8 =	.25 =	.3	DF =	6/10 =	.60 =	.6
BD =	2/9 =	.22 =	.2	EF =	3/8 =	.38 =	.4
BE =	1/5 =	.20 =	.2				

EXPLANATION

X
Organism present in sample

O
Organism ebsent from sample



FORMULA (Southwood, 1966, p. 342):

Sj = j / a + b - j

Sj = Similarity index

j = Number species, common both stations

a = Number species in one station

b = Number species in other station

MATRIX

	A	B	C	D	E	F
A	X	.2	.6	.5	.6	.3
B	X	X	.3	.S	.2	.2
C	X	X	X	.7	.7	.5
D	X	X	X	X	.4	.6
E	X	X	X	X	X	.6
F	X	X	X	X	X	X

Figure 31.--Similarity among samples for phytoplankton at station 09216565, Salt Wells Creek, 1976.

GENUS	A Aug 4. 1975	B Aug. 27. 1975	C Nov. 5. 1975	D April 1. 1976	E June 3. 1976	F June 26. 1976	G Aug. 1. 1976
Ankistrodesmus	X	O	O	O	X	O	O
Achnanthes	X	X	X	O	O	O	O
Cocconeis	X	X	O	O	O	O	O
Cymbella	X	X	X	O	O	O	O
Epithemia	X	X	O	O	O	O	O
Synedra	X	O	O	X	O	X	X
Gomphonema	X	O	X	O	X	X	X
Caloneis	X	O	O	O	X	O	O
Gyrosigma	X	O	O	O	O	O	X
Navicula	X	X	X	X	X	X	X
Nitzschia	X	X	X	X	X	X	X
Surirella		O	X	O	X	X	O
Pinnularia	O	X	O	O	O	O	X
Lyngbya	O	X	O	O	O	O	O
Rhoicosphenia	O	O	X	X	X	X	O
Anabaena	O	O	X	O	O	O	X
Chlamydomonas	(	O	O	X	O	O	O
Cymatopleura	O	O	O	X	O	O	O
Oscillatreoria	O	O	O	X	X	O	O
	12	8	8	7	8	6	7

PAIRS

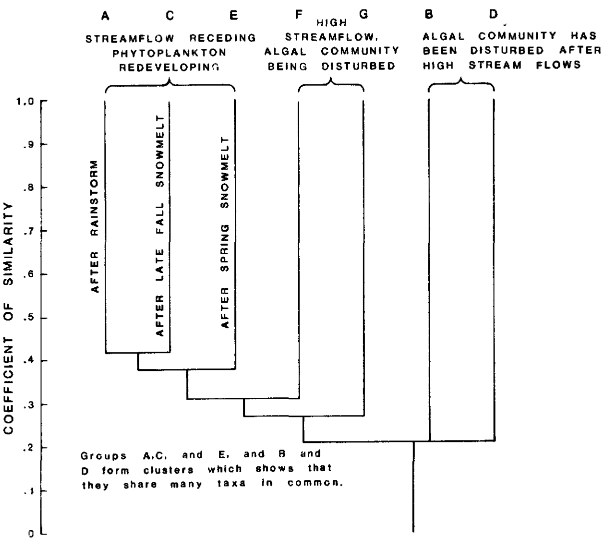
AB= 6/14= .43	BD= 2/14= .14	CG= 4/14= .29
AC= 6/14= .43	BE= 2/14= .14	DE= 4/14= .29
AD= 3/14= .21	BF= 2/14= .14	DF= 4/14= .29
AE= 6/14= .43	BG= 3/14= .21	DG= 3/14= .21
AF= 6/14= .36	CD= 3/14= .21	EF= 5/14= .36
AG= 5/14= .36	CE= 5/14= .36	EG= 3/14= .21
BC= 4/14= .29	CF= 3/14= .36	FG= 4/14= .29

EXPLANATION

X
Organism present in sample

O
Organism absent from sample

DENDROGRAM



FORMULA (Southwood, 1966, p. 342):

$S_j = j / a + b - j$

S_j = Similarity index

j = Number species, common both stations

a = Number species in one station

b = Number species in other station

MATRIX

	A	B	C	D	E	F	G
A	X	.43	.43	.21	.43	.36	.36
B	X	X	.29	.14	.14	.14	.21
C	X	X	X	.21	.36	.36	.29
D	X	X	X	X	.29	.29	.21
E	X	X	X	X	X	.36	.21
F	X	X	X	X	X	X	.29
G	X	X	X	X	X	X	X

Figure 32.--Similarity among samples for phytoplankton at station 09216576, Gap Creek, 1975-76.

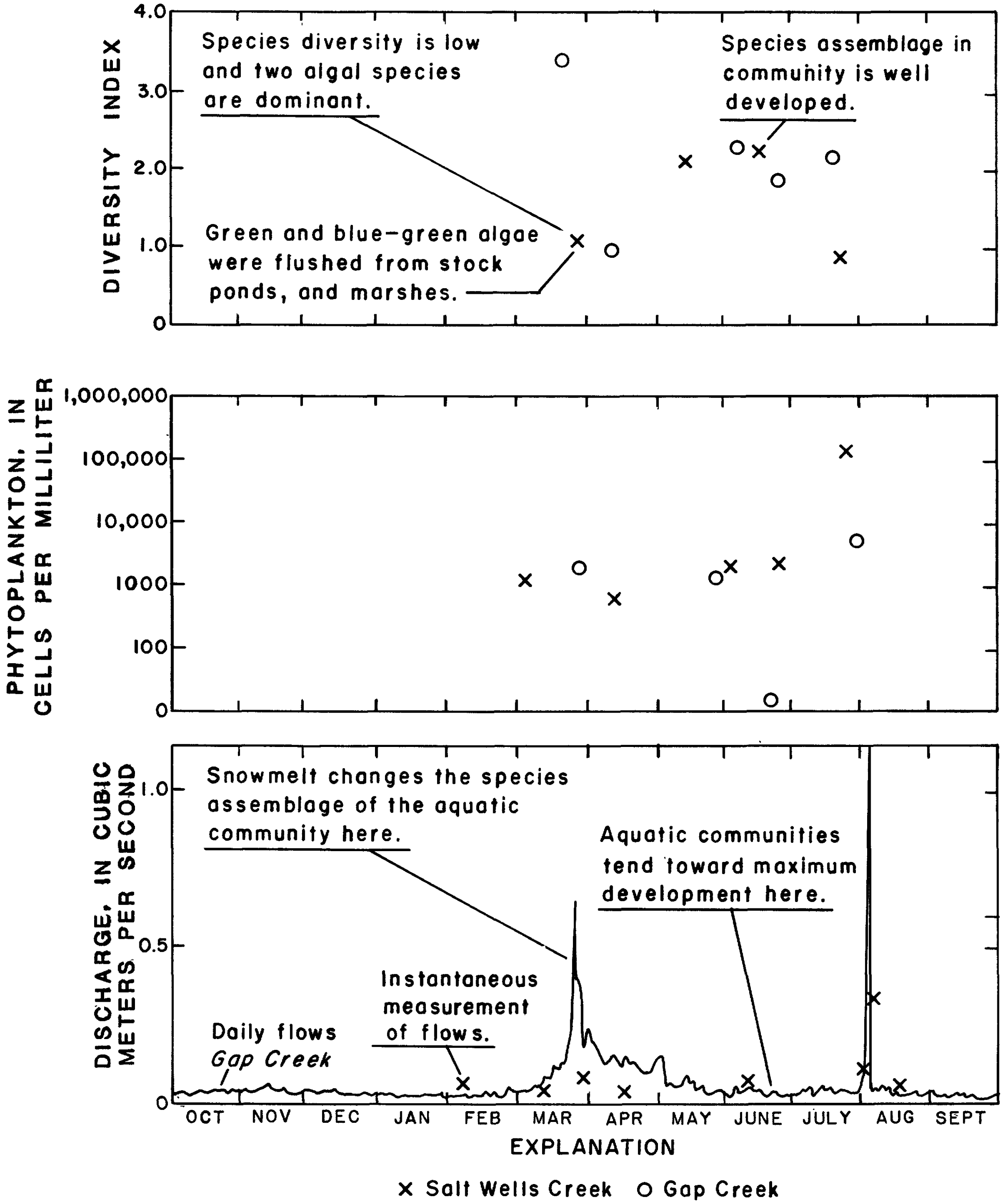


Figure 33.--Discharge, seasonal variation, and diversity indices of phytoplankton at stations 09216576, Gap Creek, and 09216565, Salt Wells Creek (1976 water year).

Table 10.--Physical characteristics that affect phytoplankton in plains streams

Time of year	Algal source		Seasonal periodicity[1]	Indicator assemblage		Growth pattern
	stock ponds	springs		stock ponds (Green and blue-green algae and the diatom, Gomphonema)	springs (Diatoms, Navicula, Nitzschia, and Surirella)	
Spring	X	---	High flow, green and blue-green algae dominant	X	---	Low
Summer	---	X	Low flow, diatoms dominant	---	X	Optimum
Fall	---	X	Medium flow, diatoms dominant	---	X	Medium

[1] Beans Spring Creek, Salt Wells Creek, and Gap Creek have high streamflows at different time periods. All three creeks exhibit the same seasonal periodicity.

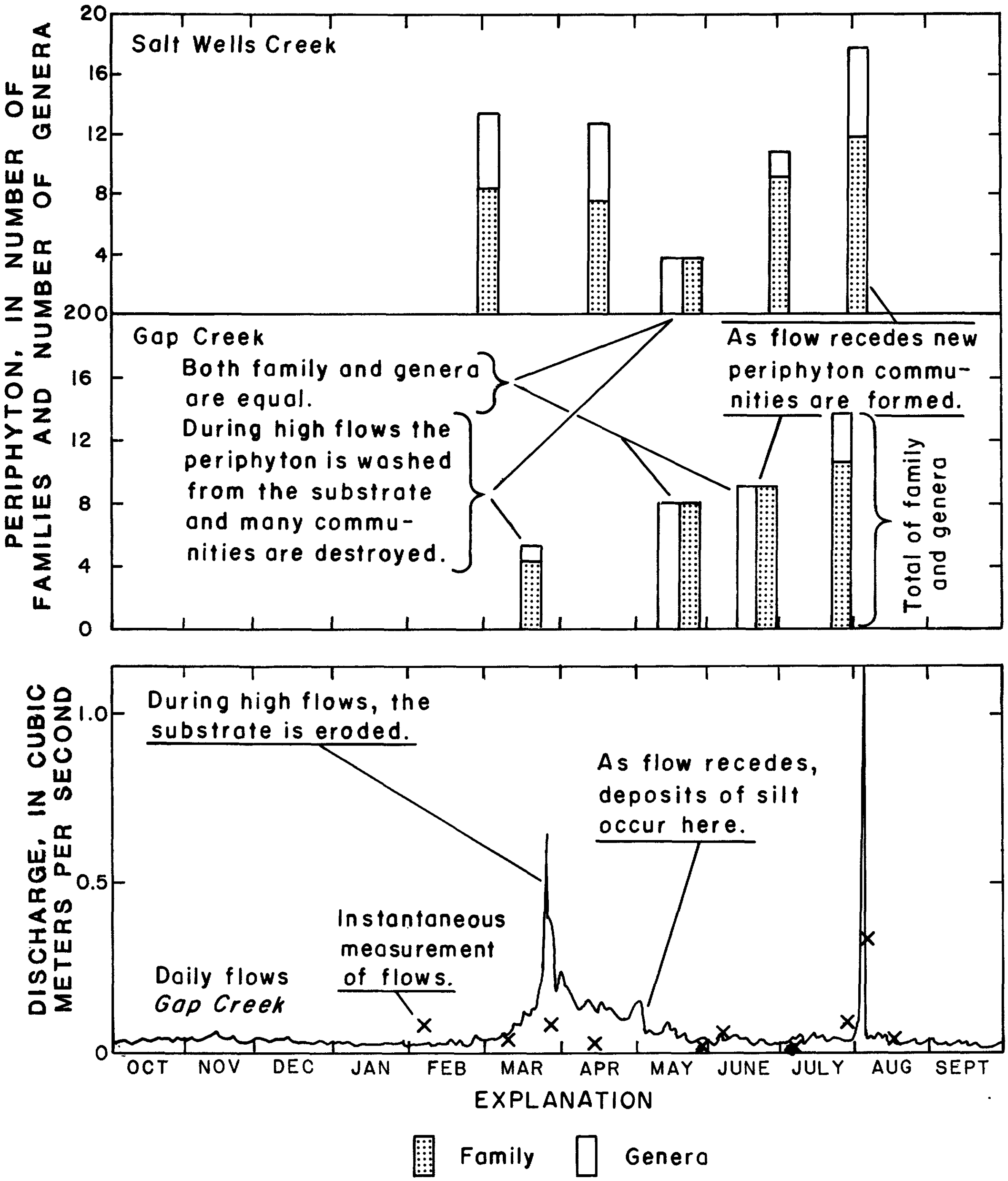
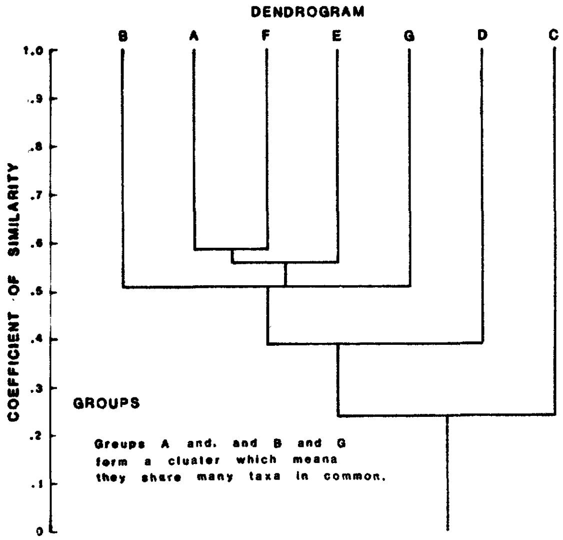


Figure 34.--Seasonal variation of periphyton expressed in number of families and number of genera, and discharge for stations 09216576, Gap Creek, and 09216565, Salt Wells Creek (1976 water year).

GENUS	A March 9. 1976	B April 23. 1976	C June 3. 1976	D June 25. 1976	E Aug. 1. 1976	F Nov. 2. 1976	G Dec. 15. 1976
Achnanthes	X	O	O	O	O	X	O
Cocconeis	X	O	O	O	O	O	O
Cymbella	X	X	O	X	X	X	X
Epithemia	X	X	O	O	X	X	X
Synedra	X	O	X	X	O	X	X
Gomphonema	X	X	O	X	X	X	X
Gyrosigma	X	X	X	O	X	X	X
Navicula	X	X	O	X	X	X	X
Pinnularia	X	X	X	O	X	X	O
Nitzschia	X	X	O	X	X	X	X
Surirella	X	X	O	X	O	X	X
Oscillatoria	X	X	O	X	O	O	O
Cladophora	O	X	O	O	X	O	O
Rhopalodia	O	X	O	O	X	X	X
Caloneis	O	X	O	O	X	X	O
Lyngbya	O	O	X	X	X	X	X
Oedogonium	O	O	O	X	X	X	O
Stigeoclonium	O	O	O	X	X	X	O
Rhoicosphenia	O	O	O	O	X	O	X
Anabaena	O	O	O	O	X	O	X
Calothrix	O	O	O	O	X	O	X
Spirogyra	O	O	O	O	O	X	O
Anomoeoneis	O	O	O	O	O	X	O
Cylindrotheca	O	O	O	O	O	X	X
Tribonema	O	O	O	O	O	X	O
Rhizoclonium	O	O	O	O	O	X	X
	12	12	4	10	16	20	15



PAIRS

AB= 9/15= .6	BD= 6/16= .38	CG= 4/15= .27
AC= 3/13= .23	BE= 16/13= .58	DE= 7/19= .37
AD= 7/15= .47	BF= 10/22= .45	DF= 9/21= .43
AE= 7/21= .33	BG= 8/19= .42	DG= 7/18= .39
AF= 10/22= .45	CD= 4/10= .40	EF= 13/23= .5
AG= 8/19= .42	CE= 4/16= .25	EG= 11/20= .6
BC= 3/13= .23	CF= 4/20= .20	FG= 12/23= .5

EXPLANATION

X
Organism present in sample

O
Organism absent from sample

FORMULA (Southwood, 1966, p. 342):

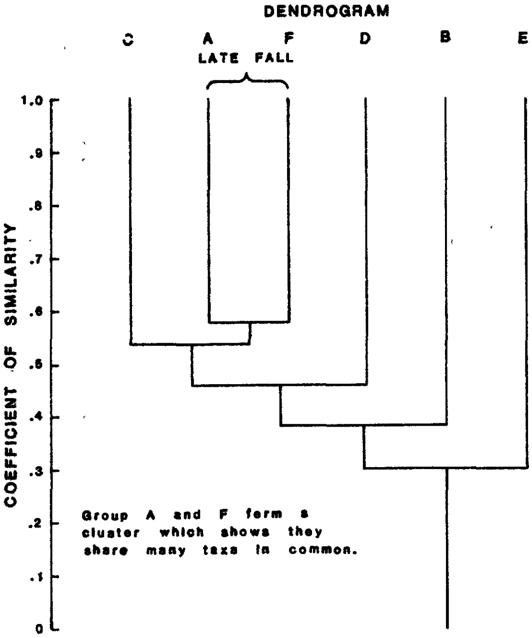
Sj = j / a + b - j
Sj = Similarity index
j = Number species, common both stations
a = Number species in one station
b = Number species in other station

MATRIX

	A	B	C	D	E	F	G
A	X	.60	.28	.47	.33	.45	.42
B	X	X	.23	.35	.56	.45	.42
C	X	X	X	.40	.25	.25	.27
D	X	X	X	X	.37	.43	.37
E	X	X	X	X	X	.51	.55
F	X	X	X	X	X	X	.52
G	X	X	X	X	X	X	X

Figure 35.--Similarity among samples for periphyton at station 09216565, Salt Wells Creek, 1976.

GENUS	A Nov. 5. 1975	B April 15. 1976	C June 3. 1976	D June 26. 1976	E Aug. 1. 1976	F Dec. 15. 1976	G
Cladophora	X	O	O	O	O	O	
Achnanthes	X	O	X	O	O	O	
Cocconeis	X	X	O	O	X	X	
Rhoicophenia	X	O	O	O	O	X	
Cybella	X	O	X	X	X	X	
Epithemia	X	O	O	O	X	X	
Synedra	X	O	O	X	X	X	
Gomphcnema	X	O	X	X	X	X	
Gyrosigma	X	X	O	O	X	O	
Navicula	X	X	X	X	X	X	
Nitzschia	X	O	X	X	X	X	
Surirella	X	O	X	X	O	X	
Tribonema	X	O	O	O	O	O	
Anabaena	X	X	O	O	O	X	
Lyngbya	X	O	X	X	O	O	
Oscillatoria	O	X	O	O	X	X	
Diatoma	O	O	X	O	O	O	
Oedogonium	O	O	O	X	X	O	
Stigeoclonium	O	O	O	X	X	O	
Rhopalodia	O	O	O	O	X	X	
Caloneis	O	O	O	O	X	O	
Calothrix	O	O	O	O	X	O	
	15	6	6	9	14	12	



PAIRS

AB= 5/16= .31	BE= 5/15= .33	EF= 9/17= .6S
AC= 7/16= .44	BF= 5/13= .S9	
AD= 7/17= .41	CD= 9/11= .55	
AE= 9/21= .36	CE= 4/18= .22	
AF= 10/17= .59	CF= 5/15= .33	
BC= 2/12= .17	DE= 7/1S= .44	
BD= 2/13= .15	DF= 2/15= .40	

EXPLANATION

X
Organism present in sample

O
Organism absent from sample

FORMULA (Southwood, 1966, p. 342):

Sj = j / a + b-j

Sj = Similarity index

j = Number species, common both stations

a = Number species in one station

b = Number species in other station

MATRIX

	A	B	C	D	E	F
A	X	.91	.44	.55	.36	.59
B	X	X	.17	.19	.33	.S6
C	X	X	X	.41	.22	.33
D	X	X	X	X	.44	.40
E	X	X	X	X	X	.63
F	X	X	X	X	X	X

Figure 36.--Dendrogram showing similarity among samples for periphyton at station 09216576, Gap Creek, 1975-76.

SCIENTIC NAME	COMMON NAME	Aug. 27, 1975	Nov. 5, 1975	June 6, 1976
CHIRONOMIDAE	MIDGES	X	X	
BASOMMATOPHORA	POND SNAILS	X	X	
HYDRACARINA	WATER MITES		X	
AMPHIPODA	SCUDS		X	
DYTISCIDAE	PREDACEOUS DIVING BEETLES		X	
ELMIDAE	RIFFLE BEETLES		X	X
HALIPLIDAE	CRAWLING WATER BEETLES		X	X
EPHEMEROPTERA	MAYFLIES		X	X
TRICHOPTERA	CADDIS FLIES		X	X
TIPULIDAE	CRANE FLIES			X
STRATIONMYHDAE	SOLDIER FLIES			X
HYDROPHILIDAE	WATER SCAVENGER BEETLES			X
		Very low flow, ponding effect, pool essentially main area of benthic growth	More similar order of internal community structure	
		D.I. = 0.95	D.I. = 2.19	Less community distriuction during high flow D.I. = 1.49

EXPLANATION

D.I.= Diversity index

Benthic invertebrates were sampled using the same quantitative method (Greeson and others, 1977, p. 157).

Figure 37.--Benthic invertebrates collected at station 09216565, Salt Wells Creek, 1975-76.

SCIENTIC NAME	COMMON NAME	April 20, 1976	June 3, 1976	Nov. 2, 1976	Dec. 15, 1976
HYDRACARINA	WATER MITES	X	X		
DRYOPIDAE	RIFFLE BEETLES	X		X	
ELMIDAE	RIFFLE BEETLES	X	X	X	
CHIRONOMIDAE	MIDGES	X		X	
TIPULIDAE	CRANEFLIES	X	X	X	
EPHEMEROPTERA	MAYFLIES	X	X		
GOMPHIDAE	DRAGONFLIES	X	X		
PLECOPTERA	STONEFLIES	X	X		
TRICHOPTERA	CADDISFLIES	X	X		X
GASTROPODA	SNAILS	X	X		
HYDROPHILIDAE	WATER SCAVENGER BEETLES		X		
GERRIDAE	WATER STRIDERS		X		
BASOMMATOPHORA	POND SNAILS		X		
		High flow did not disrupt benthic invertebrate community. Sample-site bed material consisted of cobblestones, sand, and embedded twigs.		Benthic community disrupted and destroyed during high intensity rainstorm Aug. 1-5, 1976. Growing season almost completed, redevelopment slow.	Winter drought, cold temperatures, rainstorm destruction in early Aug. 1976 have affected benthic population and community structure.
		Community structure is stable, and has high internal order of community structure.			
		D.I. = 1.91	D.I. = 2.53	D.I. = 1.67	D.I. = 0.00

EXPLANATION

D.I.= Diversity index

Benthic invertebrates were sampled using the same quantitative method (Greeson and others, 1977, p. 157).

Figure 38.--Benthic invertebrates collected at station 09216572, Beans Spring Creek, 1976.

SCIENTIC NAME	COMMON NAME	Aug. 27, 1975	Nov. 5, 1975	June 3, 1976
ELMIDAE	RIFFLE BEETLES	X	X	
CHIRONOMIDAE	MIDGES	X	X	
SIMULIIDAE	BLACK FLIES	X		
EPHEMEROPTERA	MAYFLIES	X	X	
PLECOPTERA	STONEFLIES	X	X	
TRICHOPTERA	CADDISFLIES	X	X	
OLIGOCHAETA	AQUATIC EARTHWORMS		X	X
HYDRACAINA	WATER MITES		X	
DRYOPIDAE	RIFFLE BEETLES		X	
HALIPIDAE	CRAWLING WATER BEETLES		X	
HYDROPHILIDAE	WATER SCAVENGER BEETLES		X	
CERATOPOGONIDAE	BITING MIDGES		X	
TABANIDAE	HORSEFLIES		X	
TIPULIDAE	CRANEFLIES		X	X
CORIXIDAE	WATER BOATMEN		X	
SIALIDAE	ALDERFLIES		X	
ODONATA	DRAGONFLIES		X	
NUCULOIDEA	FINGERNAIL CLAMS		X	
BASOMMATOPHORA	POND SNAILS		X	X
HURUDINEA	LEECHES			X
AMPHIPODA	SCUDS			X
GASTROPODA	SNAILS			X
		More similar internal order of community structure		New community restructuring after spring runoff D.I. = 0.49
		D.I. = 0.82	Highest community growth D.I. = 2.46	

EXPLANATION

D.I.= Diversity index

Benthic invertebrates were sampled using the same quantitative method (Greeson and others, 1977, p. 157).

Figure 39.--Benthic invertebrates collected at station 09216576, Gap Creek, 1975-76.

Table 11.--Physical characteristics that affect benthic invertebrates in plains streams

Time of year	Bank vegetation density (percent)	Bed-material composition	Discharge	Total organisms	Number of orders an families	Diversity index[1] [2]
		BEANS SPRING CREEK				
Spring	90	Cobblestone, gravel, silt, and sand	high	101	7	1.99
Summer[3]			low	85	2	.95
Fall			low	83	9	2.19
		GAP CREEK				
Spring	30	Sand, silt,	high	101	6	0.49
Summer			low	423	6	.82
Fall			low	259	18	2.42
		SALT WELLS CREEK				
Spring	20	Silt, sand, some gravel	high	343	10	1.91
Summer			low	45	11	2.53
Fall			low	28	4	1.67

1 Diversity index was calculated on a single square-foot sample for order and family identifications.
2 Benthic invertebrate were sampled by Suber square-foot sampler.
3 Snails were dominant during the summer sample.

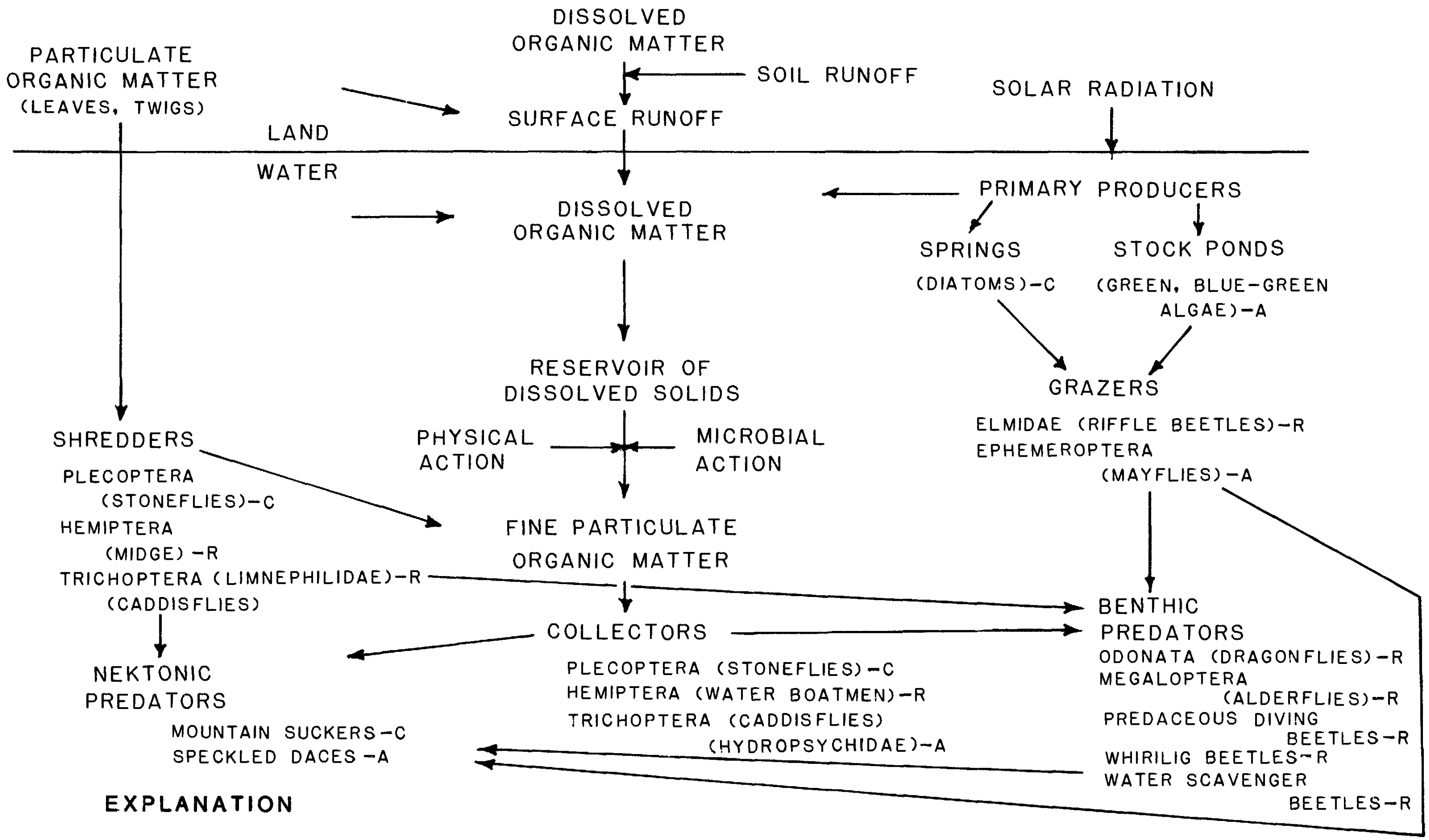
A food chain using the concept described by Odum (1971, p. 63) that consists of four nutritional (trophic) levels was developed for plains streams (fig. 40). In this food chain, algae (green plants) are primary producers and occupy the first trophic level. The benthic invertebrates, which occupy the second and third trophic levels, are plant and detritus eaters or predators. Plant and detritus eaters (grazers, collectors, and shredders) occupy the second trophic level. The benthic predators which feed upon the grazers, collectors, and shredders occupy the third level. The fish which eat the benthic predators occupy the fourth level.

A pyramid of numbers for Salt Wells Creek on April 20, 1976, was developed (fig. 41). A pyramid of numbers is a diagrammatic representation of the number of individuals present at each trophic level to support the population at the next higher level (Elton, 1946, p. 54-68). Because food is consumed and energy lost at each level, the number of individuals decreases at each successive level, causing the diagram to resemble a pyramid. The tertiary consumers, fish, are at the peak of the trophic pyramid. The number in the levels of the pyramid continuously change throughout the growing season.

A conceptual model of benthic invertebrates in Salt Wells Creek during low flows (in late summer and in the fall) was developed (fig. 42). The model shows three aquatic communities. Environment A is the fast water and riffle aquatic community. Environment B is the pondlike aquatic community. Environment C is the moderate flow aquatic community. Aquatic communities A and B are climax communities (Odum, 1971, p. 251). Aquatic community C is an ecotone (Reid and Wood, 1976, p. 291). Climax communities and ecotones develop by seasonal periodicity (Reid and Wood, 1976, p. 416-418). Often the number of organisms in an ecotone is greater than either of the climax communities. This population increase is called the edge effect (Reid and Wood, 1976, p. 291) and is illustrated in the conceptual model. The aquatic community of shallow water and slow flowing plains streams tends toward climax conditions during late summer.

Hart and Fuller (1974, p. 314) have reported the range of water chemistry for benthic invertebrates. Table 12 shows the observed range of water chemistry for benthic invertebrates in Salt Wells Creek and Gap Creek. The water chemistry is related to the benthic invertebrates on the conceptual model by use of tables 13, 14, and 15.

The values in the tables are the comparisons of the reported range of water chemistry (Hart and Fuller, 1974, p. 314-363) to the observed range of water chemistry in Salt Wells Creek and Gap Creek. The observed values for several organisms were significantly higher or lower than the reported values. These increased or decreased values have been underlined in the tables.



EXPLANATION

A Abundant
C Common
R Rare

Note: See Figure 41 for relative abundance of organism groups.

Figure 40.--Trophic relations in Salt Wells Creek and Gap Creek.

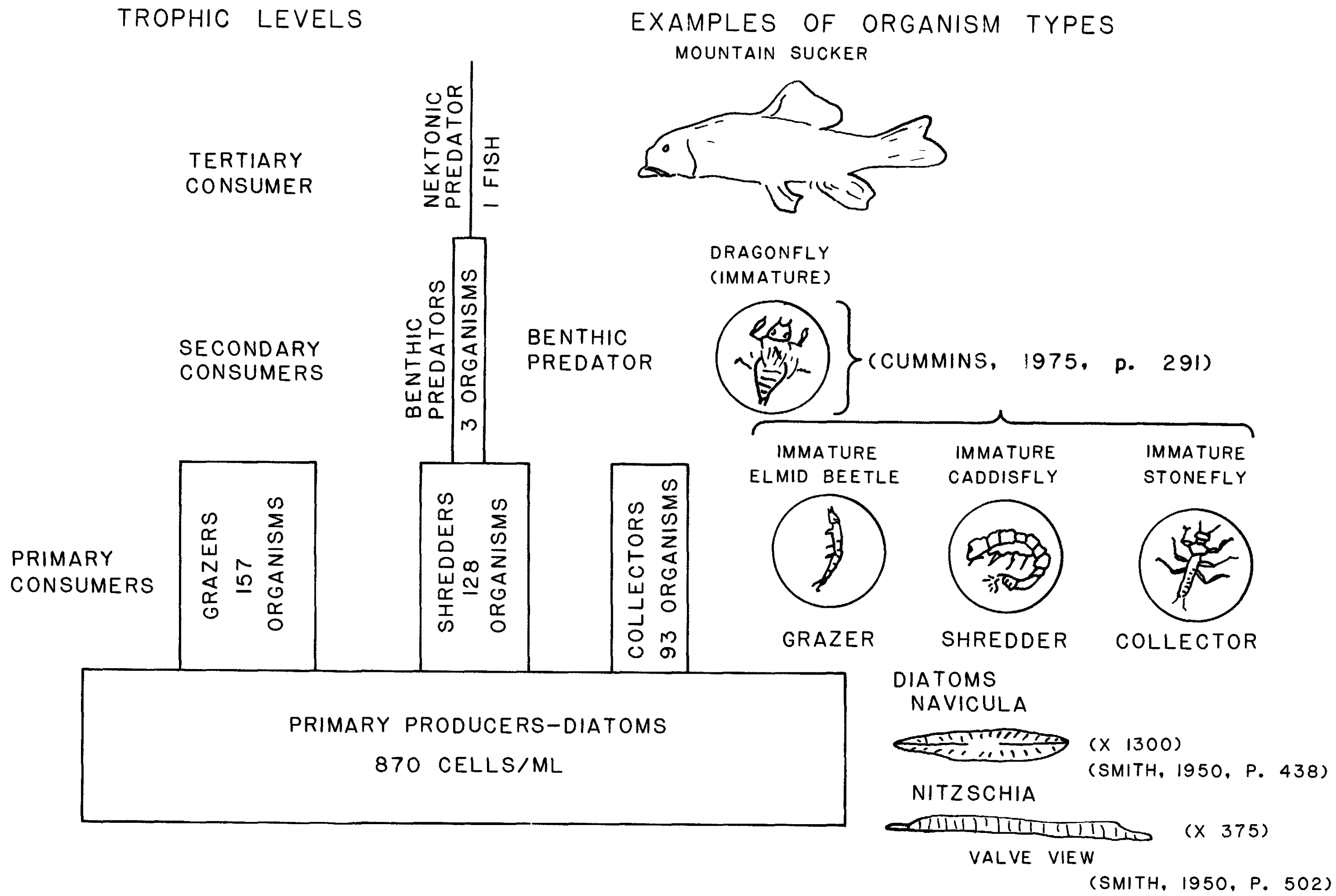


Figure 41.--Pyramid of community structure per number of organisms for Salt Wells Creek drainage, April 20, 1976.

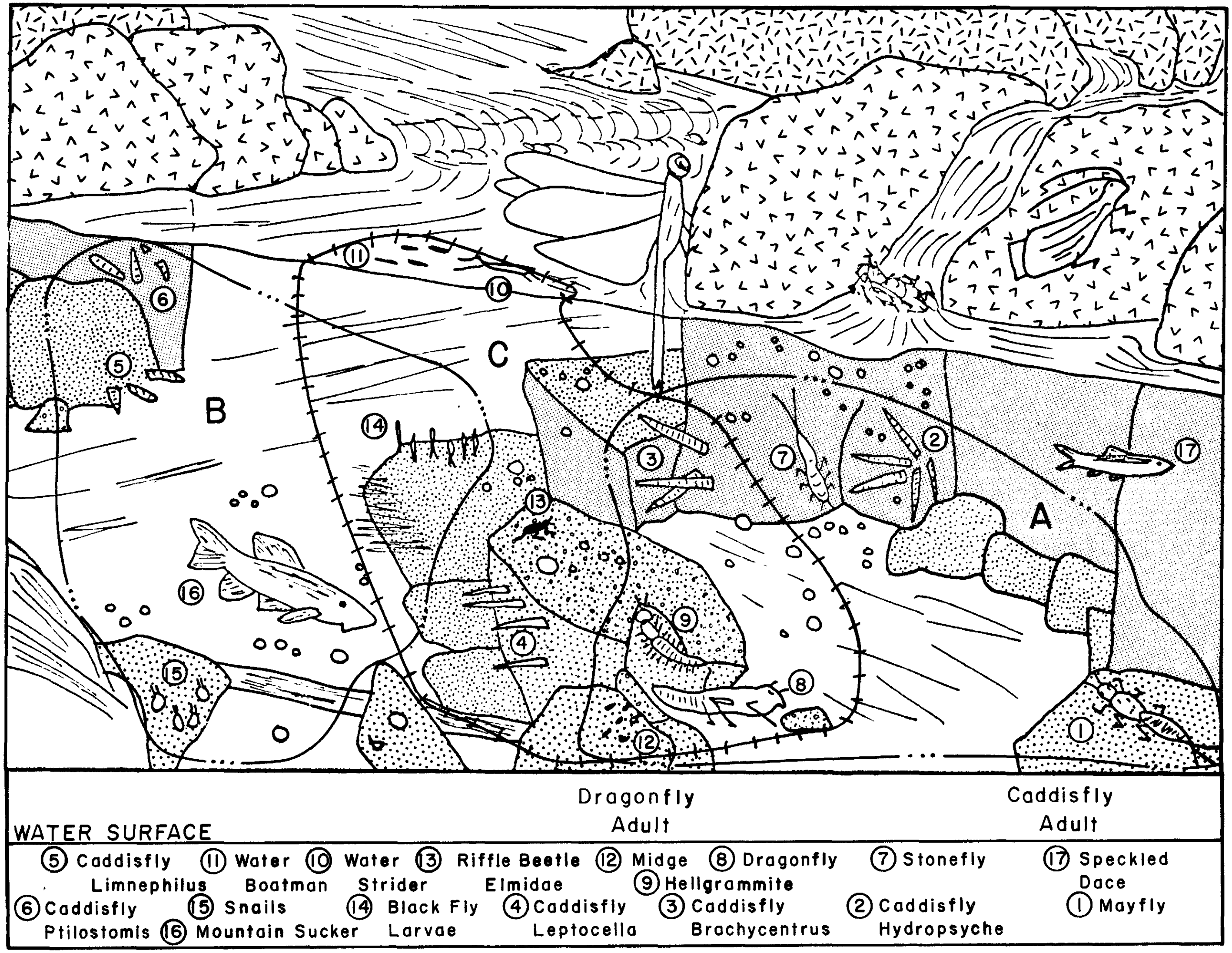


Figure 42.--Conceptual model of benthic invertebrate location within community structure for riffle (A), pondlike (B), and ecotone (C) communities in Salt Wells Creek.

Table 12.--Observed ranges of water chemistry in Salt Wells Creek during the study period

Location	Temperature (°C)	Turbidity (Jackson turbidity units)	Specific conductance (µmho/cm at 25°C)	Dissolved oxygen (mg/L)	pH (units)	Carbon dioxide (CO_2) (mg/L)	Bicarbonate (HCO_3) (mg/L)
Salt Wells Creek	0-27	2-3,000	800-1,430	6.3-11.3	7.9-8.7	1.0-1.4	225-359
Gap Creek	0-21	----	270-2,020	8.3-12.8	7.9-8.7	2.4-5.3	265-444

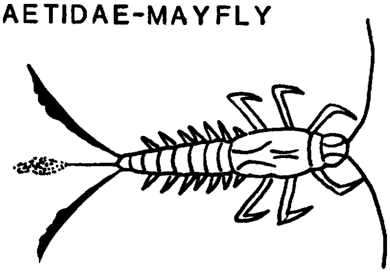
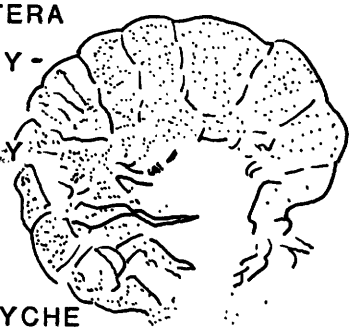
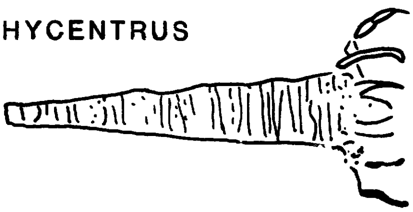
Location	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Tital iron (Fe) (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved solids (sum of constituents) (mg/L)
Salt Wells Creek	49- 92	52- 86	79-150	4.4-8.4	30-130	290-600	615-1,090
Gap Creek	80-120	32-120	16-110	3.9-9.0	0-260	120-610	382-1,210

Location	Total nitrogen (N) (mg/L)	Total organic nitrogen (N) (mg/L)	Total ammonia nitrogen (N) (mg/L)	Total Kjeldahl nitrogen (N) (mg/L)	Total nitrate + nitrate (N) (mg/L)	Dissolved orthophosphate (PO_4) (mg/L)	Total phosphorus (P) (mg/L)	Dissolved phosphorus (P) (mg/L)
Salt Wells Creek	2.0 -2.1	1.8 -2.0	0-0.03	1.8 -2.0	0.06-0.22	0 -0.09	0.48-1.5	0.01-0.03
Gap Creek	.24-1.8	.24-1.6	0- .9	.24-1.8	0 - .19	.03- .09	.10- .85	0 - .03

Table 13.--Physicochemical range of reported and observed data for determination of tolerance limits.

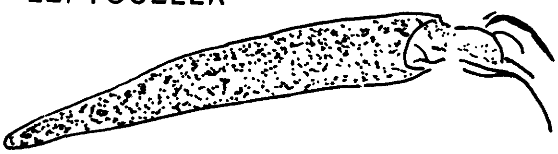
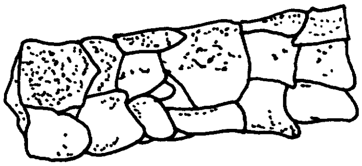
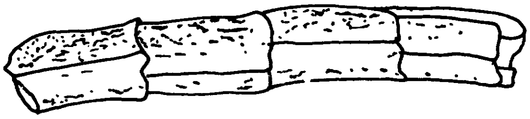
EXPLANATION

TEMP. - Temperature
D.O. - Dissolved oxygen
TURB. - Turbidity
JTU - Jackson turbidity unit
N/A - Not reported

	TEMP.		pH		D.O.		TURB.	
	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY
① EPHEMEROPTERA BAETIDAE-MAYFLY 	N/A	0° C - 27° C	5.6 - 8.8	7.9 - 8.7	3 - 11mg/L	6.3 - 11.3mg/L	12 - 140JTU	2 - 3,000JTU
② TRICHOPTERA HYDROPSY-CHIDAE-CADDISFLY HYDROPSYCHE 	N/A	0° C - 27° C	5.9 - 8.8	7.9 - 8.7	6 - 14mg/L	6.3 - 11.3mg/L	3 - >72,000JTU	2 - 3,000JTU
③ TRICHOPTERA BRACHYCENTRIDAE-CADDISFLY BRACHYCENTRUS 	N/A	0° C - 27° C	6.3 - 6.9	7.9 - 8.7	8 - 9mg/L	6.3 - 11.3mg/L	5 - 96JTU	2 - 3,000JTU

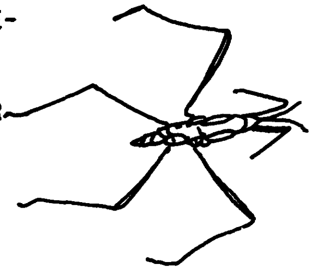
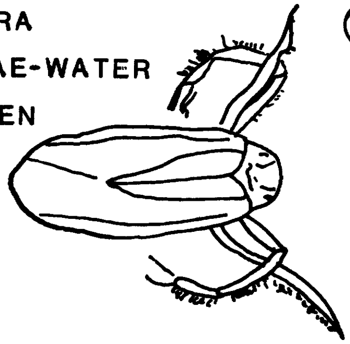
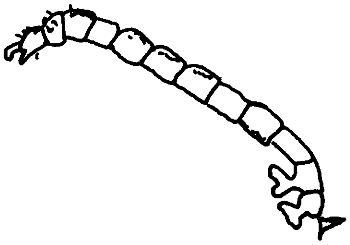
DATA UNDERLINED IS SIGNIFICANTLY HIGHER OR LOWER THAN REPORTED LITERATURE
(Sketches modified from Pennak, 1953)

Table 13.--(Continued)

EXPLANATION TEMP. - Temperature D.O. - Dissolved oxygen TURB. - Turbidity JTU - Jackson turbidity unit N/A - Not reported	TEMP.		pH		D.O.		TURB.	
	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY
(4) TRICHOPTERA LEPTOCERIDAE-CADDISFLY LEPTOCELLA 	N/A	0° C - 27° C	6.4 - 8.2	7.9 - 8.7	5 - 8 mg/L	6.3 - 11.3mg/L	3 - >72,000JTU	2 - 3,000JTU
(5) TRICHOPTERA LIMNEPHILIDAE-CADDISFLY LIMNEPHILUS 	N/A	0° C - 27° C	6.4 - 8.5	7.9 - 8.7	9 - 12 mg/L	6.3 - 11.3mg/L	12 - 20JTU	2 - 3,000JTU
(6) TRICHOPTERA PHRYGANEIDAE-CADDISFLY PTILOSTOMIS 	N/A	0° C - 27° C	3.3 - 7.4	7.9 - 8.7	8 - 10 mg/L	6.3 - 11.3mg/L	5 - 19JTU	2 - 3,000JTU

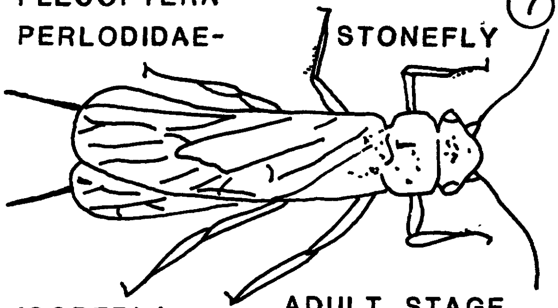
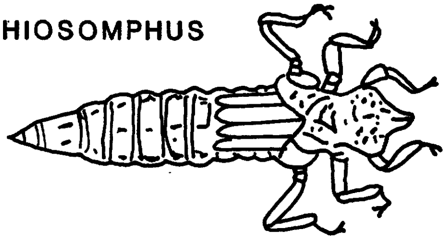
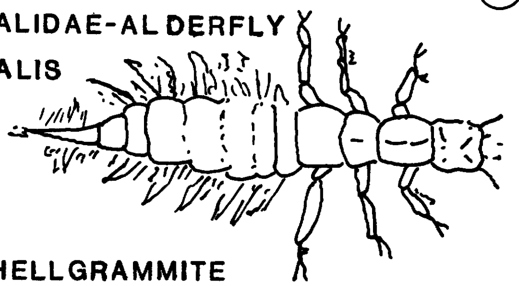
DATA UNDERLINED IS SIGNIFICANTLY HIGHER OR LOWER THAN REPORTED LITERATURE
(Sketches modified from Pennak, 1953)

Table 13.--(Continued)

EXPLANATION TEMP. - Temperature D.O. - Dissolved oxygen TURB. - Turbidity JTU - Jackson turbidity unit N/A - Not reported	TEMP.		pH		D.O.		TURB.	
	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY
(10) HEMIPTERA GERRIDAE-WATER STRIDER 	N/A	0° C - 27° C	5.5 - 8.5	7.9 - 8.7	4 - 12mg/L	6.3 - 11.3 mg/L	3 - 548JTU	2 - <u>3,000</u>JTU
(11) HEMIPTERA CORIXIDAE-WATER BOATMEN 	N/A	0° C - 27° C	3.3 - 8.7	7.9 - 8.7	5 - 14 mg/L	6.3 - 11.3mg/L	5 - 96JTU	2 - <u>3,000</u>JTU
(12) DIPTERA CHIRONOMIDAE-MIDGE 	N/A	0° C - 27° C	N/A	7.9 - 8.7	N/A	6.3 11.3mg/L	19 - 29JTU	2 - <u>3,000</u>JTU

DATA UNDERLINED IS SIGNIFICANTLY HIGHER OR LOWER THAN REPORTED LITERATURE
(Sketches modified from Pennak, 1953)

Table 13.--(Continued)

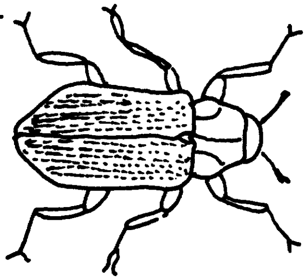
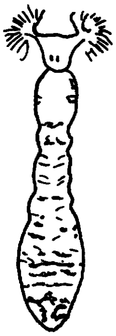
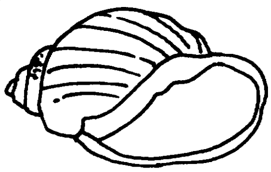
EXPLANATION TEMP. - Temperature D.O. - Dissolved oxygen TURB. - Turbidity JTU - Jackson turbidity unit N/A - Not reported	TEMP.		pH		D.O.		TURB.	
	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY
(7) PLECOPTERA PERLODIDAE- STONEFLY  ISOPERLA ADULT STAGE	N/A	0° C - 27° C	6.4 - 6.9	7.9 - 8.7	7 - 11mg/L	6.3 - 11.3mg/L	5 - 120JTU	2 - 3,000JTU
(8) ODONATA GOMPHIDAE-DRAGONFLY ODHIOSOMPHUS 	N/A	0° C - 27° C	7.6 - 8.3	7.9 - 8.7	8 - 12 mg/L	6.3 - 11.3mg/L	26 - >72,000JTU	2 - 3,000JTU
(9) MEGALOPTERA SIALIDAE-ALDERFLY SIALIS  HELLGRAMMITE	N/A	0° C - 27° C	3.3 - 8.8	7.9 - 8.7	5 - 14mg/L	6.3 - 11.3mg/L	1 - 125JTU	2 - 3,000JTU

DATA UNDERLINED IS SIGNIFICANTLY HIGHER OR LOWER THAN REPORTED LITERATURE
(Sketches modified from Pennak, 1953)

Table 13.--(Continued)

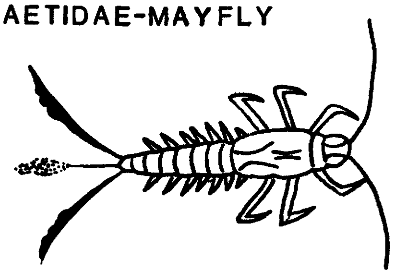
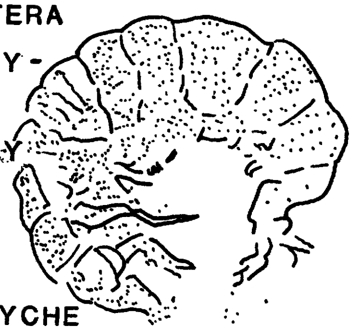
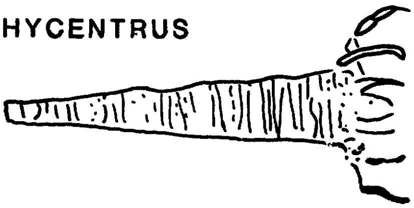
EXPLANATION

TEMP. - Temperature
D.O. - Dissolved oxygen
TURB. - Turbidity
JTU - Jackson turbidity unit
N/A - Not reported

EXPLANATION	TEMP.		pH		D.O.		TURB.	
	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY
(13) COLEOPTERA ELMIDAE-RIFFLE BEETLE 	N/A	0° C - 27° C	5.5 - 8.8	7.9 - 8.7	3 - 14mg/L	6.3 - 11.3mg/L	3 - >72,000	2 - 3,000JTU
(14) DIPTERA SIMULIIDAE-BLACK FLY 	N/A	0° C - 27° C	N/A	7.9 - 8.7	N/A	6.3 - 11.3mg/L	N/A	2 - 3,000JTU
(15) GASTROPODA BASOMMATOPHORA-POND SNAIL PHYSIDAE 	0° C - 30° C	0° C - 27° C	6.7 - 9.0	7.9 - 8.7	0 - 16mg/L	6.3 - 11.3mg/L	N/A	2 - 3,000JTU

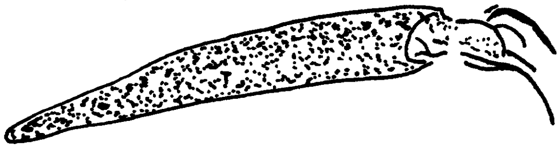
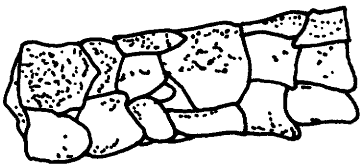
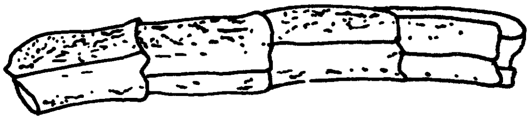
DATA UNDERLINED IS SIGNIFICANTLY HIGHER OR LOWER THAN REPORTED LITERATURE
(Sketches modified from Pennak, 1953)

Table 14.--Chemical data for elements of reported and observed data for determination of tolerance limits.

	Fe		Ca		Mg		SO_4	
	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY
(1) EPHEMEROPTERA BAETIDAE-MAYFLY 	<0.01 - 2.89 mg/L	30 - 130 µg/L	3 - 398 mg/L	49 92 mg/L	1 - 200 mg/L	52 - 86 mg/L	<1.0 - 580 mg/L	290 - 600 mg/L
(2) TRICHOPTERA HYDROPSYCHIDAE-CADDISFLY HYDROPSYCHE 	<0.01 - 2.9 mg/L	30 - <u>130</u> µg/L	2 - 865 mg/L	49 - 92 mg/L	<1 - 43 mg/L	52 - 86 mg/L	0.8 - 450 mg/L	290 - 600 mg/L
(3) TRICHOPTERA BRACHYCENTRIDAE-CADDISFLY BRACHYCENTRUS 	0.3 - 0.10 mg/L	30 - <u>130</u> µg/L	2 - 3 mg/L	<u>49</u> - <u>92</u> mg/L	<1 - 4 mg/L	<u>52</u> - <u>86</u> mg/L	2.3 - 2.5 mg/L	<u>190</u> - <u>600</u> mg/L

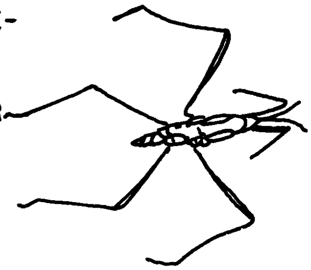
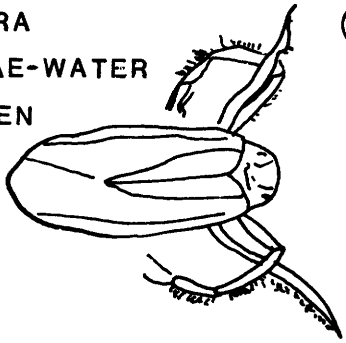
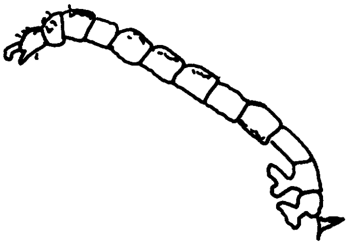
DATA UNDERLINED IS SIGNIFICANTLY HIGHER OR LOWER THAN REPORTED LITERATURE
(Sketches modified from Pennak, 1953)

Table 14.--(Continued)

EXPLANATION N/A - Not reported	Fe		Ca		Mg		SO_4	
	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY
(4) TRICHOPTERA LEPTOCERIDAE-CADDISFLY LEPTOCELLA 	<0.01 - 2.89mg/L	30 - 130 µg/L	2 - 2,000mg/L	49 - 92mg/L	<1 - 200mg/L	52 - 86mg/L	<1.0 - 570mg/L	290 - 600mg/L
(5) TRICHOPTERA LIMNEPHILIDAE-CADDISFLY LIMNEPHILUS 	<0.01 - 16.10mg/L	30 - 130 µg/L	2 - 220mg/L	49 - 92mg/L	1 - 39mg/L	52 - 86mg/L	2.5 - 450mg/L	290 - 600mg/L
(6) TRICHOPTERA PHRYGANEIDAE-CADDISFLY PTILOSTOMIS 	N/A	30 - 130 µg/L	55 - 64mg/L	49 - 92mg/L	14 - 15mg/L	52 - 86mg/L	115 - 135mg/L	290 - 600mg/L

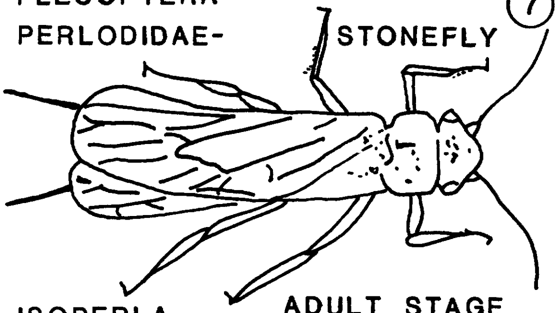
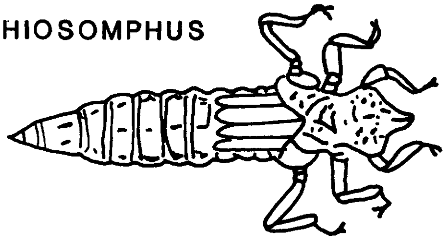
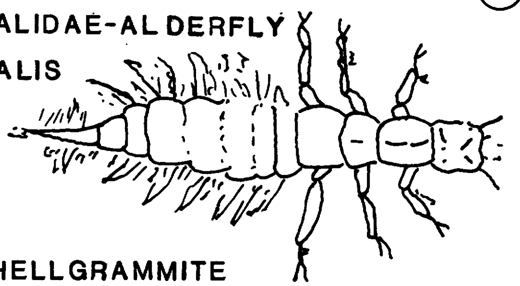
DATA UNDERLINED IS SIGNIFICANTLY HIGHER OR LOWER THAN REPORTED LITERATURE
(Sketches modified from Pennak, 1953)

Table 14.--(Continued)

	Fe		Ca		Mg		SO_4	
	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY
(10) HEMIPTERA GERRIDAE-WATER STRIDER 	<0.01 - 0.82 mg/L	30 - 130 µg/L	22 - 49 mg/L	49 - 92 mg/L	3 - 11 mg/L	52 - 86 mg/L	25.0 - 28.8 mg/L	290 - 600 mg/L
(11) HEMIPTERA CORIXIDAE-WATER BOATMEN 	0.02 - 0.10 mg/L	30 - 130 µg/L	22 mg/L	49 - 92 mg/L	3 mg/L	52 - 86 mg/L	25 mg/L	290 - 600 mg/L
(12) DIPTERA CHIRONOMIDAE-MIDGE 	0.32 - 8.75 mg/L	30 - 130 µg/L	2 - 47 mg/L	49 - 92 mg/L	1 - 11 mg/L	52 - 86 mg/L	2.4 - 24 mg/L	290 - 600 mg/L

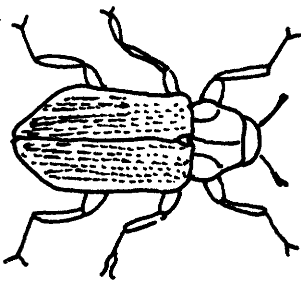
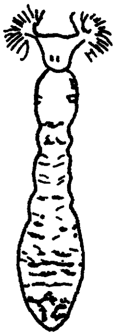
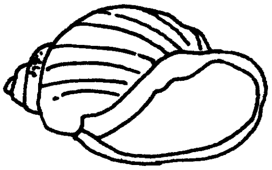
DATA UNDERLINED IS SIGNIFICANTLY HIGHER OR LOWER THAN REPORTED LITERATURE
(Sketches modified from Pennak, 1953)

Table 14.--(Continued)

	Fe		Ca		Mg		SO_4	
	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY
PLECOPTERA PERLODIDAE- STONEFLY ISOPERLA ADULT STAGE ⑦ 	0.05 - 0.16mg/L	30 - 130µg/L	2 - 4mg/L	49 - 92mg/L	1 - 2mg/L	52 - 86mg/L	2.4 - 3.1mg/L	290 - 600mg/L
ODONATA GOMPHIDAE-DRAGONFLY ODHIOSOMPHUS ⑧ 	7.6 - 8.3mg/L	30 - 130µg/L	128 - 171mg/L	49 - 92mg/L	36 - 40 mg/L	52 - 86mg/L	10.5 - 31mg/L	290 - 600mg/L
MEGALOPTERA SIALIDAE-ALDERFLY SIALIS HELLGRAMMITE ⑨ 	0.03 - 16.1mg/L	30 - 130µg/L	3 - 180mg/L	49 - 92mg/L	1 - 36mg/L	52 - 86mg/L	1.0 - 370mg/L	210 - 600mg/L

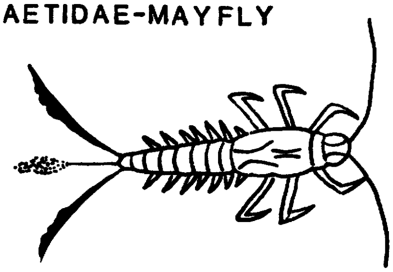
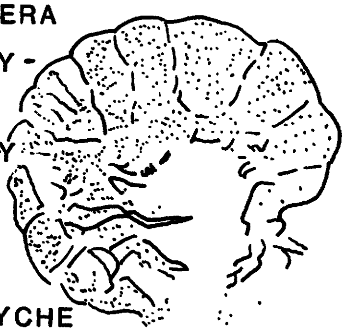
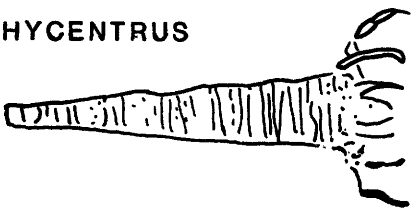
DATA UNDERLINED IS SIGNIFICANTLY HIGHER OR LOWER THAN REPORTED LITERATURE
(Sketches modified from Pennak, 1953)

Table 14.--(Continued)

EXPLANATION N/A - Not reported	Fe		Ca		Mg		SO_4	
	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY
(13) COLEOPTERA ELMIDAE-RIFFLE BEETLE 	<0.01 - 2.89 mg/L	30 - 130 µg/L	2 - 392 mg/L	49 - 92 mg/L	<1 - 43 mg/L	52 - 86 mg/L	<1.0 - 450 mg/L	290 - 600 mg/L
(14) DIPTERA SIMULIIDAE-BLACK FLY 	N/A	30 - 130 µg/L	N/A	49 - 92 mg/L	N/A	52 - 86 mg/L	N/A	290 - 600 mg/L
(15) GASTROPODA BASOMMATOPHORA-POND SNAIL PHYSIDAE 	N/A	30 - 130 µg/L	N/A	49 - 92 mg/L	N/A	52 - 86 mg/L	N/A	290 - 600 mg/L

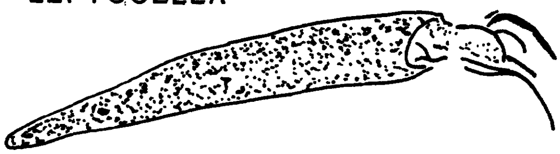
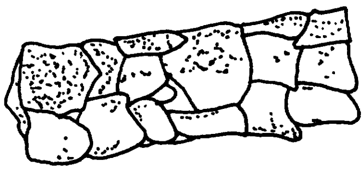
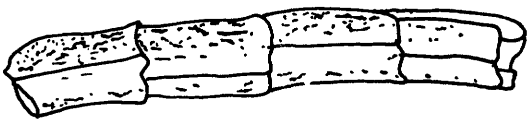
DATA UNDERLINED IS SIGNIFICANTLY HIGHER OR LOWER THAN REPORTED LITERATURE
(Sketches modified from Pennak, 1953)

Table 15.--Chemical data for selected nutrients of reported and observed data for determination of tolerance limits.

	NH_4 as N		$NO_2 + NO_3$ as N		PO_4 as P	
	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY
(1) EPHEMEROPTERA BAETIDAE-MAYFLY 	<0.01 - 5.00 mg/L	0.00 - 0.02 mg/L	<0.04 - 1.35 mg/L	0.27 - 0.97 mg/L	<0.01 - 0.82 mg/L	0.00 - 0.28 mg/L
(2) TRICHOPTERA HYDROPSYCHIDAE-CADDISFLY HYDROPSYCHE 	<0.01 - 5.80 mg/L	0.00 - 0.02 mg/L	<0.13 - 2.39 mg/L	0.27 - 0.97 mg/L	<0.01 - 0.72 mg/L	0.00 - 0.28 mg/L
(3) TRICHOPTERA BRACHYCENTRIDAE-CADDISFLY BRACHYCENTRUS 	0.01 - 0.64 mg/L	0.00 - 0.02 mg/L	<0.01 mg/L	0.27 - <u>0.97</u> mg/L	2.4 mg/L	0.00 - 0.28 mg/L

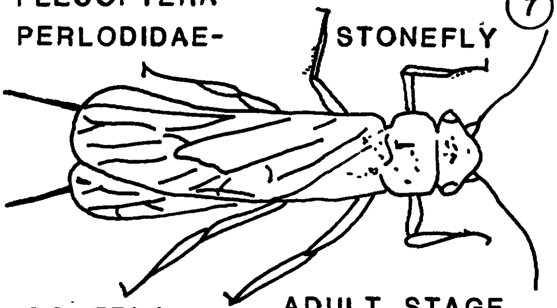
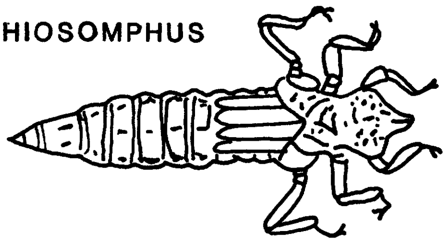
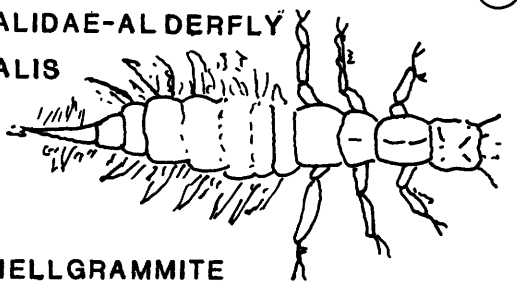
DATA UNDERLINED IS SIGNIFICANTLY HIGHER OR LOWER THAN REPORTED LITERATURE (Sketches modified from Pennak, 1953)

Table 15.--(Continued)

	NH_4 as N		$NO_2 + NO_3$ as N		PO_4 as P	
	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY
(4) TRICHOPTERA LEPTOCERIDAE-CADDISFLY LEPTOCELLA 	0.02 - 0.14mg/L	0.00 - 0.02mg/L	<0.04 - 0.51mg/L	0.27 - 0.97mg/L	<0.01 - 0.05mg/L	0.00 - 0.28mg/L
(5) TRICHOPTERA LIMNEPHILIDAE-CADDISFLY LIMNEPHILUS 	0.09mg/L	0.00 - 0.02mg/L	0.05mg/L	0.27 - 0.97mg/L	0.05mg/L	0.00 - 0.28mg/L
(6) TRICHOPTERA PHRYGANEIDAE-CADDISFLY PTILOSTOMIS 	0.01 - 0.16mg/L	0.00 - 0.02mg/L	<0.04mg/L	0.27 - 0.97mg/L	<0.01 - 0.03mg/L	0.00 - 0.28mg/L

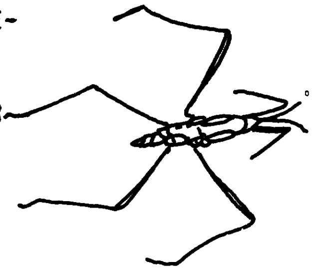
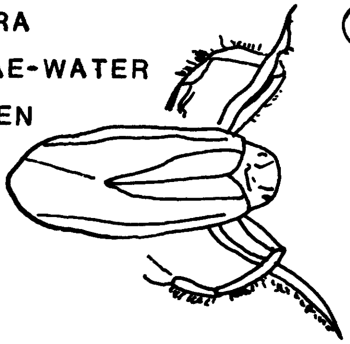
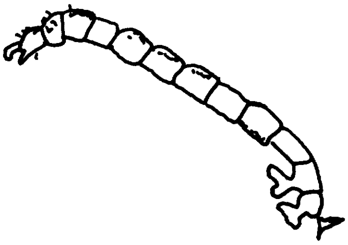
DATA UNDERLINED IS SIGNIFICANTLY HIGHER OR LOWER THAN REPORTED LITERATURE (Sketches modified from Pennak, 1953)

Table 15.--(Continued)

EXPLANATION N/A - Not reported	NH_4 as N		$NO_2 + NO_3$ as N		PO_4 as P	
	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY
(7) PLECOPTERA PERLODIDAE- STONEFLY  ISOPERLA ADULT STAGE	0.01 - 0.16mg/L	0.00 - 0.02mg/L	<0.01mg/L	0.27 - 0.97 mg/L	<0.01mg/L	0.00 - 0.28mg/L
(8) ODONATA GOMPHIDAE-DRAGONFLY ODHIOSOMPHUS 	N/A	0.00 - 0.02mg/L	<0.01 - 0.17mg/L	0.27 - 0.97mg/L	N/A	0.00 - 0.28 mg/L
(9) MEGALOPTERA SIALIDAE-ALDERFLY SIALIS  HELLGRAMMITE	0.02 - 1.09mg/L	0.00 - 0.02 mg/L	<0.09 - 0.51mg/L	0.27 - 0.97mg/L	<0.01 - 0.12mg/L	0.00 - 0.28mg/L

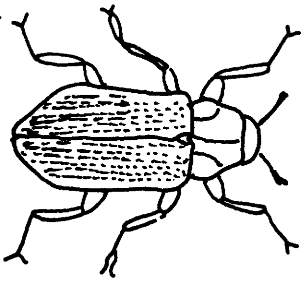
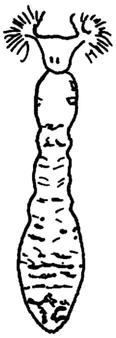
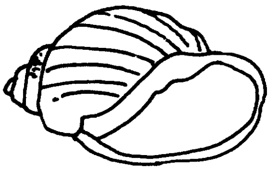
DATA UNDERLINED IS SIGNIFICANTLY HIGHER OR LOWER THAN REPORTED LITERATURE (Sketches modified from Pennak, 1953)

Table 15.--(Continued)

	NH_4 as N		$NO_2 + NO_3$ as N		PO_4 as P	
	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY
HEMIPTERA GERRIDAE-WATER STRIDER (10) 	<0.01 - 13.40mg/L	0.00 - 0.02mg/L	<0.04 - 2.67mg/L	0.27 - 0.97 mg/L	<0.01 - 0.72mg/L	0.00 - 0.28mg/L
HEMIPTERA CORIXIDAE-WATER BOATMEN (11) 	<0.01 - 2.50mg/L	0.00 - 0.02mg/L	<0.03 - 0.52mg/L	0.27 - <u>0.97</u> mg/L	<0.01 - 0.72mg/L	0.00 - 0.28mg/L
DIPTERA CHIRONOMIDAE-MIDGE (12) 	0.15 - 0.21mg/L	0.00 - 0.02mg/L	1.20 - 1.30mg/L	0.27 - 0.97 mg/L	0.30 - 0.56mg/L	0.00 - 0.28mg/L

DATA UNDERLINED IS SIGNIFICANTLY HIGHER OR LOWER THAN REPORTED LITERATURE (Sketches modified from Pennak, 1953)

Table 15.--(Continued)

EXPLANATION N/A - Not reported	NH_4 as N		$NO_2 + NO_3$ as N		PO_4 as P	
	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY	REPORTED (HART & FULLER, 1974)	DATA OBSERVED IN STUDY
(13) COLEOPTERA ELMIDAE-RIFFLE BEETLE 	<0.01 - 5.00mg/L	0.00 - 0.02mg/L	<0.13 - 0.94mg/L	0.27 - 0.97mg/L	<0.01 - 0.72mg/L	0.00 - 0.28mg/L
(14) DIPTERA SIMULIIDAE-BLACK FLY 	N/A	0.00 - 0.02mg/L	N/A	0.27 - 0.97mg/L	N/A	0.00 - 0.28mg/L
(15) GASTROPODA BASOMMATOPHORA-POND SNAIL PHYSIDAE 	N/A	0.00 - 0.02mg/L	N/A	0.27 - 0.97mg/L	N/A	0.00 - 0.28mg/L

DATA UNDERLINED IS SIGNIFICANTLY HIGHER OR LOWER THAN REPORTED LITERATURE (Sketches modified from Pennak, 1953)

The tables show the most common benthic invertebrates collected during the study. The benthic invertebrates are given a number which identifies their location on the conceptual model.

The amphipods, Gammarus (scuds), are the most abundant benthic invertebrates along Salt Wells Creek and Gap Creek. The scuds are found in submerged vegetation, under rocks, and between debris and small stones. As a group, the scuds are widely distributed and are an excellent indicator of clean water habitats (Pennak, 1953, p. 438). Trichoptera (caddisflies) were the second most abundant benthic invertebrate and are found in both riffles and pondlike habitats.

A flow diagram (fig. 43) was developed for plains streams. The diagram shows the relations between streamflow, dissolved-solids concentration, and biological abundance during the spring, summer, fall, and winter.

SUMMARY

In the Salt Wells Creek drainage area the density of bank vegetation, the composition of upper and lower bank materials, and the bed materials changed with a decrease in elevation and an increase in stream reach. During high streamflows, the aquatic habitat was disturbed and changed. Deposition of bed materials, light, temperature, and a reservoir of dissolved nutrients are influential factors that help rebuild aquatic environments. During low streamflows, plains streams are pondlike. There are three sources of phytoplankton in the Salt Wells Creek drainage. The first source exists in springs and is dominated by diatoms. A second source was observed growing in stock ponds and was dominated by green and blue-green algae. A third source was the dislodged periphytic algae from the stream bed. The two streams, Salt Wells Creek and Gap Creek, have seasonal algal growth fluctuations. During high streamflows, the phytoplankton is dominated by the green and blue-green algae. During low flows, the phytoplankton is dominated by diatoms. The phytoplankton community was characterized by an assemblage of the diatoms Navicula, Nitzschia, Gomphonema, and Surirella. The maximum growth of phytoplankton occurred during the summer months. Periphyton and benthic invertebrates developed in seasonal succession during the spring, summer, and fall. The maximum population and maximum community diversity occurred during late summer and early fall.

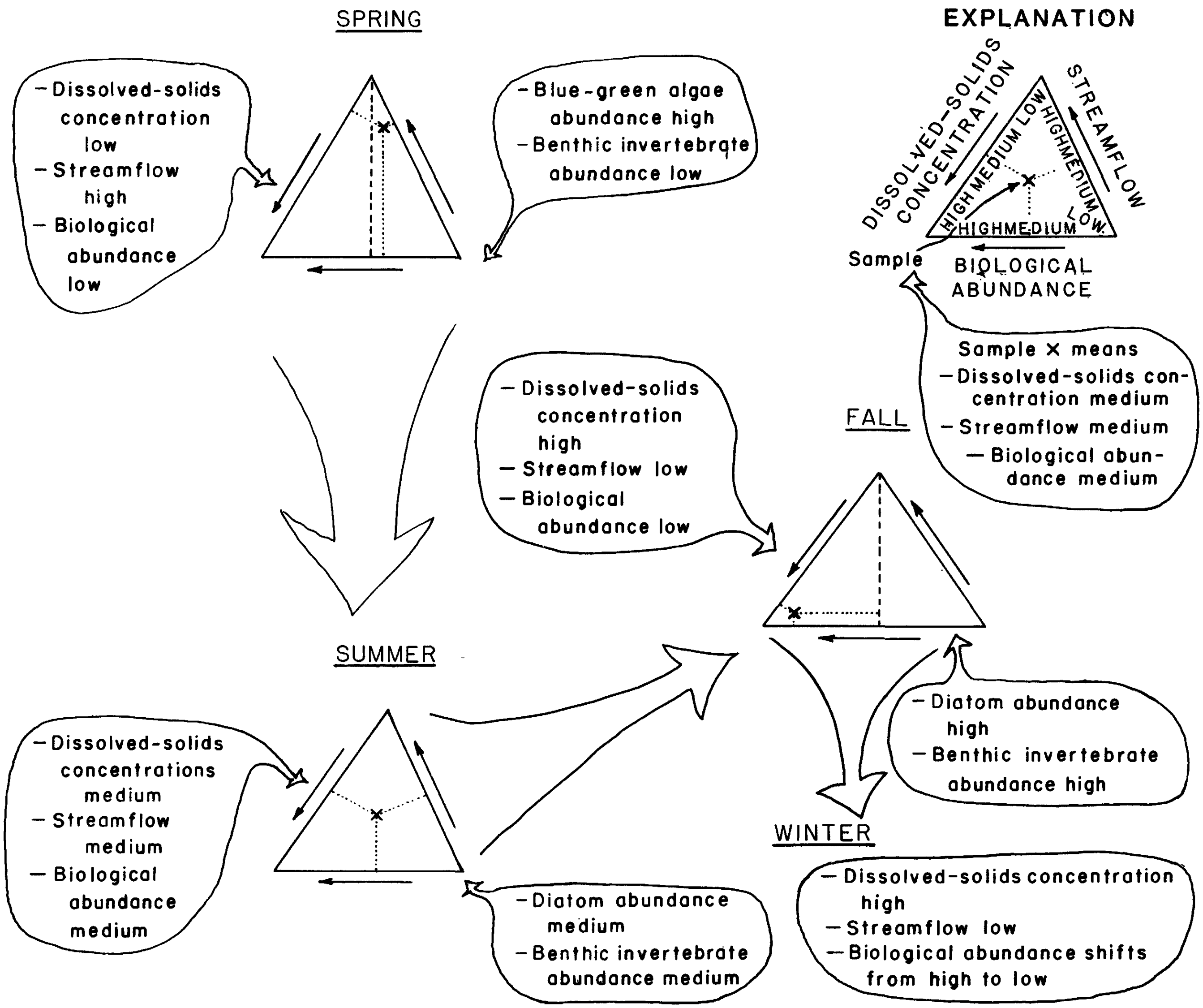


Figure 43.--Flow chart of streamflow, dissolved-solids concentration, and biological abundance for plains streams during the spring, summer, fall, and winter.

Based on the findings, a food chain consisting of four trophic levels was described. The first trophic level was composed of phytoplankton and periphyton. The second trophic level consisted of the riffle beetles, mayflies, black flies, stoneflies, caddisflies, and the water boatmen. The third trophic level consisted of the dragonflies, alderflies, predaceous diving beetles, and the water scavenger beetles. The fourth trophic level consisted of the mountain sucker and the speckled dace. A pyramid of numbers diagramatically showed the decrease in number of organisms at each of the higher trophic levels.

A conceptual model developed for plains streams showed two communities which overlapped, forming a third community. The region of overlap was enriched in numbers and types of organisms. This enrichment is called the edge effect. The conceptual model and benthic invertebrates were related to water chemistry by comparing observed ranges of chemical properties with ranges reported in the literature for the various benthic taxa. Tables relating water chemistry and benthic invertebrates are keyed to the conceptual model. This method demonstrated and identified the community in which each organism was most frequently found.

Salt Wells Creek has a low nutrient level, a large number of diatomtaxa, a good assortment of insect taxa, and several other invertebrate taxa such as snails, worms, and scuds. The scuds, due to their relative abundance along the stream reach, are the principle benthic organism found in the basin. Trichoptera, due to both the number of individuals and number of taxa, were the second most abundant benthic invertebrate.

Two species of fish were found: the mountain sucker, Catostoma platyrhynchus (Cope), and the speckled dace, Rhinichthys osculus (Girard). Both species have an extremely large range of tolerance to environmental factors (Baxter and Simon, 1970, p. 75 and 111).

A flow diagram of streamflow, dissolved-solids concentration, and biological abundance for plains streams shows the way in which these properties vary seasonally.

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