FISHERY AND MACROINVERTEBRATE STUDIES OF THE JORDAN RIVER IN SALT LAKE COUNTY
NOVEMBER 1986

BIO/WEST, Inc.

Resource Management and Problem Solving Services

FISHERY AND MACROINVERTEBRATE STUDIES OF THE JORDAN RIVER IN SALT LAKE COUNTY NOVEMBER 1986

for

CENTRAL VALLEY WATER RECLAMATION FACILITY BOARD
Salt Lake City, Utah

by

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INTRODUCTION

The Jordan River drains Utah Lake and flows approximately 56 miles to the Great Salt Lake. Its route traverses the most densely populated area in Utah, the Salt Lake Valley, which includes Salt Lake City and suburbs. The Jordan River has been heavily used by man since shortly after the valley was settled in the mid 1800's. It has served for many years as the major source of irrigation water for much of the valley and because it is the major drainage system of the valley, it also serves as the common endpoint for all materials dumped into any of the flowing waters of the area. Much of the Jordan River below 123rd South has been dredged and channelized to improve the carrying capacity of the river and reduce flooding of nearby residential property. These flood control measures are usually associated with degradation of the affected aquatic habitats.

During recent years the numerous wastewater treatment facilities that drained into the river have been consolidated into fewer, more modern facilities. Water quality characteristics of the effluents, and therefore the river, have changed due to the improved treatment efficiency of these modern facilities. During this same time period, physical habitat in the Jordan River has not been improved and may have been negatively affected by flood control activities.

The Clean Water Act (CWA) requires that whenever attainable, States must set water quality standards that provide for the protection and propagation of fish, shellfish and wildlife and provide for recreation in and on the water (33 U.S.C. 1251 et seq). EPA Regulations require that: "when a State changes the designated uses of its waters such that the uses of the water body do not include the uses specified in the Act, the State will have to demonstrate, through a use attainability analysis, that these uses are not attainable based on physical, chemical, biological or organic factors. Where water quality improvements result in new uses, States must revise their standards to reflect these new uses" (48 Fed. Reg. 51400, November 8, 1983).

In the preamble to its Water Quality Standards Regulations, (48 Fed. Reg. 51400, 51401, November 8, 1983, EPA stressed that "common sense and good judgement play an important role in setting appropriate uses." This is especially pertinent where the physical limitations of a stream are an overriding concern.

> There are instances where non-water quality related factors preclude the attainment of uses regardless of improvements in water quality. This is particularly true for fish and wildlife protection uses where the lack of a proper substrate may preclude certain forms of aquatic life from using the stream for propagation or the lack of cover, depth, flow, pools, riffles or impact from channelization, dams and diversion may preclude particular forms of aquatic life from the stream altogether (Ibid).

Because of the past dredging and channelization of the lower Jordan River, Central Valley, along with other State authorities, has questioned the efficacy of providing increased treatment levels to achieve a diverse warm water sport fishery. In 1977 the Utah Division of Wildlife Resources stated the following in response to a 208 planning report entitled "Fishery Potential of the Jordan River as Affected by Wastewater Treatment Alternatives":

> . . . we cannot concur with the part of the report dealing with fisheries. The conclusions are based primarily on expected water quality in the river following implementation of one of the wastewater treatment alternatives. Little consideration was given to the biological and physical information in formulating conclusions. . . . The limited water quality evaluation in your preliminary report does not adequately describe the habitat potential of the Jordan River for warm water sport fish.

In response to the use attainability and habitat issues raised, the State in conjunction with the EPA planned to conduct detailed analyses of the Jordan River to determine if the $30 million nitrification facilities proposed to be constructed at Central Valley would, in fact, result in improved fisheries. Unfortunately, funding restrictions and high river flows restricted the implementation of the studies.

Central Valley Water Reclamation Facility has conducted this comprehensive habitat and fishery evaluation to determine and define (1) what the aquatic life of the Jordan River consists of, (2) what the major limiting factors in the system are, and (3) whether further improvements in water quality will result in greater fishery diversity. The study examines fish populations, benthic macroinvertebrates and physical habitat and the relationship between these factors and water quality. Consistent with the goals of the Clean Water Act and EPA Regulations, this study was conducted to determine what, if any, new uses will result due to the improved treatment facilities and to determine what water quality standards must be established to protect the reasonable fishery uses of the Jordan River.

STUDY AREA

The major focus of the study was on the area below the mouth of Mill Creek because that is where Central Valley discharges its effluent. To adequately evaluate this area, information on the river above Mill Creek was also needed so that differences, if any, could be ascertained. Therefore, following discussions with the Utah Division of Wildlife Resources (DOW) and Utah Department of Public Health, the river was broken into five general reaches that corresponded to areas with different physical and/or water quality characteristics. These reaches, in a downstream direction, included:

1. The river as it enters the Salt Lake Valley where natural habitat has not been significantly altered and water quality has not been significantly altered from that of Utah Lake.

2. The river above Mill Creek (Central Valley) where water quality has been influenced by discharge in the Salt Lake Valley and habitat is partially degraded by channelization.

3. The river immediately below Mill Creek (Central Valley) where impacts of Central Valley's discharge may be most evident.

4. The Jordan River below the Surplus Canal diversion where its flow is regulated.

5. The Surplus Canal, which drains most of the Jordan River water to the Great Salt Lake.

Two stations were set up within each of these five reaches so the potential variation of each area could be measured. The exact location of each of these stations is discussed in the Results section in complete detail.

METHODS

The study involved three major components, a general literature review of existing information on aquatic life, water chemistry and river flow, a physical habitat measurement of each station, and a field survey of fishery and macroinvertebrate populations of each station. The literature review involved gathering all available information on the Jordan River, especially as related to fishes and macroinvertebrates. This process included a standard library search and gathering unpublished information from various state agencies, in particular the DOW and Public Health. This task is not reported on separately in the Results section but is included in the discussion and analysis where appropriate. The other two tasks are separately reported and the methods used are discussed in more detail below.

Habitat Measurement

Each station was measured using cross-sectional transects of the river. Three or four transects were all that were generally required to adequately characterize most stations. Each station and its transects were surveyed so the exact configuration of the station and location of the transects was known. Measurements of depth, velocity, substrate and cover were taken across each transect following guidelines of the Instream Flow Incremental

Methodology (Bovee 1978). Sketches of each station were made to support the transect measurements.

Biological Field Survey

A standardized biological survey was conducted at each of the ten stations. The survey included macroinvertebrate sampling, fishery sampling and a minimal water quality analysis. A 500 foot area was set up at each station and served as the major analysis area.

Macroinvertebrates were sampled using a Hess type sampler (1 ft^2) in areas with shallow depths and cobble or gravel substrates, which occurred only in the Bluffdale, Riverton and 45th South stations. A petite ponar dredge (1/4 ft^2) was used in finer substrates which occurred at most sites. A stratified-random sampling scheme utilizing four replicate samples within each general habitat type at each station was used. Habitat types at most stations were limited to run type habitat. The exception was a few stations that also included riffle or backwater habitat. Eight samples, two sets of four replicate samples, were taken at all stations even if only one habitat type was present. Each replicate sample consisted of one square foot of bottom. Thus each sample taken with the Hess sampler was considered a replicate. When the Ponar sampler was used, four samples were combined for each replicate due to its smaller size. Each sample was preserved in the field and transferred to the BIO/WEST lab for sorting and identification.

Fish sampling was conducted using an electrofishing boat with a 3500 watt generator and Coffelt VVP 15. Each 500 foot station was thoroughly electrofished using a multiple pass or mark/recapture technique. All fish captured were held until the sampling was complete. They were then identified to species, measured, weighed, marked if recapture was to be attempted, and released. A second thorough sampling was conducted either later the same day or early the next day at stations where the mark-recapture technique was used.

The population estimation collection effort at each 500 foot station was supported with additional sampling in the immediate area of the station. This additional sampling was primarily conducted with electrofishing, but seining was also utilized where possible. This additional sampling was done to investigate habitats not found within the 500 foot station or to see if rare fish species could be found. All electrofishing efforts where timed so catch per unit effort could be determined. Approximately one day of sampling was conducted at each station.

Therefore, two different but similar types of fish sampling occurred at each of the 10 stations. Sampling for a population estimate was conducted within the 500 foot station. Additional sampling was conducted in nearby habitats.

Basic water quality parameters taken at each station included temperature, pH, conductivity, salinity, alkalinity, hardness, turbidity, and dissolved oxygen, chlorine, ammonia, and nitrate content. Dissolved oxygen, conductivity, temperature and pH were measured with portable electronic meters. The remaining parameters were measured with a Bauch and Lomb field water quality test kits that utilize titration and spectrophotometric techniques.

RESULTS AND DISCUSSION

Station Description and Habitat Analysis

Figure 1 is a general map of the study area showing the location of the 10 stations used in the field study. Figure 2 shows the locations of wastewater treatment plants in relation to the stations. A description of each station follows.

Uppermost Reach

Bluffdale. The most upstream station was located about 1/2 mile above the Bluffdale bridge. Figure 3 depicts this station in surface and cross-sectional view. This site has a fairly natural tree-lined channel along the left bank and in the upper sections, although much of the right bank was diked. The channel was braided in the upper portion around a series of small islands. Overall about 58% of the shoreline in the station exhibited some form of riparian vegetation cover and 42% was small riprap and no cover (Table 1). Approximately 27% of the station was riffle habitat, 9% eddies and the remainder a fast run. This reach of the river has never been dredged (Table 2), although areas just below the station near the Bluffdale Bridge have been dredged in the past. Substrate was primarily large and small cobble in the channel, with silt occurring in eddies and small embayments along shore. Velocities were generally above 3 feet per second (fps) in the channel, but dropped off near the shore.

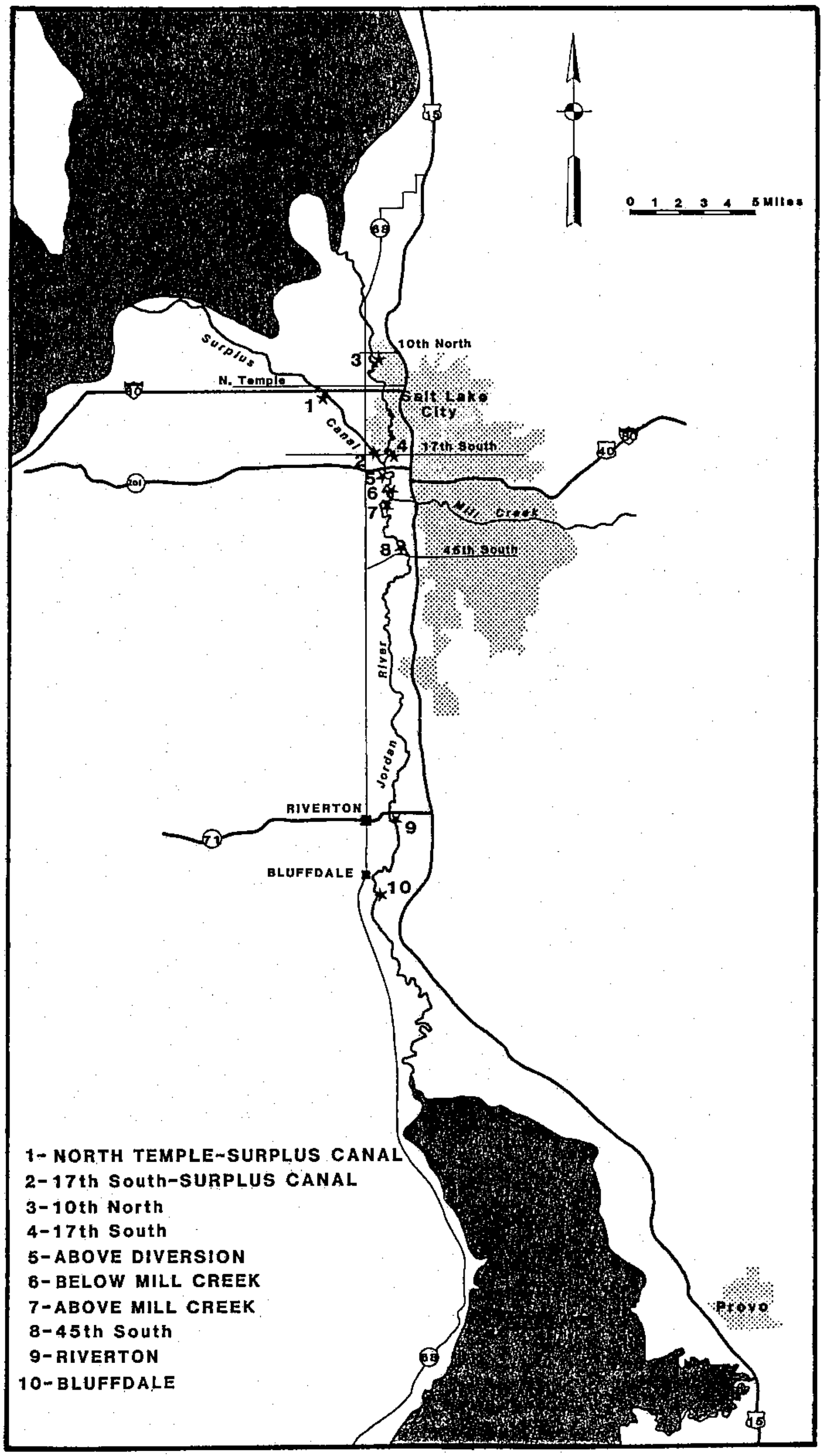


FIGURE 1. General location map of sampling stations.

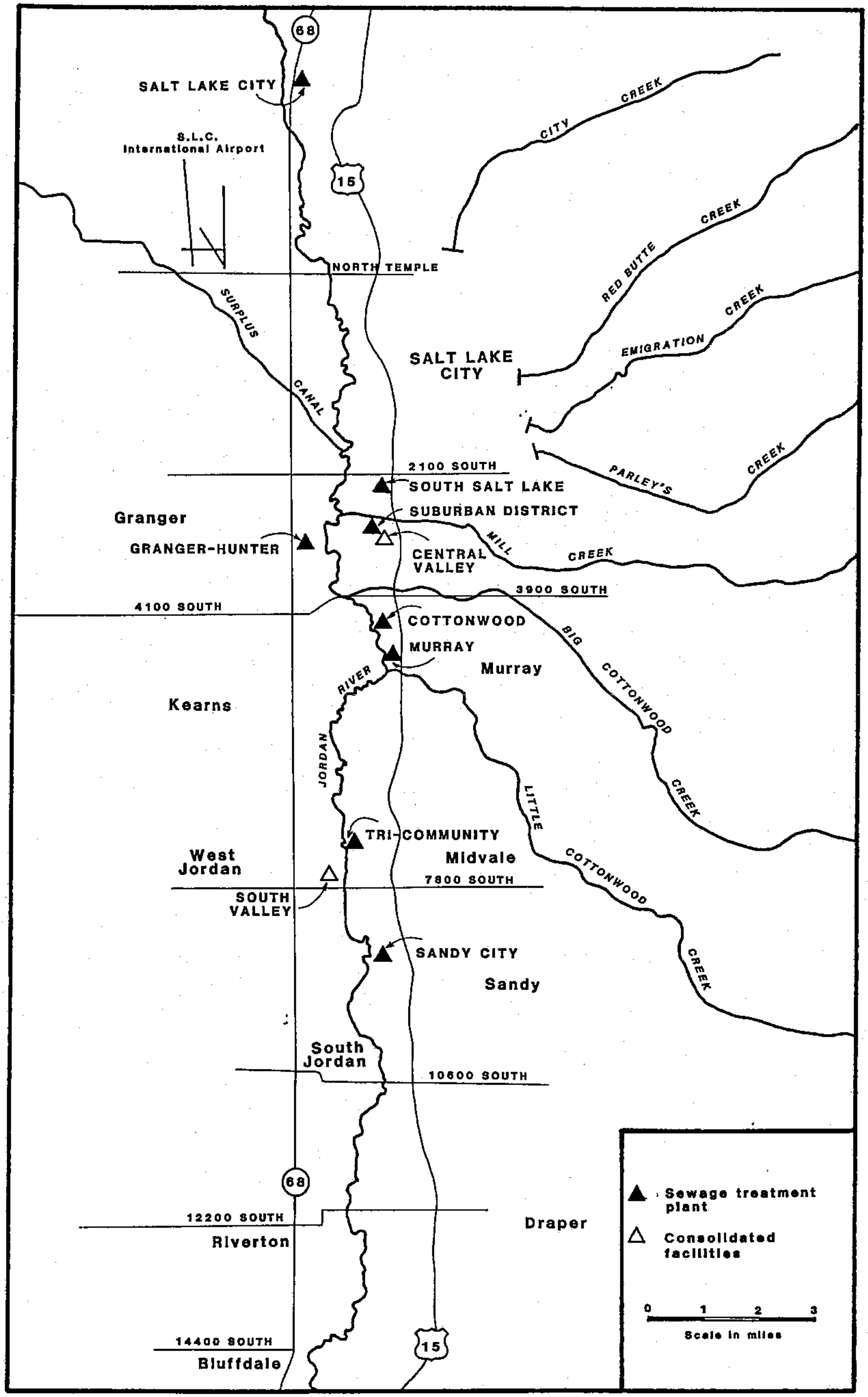


Figure 2. Map of the Jordan River showing sewage treatment plant locations.

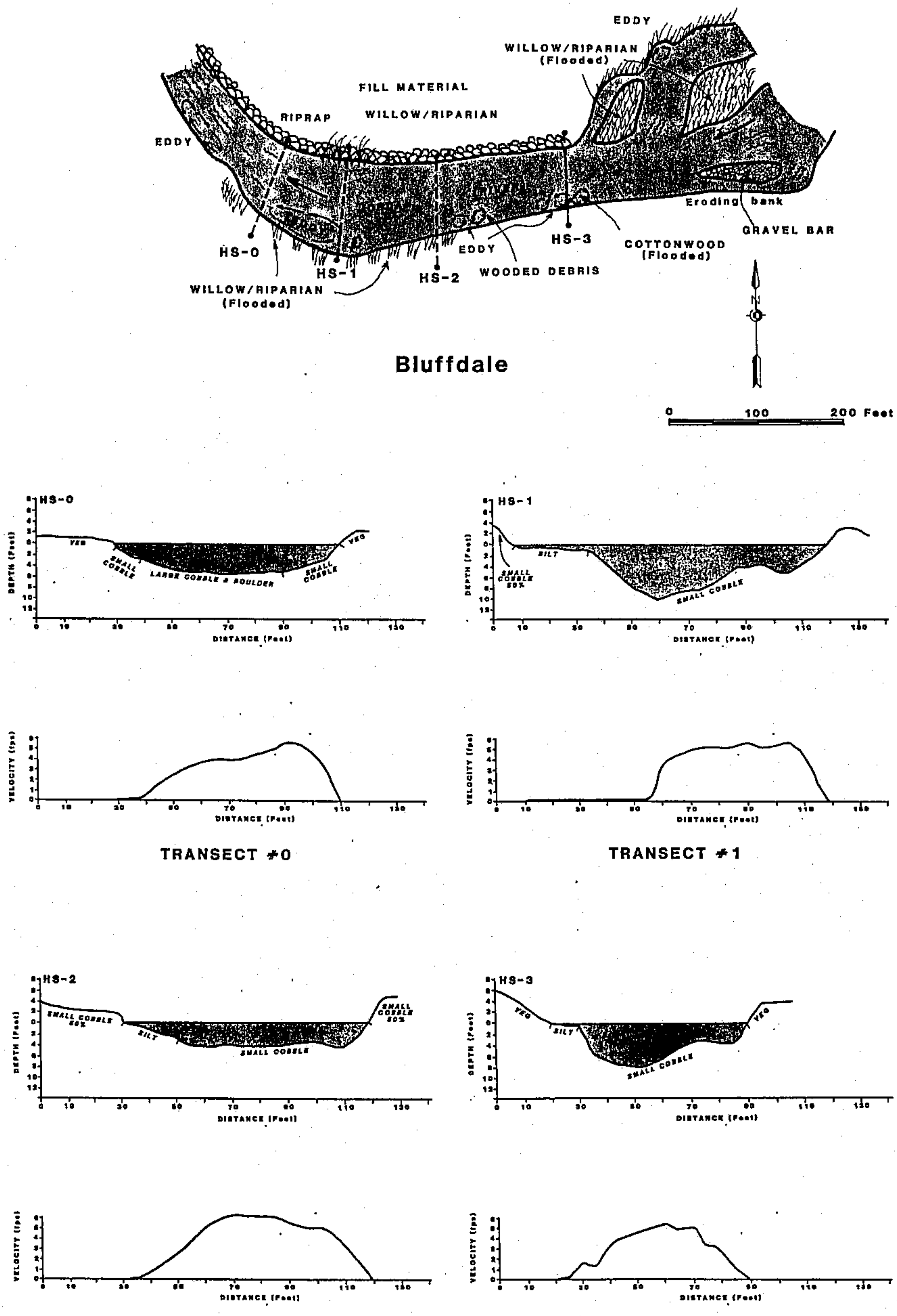


FIGURE 3. General diagram and cross-sectional profiles for the station at Bluffdale.

Table 1

PER CENT COMPOSITION OF VARIOUS HABITAT AND COVER TYPES AT STATIONS ON THE JORDAN RIVER

Station	SC NT	SC 17S	JR 10N	JR 17S	JR AD	JR BMC	JR AMC	JR 45S	JR RT	JR BD
Length of River Station Surveyed (ft)	1000	770	700	1080	1500	1000	720	1152	1440	800
Overall Habitat Types (% of Surface Area)										
Riffle	0	0	0	3	0	0	0	20	0	27
Run	99	99	99	79	98	93	95	77	92	64
Eddy	<1	<1	<1	<1	2	0	5	3	<1	9
Backwater	0	0	0	17	0	7	0	0	7	0
Shoreline Cover Types (% of Shoreline)										
Cutbank or No Cover	0	3	0	0	0	0	21	10	20	20
Rip Rap	0	0	0	0	0	0	11	90	0	22
Grassbank	88	82	92	76	97	95	49	0	79	0
Riparian Vegetation	12	7	8	21	0	5	19	0	<1	58
Special Features	0	8	0	3	3	0	0	0	0	0

*Station Codes: SC-NT= Surplus Canal, North Temple; SC-17S= Surplus Canal, 17th S; JR-10N= Jordan River, 10th N; JR-17S= Jordan River, 17th S; JR-AD= Jordan River, above Diversion; JR-BMC= Jordan River, below Mill Creek; JR-AMC= Jordan River, above Mill Creek; JR-45S= Jordan River, 45th S; JR-RT= Jordan River, Riverton; JR-BD= Jordan River, Bluffdale.

Table 2.

RECENT HISTORY OF PHYSICAL MODIFICATIONS OF THE JORDAN RIVER.

Station*	SC NT	SC 17S	JR 10N	JR 17S	JR AD	JR BMC	JR AMC	JR 45S	JR RT	JR BD
Dredging	1983–84	1983–84	1981–82	1985[a]	1983–84	1983–84	1983	1983–84	None	None
Channelization	1960	1960	1981–82	N/A[b]	1960	1960	1950's	1950's	None	None
Bank Modification[c]	1960[d]	1960[d]	1981–82[e]	N/A	1960[d]	1960[d]	1983[f]	1983–84[f]	None	N/A[d]

*Station Codes: SC-NT= Surplus Canal, North Temple; SC-17S= Surplus Canal, 17th S; JR-10N= Jordan River, 10th N; JR-17S= Jordan River, 17th S; JR-AD= Jordan River, above Diversion; JR-BMC= Jordan River, below Mill Creek; JR-AMC= Jordan River, above Mill Creek; JR-45S= Jordan River, 45th S; JR-RT= Jordan River, Riverton; JR-BD= Jordan River, Bluffdale.

[a] This station has been dredged annually for the past five years, excluding 1986.
[b] No information available
[c] Bank modification records are vague and in many cases recent history is based on dredging/channelization information.
[d] Diked
[e] Levee work
[f] riprapping

Riverton. Figure 4 depicts this station which was located about 1/4 mile above the Highway 71 bridge near Riverton. The river in this reach is swift, with meanders and eroding banks. Shoreline vegetation was sparse or nonexistent, perhaps a result of past cattle grazing. Almost no riparian vegetation occurred in this station and shoreline cover was limited to grass banks. Twenty percent of the streambank exhibited no vegetation at all Table 1). The station was composed primarily of run type habitat, which comprised 92% of the available habitat, with a swift, deeper thalweg along the left bank. Other habitats in the area included fast shallow runs and several small to moderate size backwaters. A large, deep backwater that contained a sewage outfall was also present near the station and was sampled. This reach of the river, except for a short section near the Highway 71 bridge, has never been dredged (Table 2). Substrate was primarily fine and course gravel, with sand and silt along the shallow shoreline. Velocities were often above 3 fps in the main channel (Figure 4).

Reach Above Mill Creek

45th South. This station was within a fairly recently channelized section of the Jordan River. The banks were 90% rip-rapped with the remainder exhibiting significant erosion and no cover (Figure 5). Bank stabilization was performed during 1983-1984 (Table 2), but the river still meandered through this general area. The channel was fairly uniform in shape, although

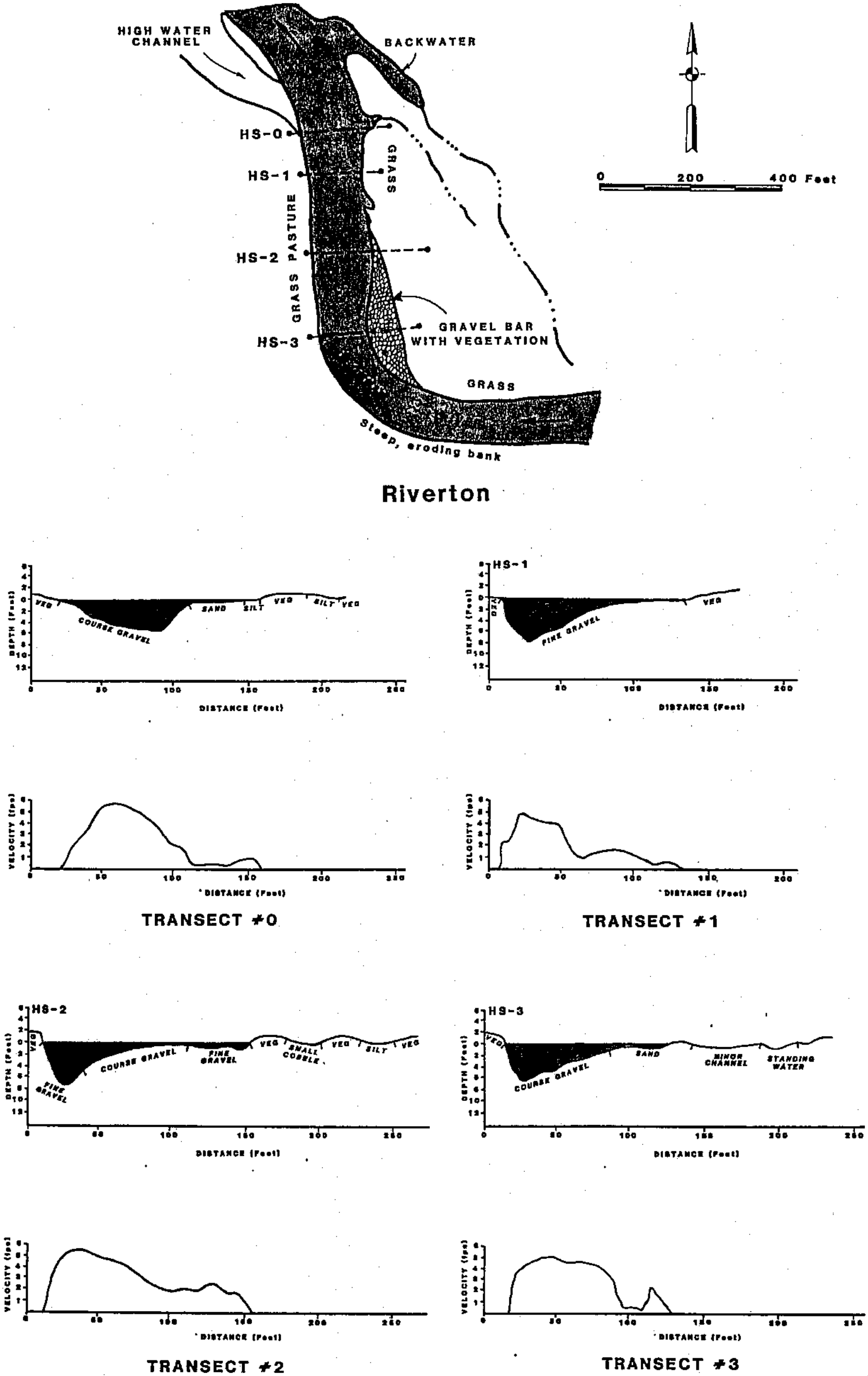


FIGURE 4. General diagram and cross-sectional profiles for the station at Riverton.

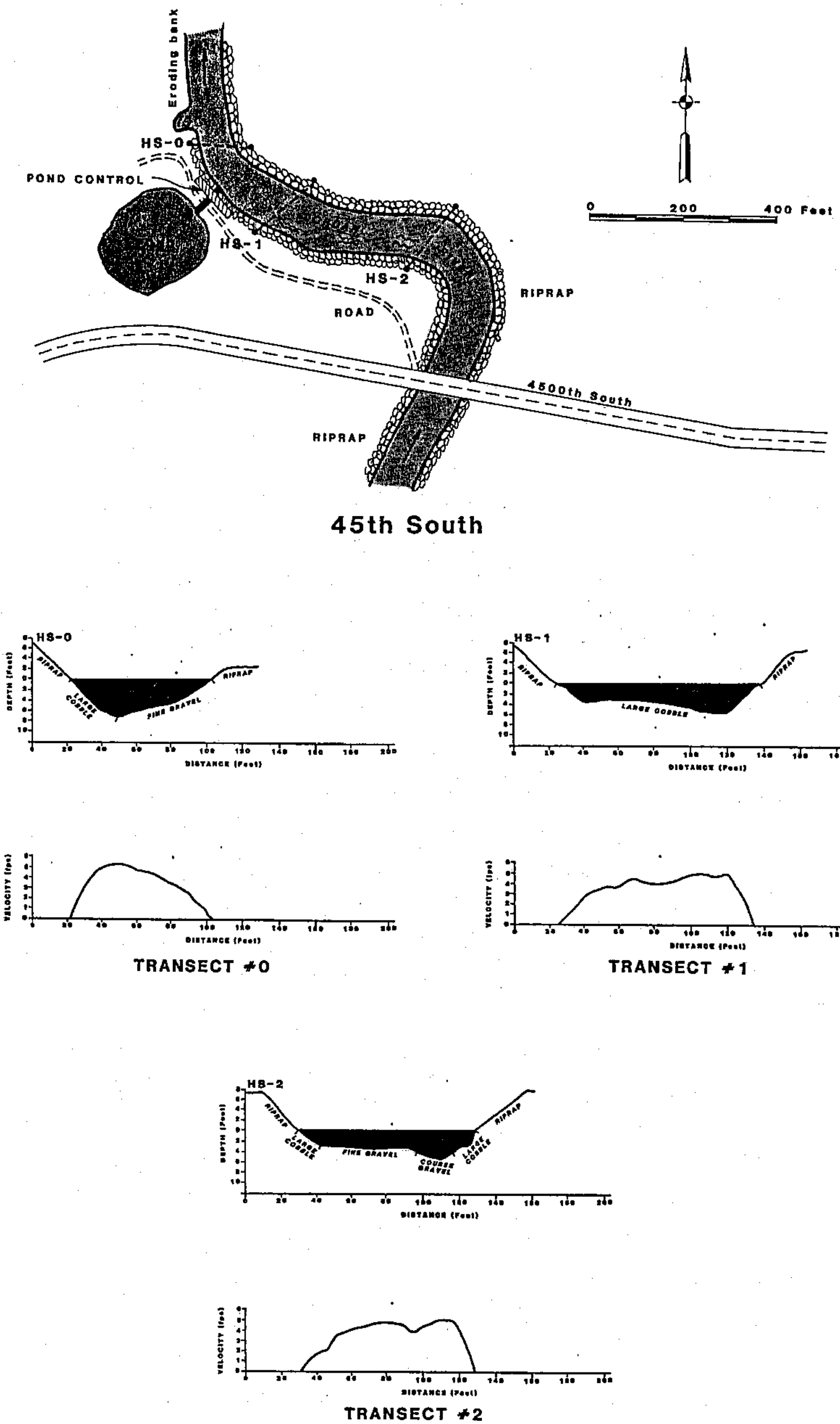


FIGURE 5. General diagram and cross-sectional profiles for the station at 45th South.

a thalweg was evident. This reach was last dredged during the flood control operations of Autumn 1983 and Spring 1984 (Table 2). Substrate was composed of cobbles and gravels. Streamside vegetation was absent due to the rip-rap, and velocities were swift, generally over 3 fps. Habitat types in the area included 20% deep riffle, 77% run and 3% eddy (Table 1). A backwater habitat that had a sewage discharge occurred just below the station. The backwater was actually the lower end of Little Cottonwood Creek which exhibited almost no flow at the time of sampling, other than the sewage discharge.

Above Mouth of Mill Creek. This station was located only a few hundred yards above the mouth of Mill Creek. The river in this area is relatively natural in that it has some meandering (Figure 6), although channelization had occurred in the past. This section of the river was last dredged in Autumn 1983 (Table 2). Streamside vegetation was fair to good, with a few trees providing instream cover. Approximately 19% of the station exhibited shoreline riparian cover primarily in the form of willows, 49% of the station was stabilized grass banks, 11% was riprapped bank and 21% was eroding banks with little or no cover (Table 1). A drainage canal entered along the east side of the 500 foot station forming an eddy at its junction with the river and a backwater habitat further inland. The station was composed primarily of run habitat (95%), with a firm clay-silt/gravel substrate. Velocities were fairly intermediate, generally between 2 and 3 fps, with 3 fps being the fastest recorded. This

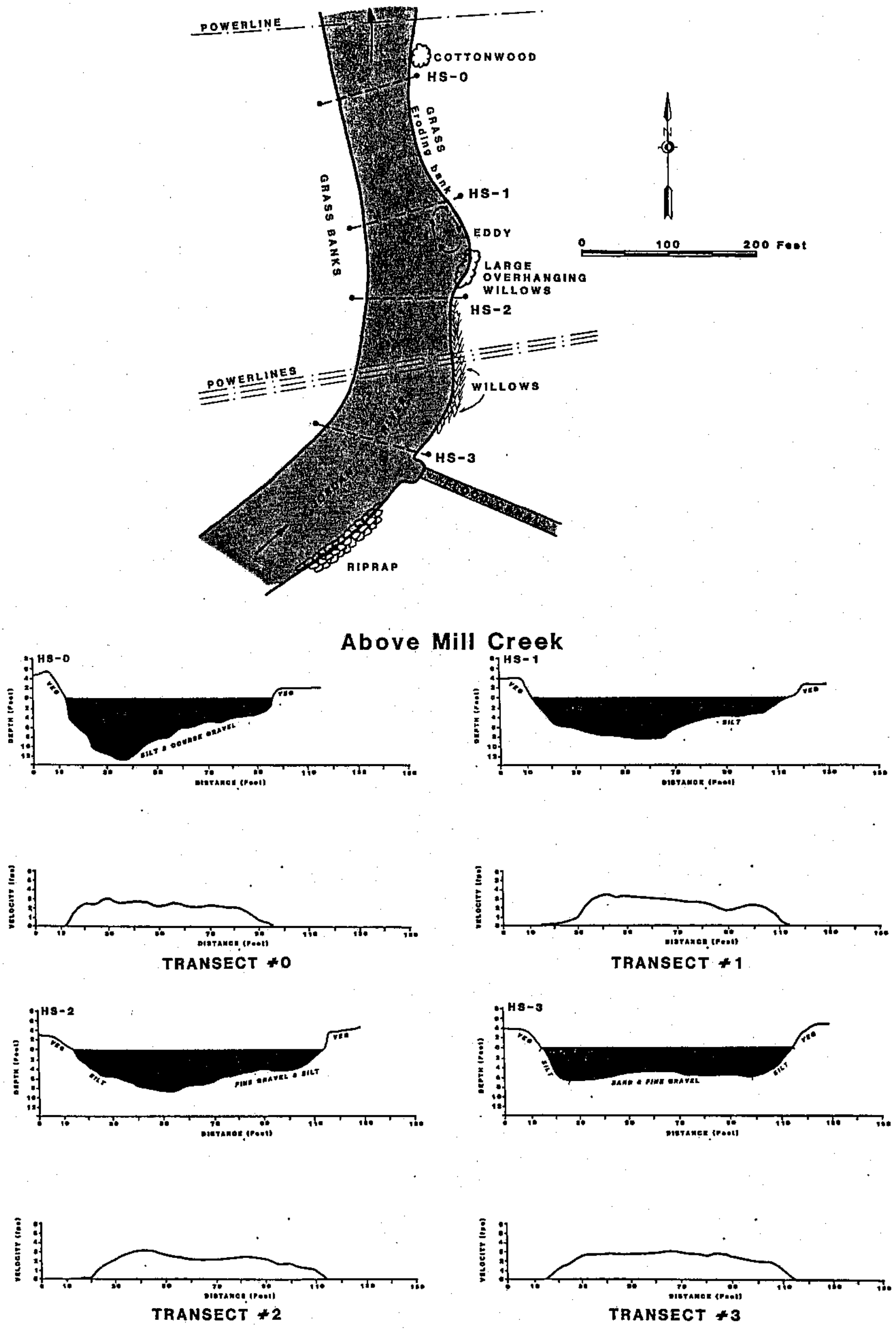


FIGURE 6. General diagram and cross-sectional profiles for the station above Mill Creek.

station had the deepest area recorded in the study, just over 12 feet deep.

Below Mouth of Mill Creek

Just Below Mill Creek. This station was located immediately below the mouth of Mill Creek in a short section which had been modified into a large canal between the mouth of Mill Creek and the Surplus Canal Diversion. The diagram of the station (Figure 7) shows the uniform nature of the station. The river from the confluence with Mill Creek through the Surplus Canal was initially enlarged during 1960. By 1983, extensive sediment deposition within this section necessitated a large-scale dredging operation. Dredging activities were conducted during 1983-1984, and included the channel at this station (Table 2). Velocities were intermediate, generally not much over 2 fps in the channel. Substrate was generally a firm clay-silt or gravel, and depths were fairly uniform across the channel. The station was almost entirely run habitat (95%), although a large backwater formed by a canal that was not flowing at the time of sampling was also located immediately downstream (Table 1). Banks were stable with shoreline vegetation composed primarily of luxuriant growths of grasses (95%) interspersed with some willows.

Above Surplus Canal Diversion. This station was similar to the one noted above, and was only about a 1/4 mile downstream (Figure 8). The river was very uniform and canal-like, with run being the predominate (98%) habitat type (Table 1).

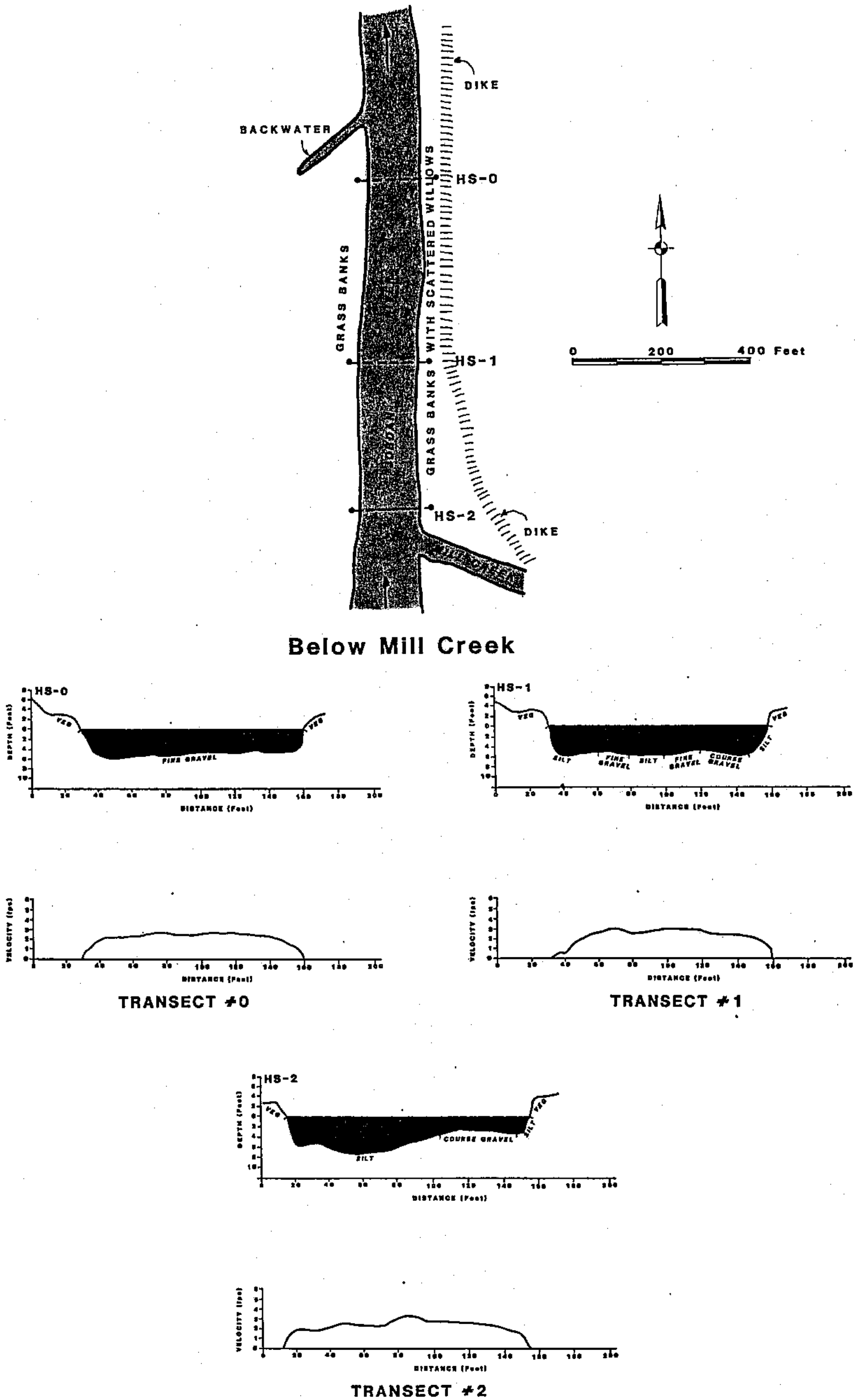
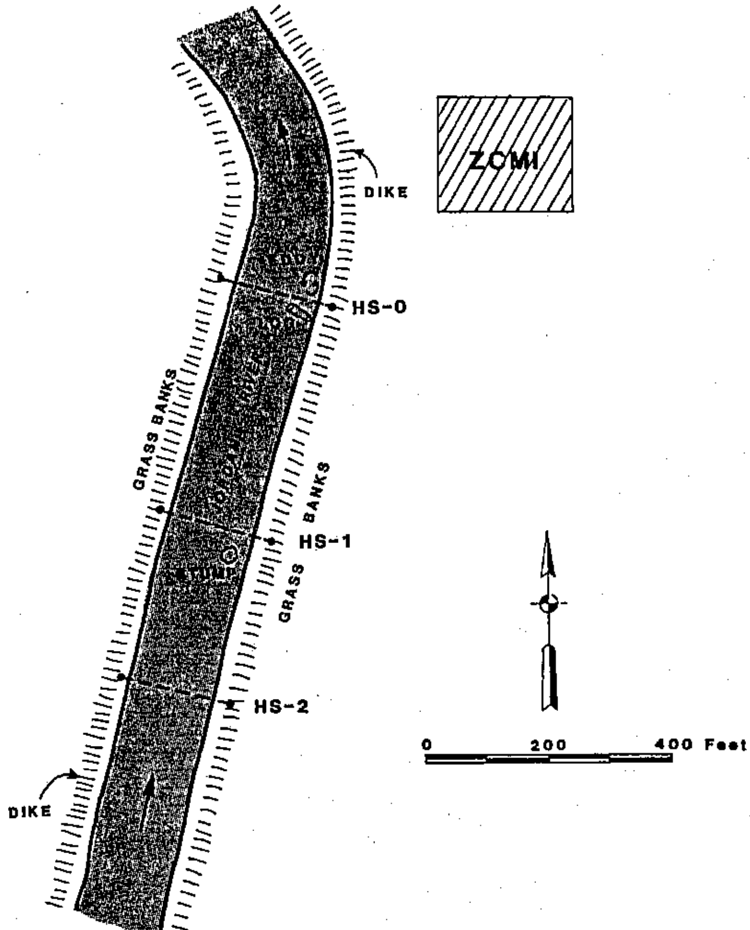
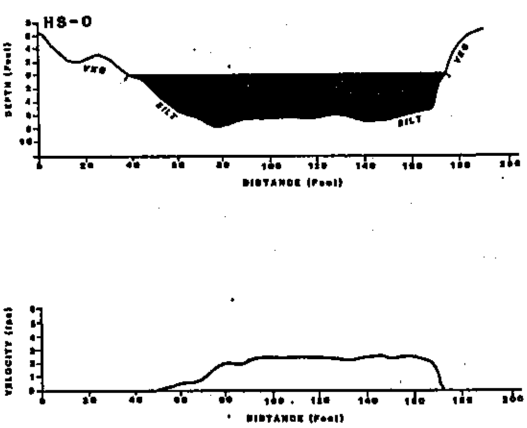


FIGURE 7. General diagram and cross-sectional profiles for the station below Mill Creek.



Above Diversion



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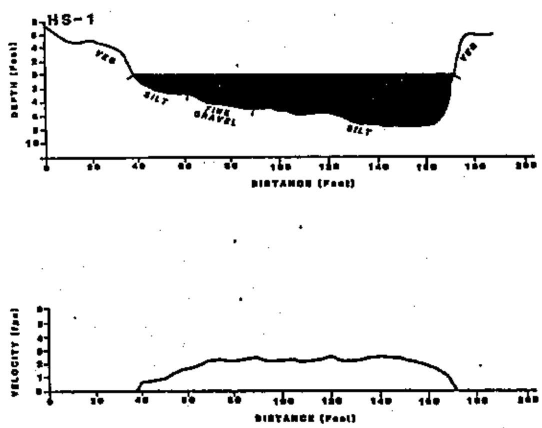

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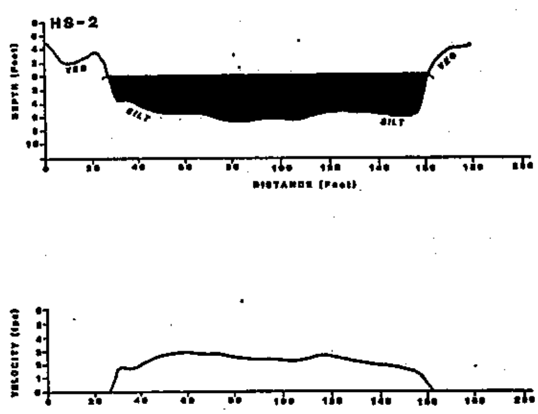

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FIGURE 8. General diagram and cross-sectional profiles for the station above diversion for surplus canal.

Substrate was primarily composed of a firm clay-silt with some gravel. Velocities were intermediate and depths moderate. The dredging history at this station is the same as described for the station immediately above and was last conducted during 1983-1984 (Table 2). Banks were stable and vegetated almost exclusively with tall grasses similar to the station just upstream. Limited instream cover was present in the form several stumps and floating debris.

Jordan River Below Surplus Canal Diversion

17th South. This station, located just below the diversion, was a slow run, with soft silt and sand substrates underlain by gravel and medium depths (Figure 9). Flows were less than 25 percent of the Jordan River above the diversion. Because of the boat launch facilities present at 17th South, dredging operations have occurred annually at this reach for the past five years; however, this section was not dredged last year (1986). Velocities were low, approximately 1 fps. Streamside vegetation was generally good, but variable within the area sampled. Streamside cover within the representative reach was approximately 76% grasses and 21% riparian vegetation. Some additional instream cover was provided by the railroad bridge at the station. The general area sampled included the river up to the diversion. Higher velocities and turbulence, as well as greater depths and increased riparian vegetation were noted just near the diversion. Overall habitat was a run (79%). One large backwater formed for

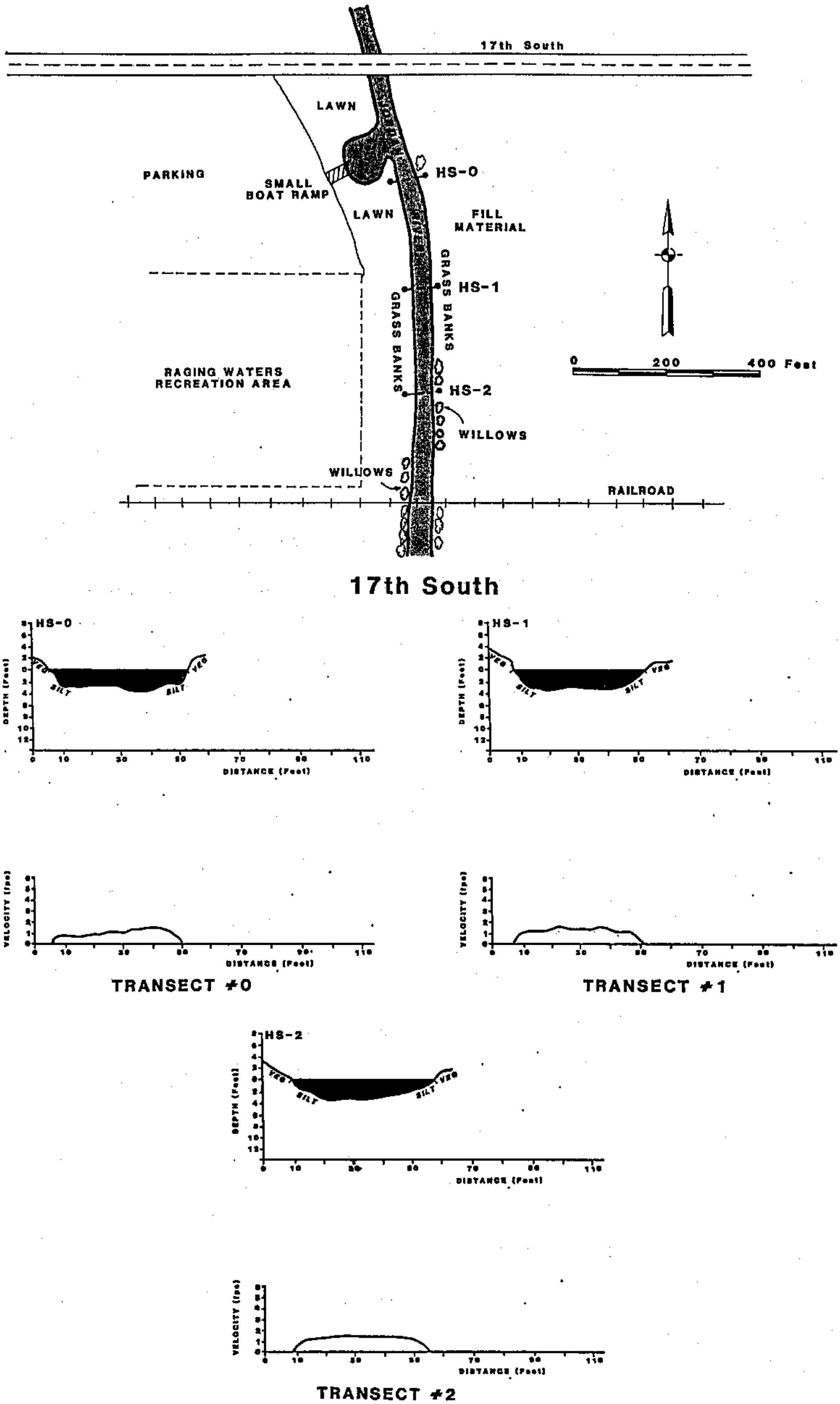


FIGURE 9. General diagram and cross-sectional profiles for the station at 17th South.

the boat launch was present, as well as limited amounts of eddy and riffle habitat (Table 1).

10th North. This station was predominately run habitat (99%), with fairly shallow depths, very slow velocities (less than 1 fps) and a sand or occasionally soft silt substrate (Figure 10). Streambanks were stable and streamside vegetation was generally good to excellent (Table 1), consisting primarily of heavy growths of grass (92%) and riparian vegetation (8%). Some instream cover consisting of trees and debris was noted. This reach has a fairly natural channel shape as it winds through the parkway. The river from approximately North Temple downstream past this station underwent extensive bank modification and dredging during 1981-1982 (Table 2).

Surplus Canal

17th South. The canal in this section appears very much like the Jordan River near Mill Creek. The channel is quite uniform, but overall depth is greater and velocity is generally lower than the upstream stations (Figure 11). Depth was near 12 feet at one transect. The river from the confluence with Mill Creek through the Surplus Canal was initially enlarged during 1960. By 1983, extensive sediment deposition within this section necessitated a large-scale dredging operation. Dredging activities were conducted during 1983-1984, and included the channel at this station. Substrate was a firm clay/gravel substrate.

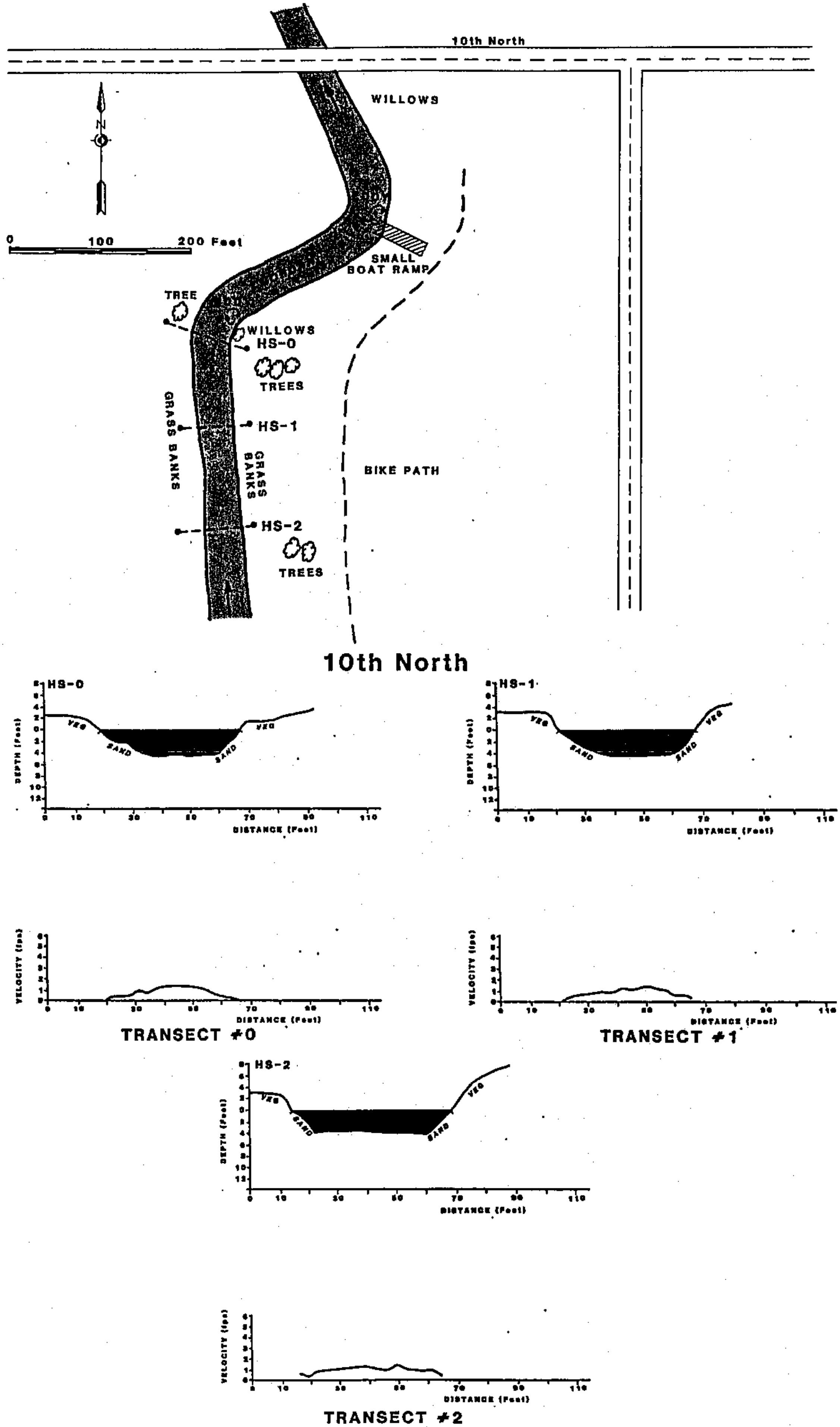


FIGURE 10. General diagram and cross-sectional profiles for the station at 10th North.

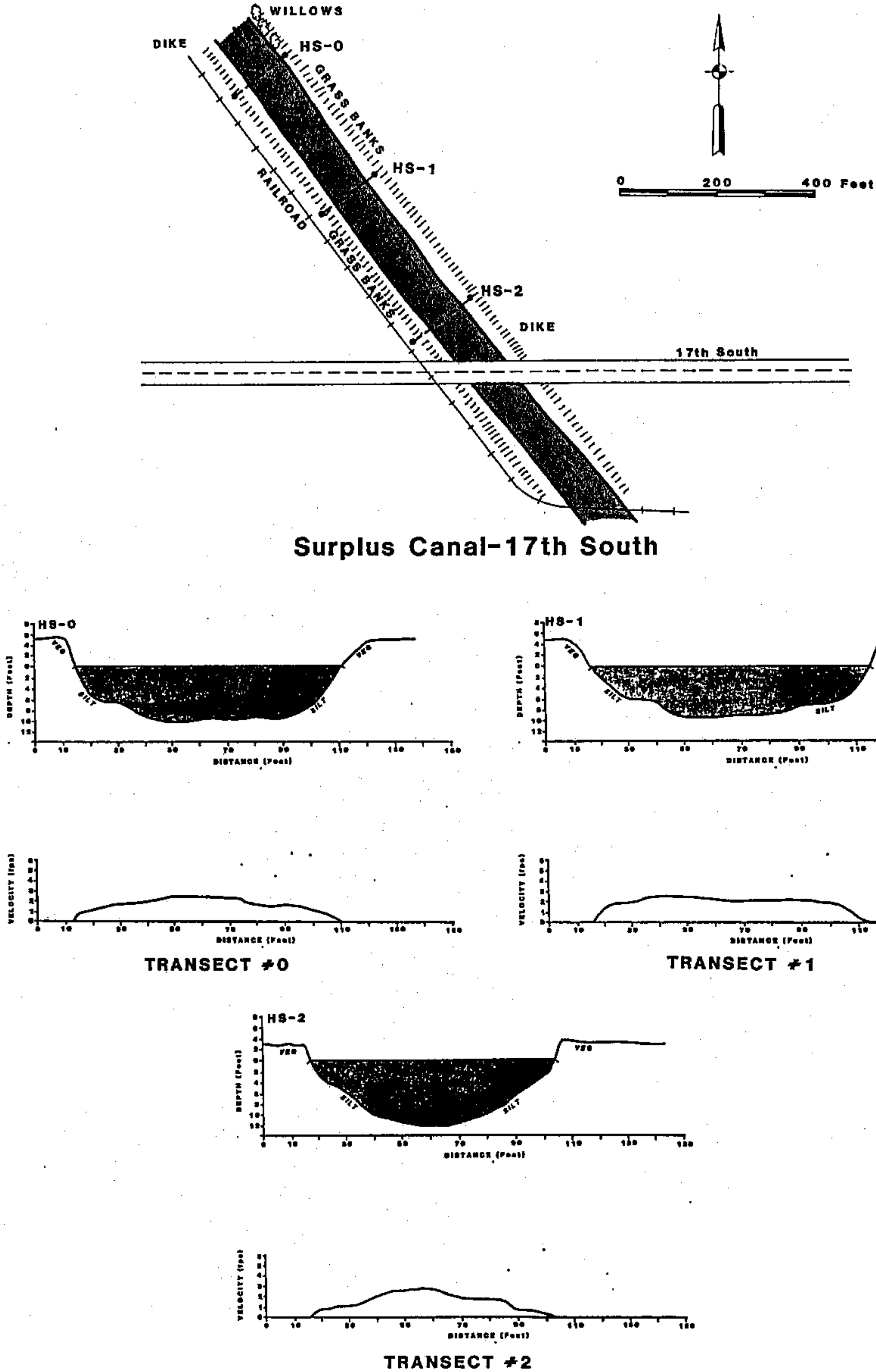


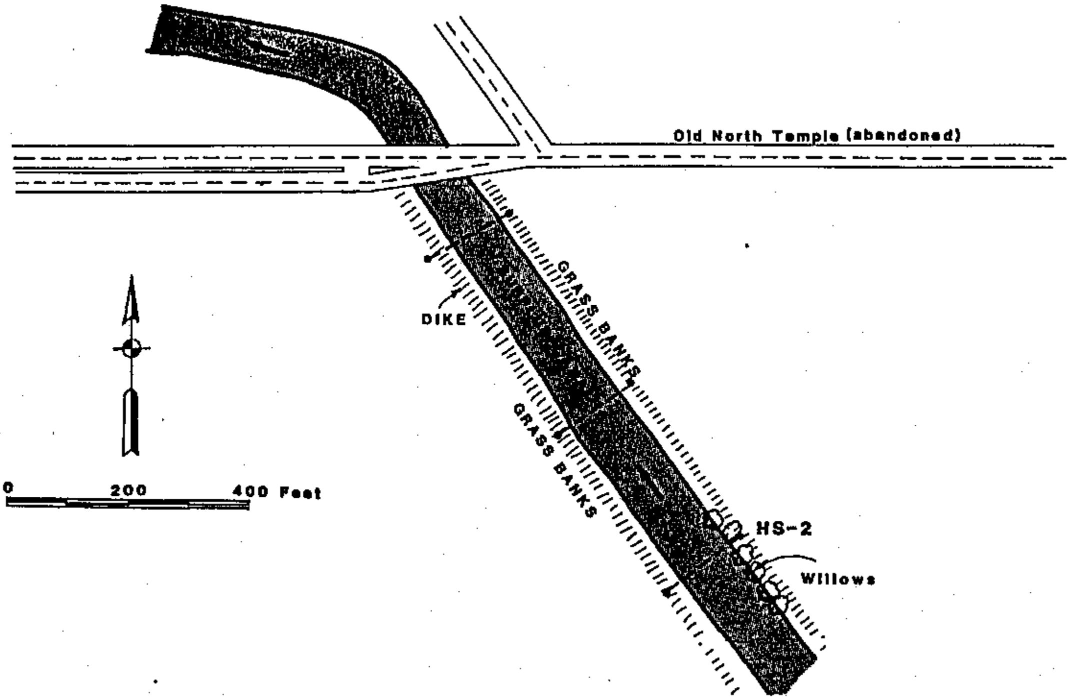
FIGURE 11. General diagram and cross-sectional profiles for the Surplus Canal station at 17th South.

The banks were stable and well vegetated with grasses (82%) and some riparian vegetation (7%) (Table 1). The entire area was run habitat with some instream cover provided by bridge pilings and occasional debris or flooded trees.

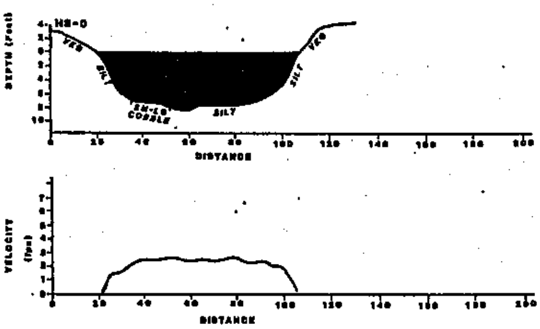
North Temple. This section of the lower Surplus Canal was quite similar to the 17th South station. It was not as wide, and had some rip-rapped banks, but otherwise was a similar uniform run habitat. It was fairly deep and exhibited intermediate velocities. The recent dredging history at this station is identical to that described for the upper station on the Surplus Canal (17^{th} South). Substrate was generally firm silt substrate, although some sand and cobble was also noted (Figure 12). Within the general area a series of wing dams had been placed in the channel to protect the banks from eroding, and provided a different habitat. Streambanks were relatively stable and bank vegetation was generally fair, consisting of grasses (88%) and some riparian vegetation.

Summary of Habitat

Habitat varied considerably between sections of the river, and at least as much within some sections. The upper most section, Riverton and Bluffdale, was the only area that had not been extensively dredged. The Bluffdale station had a variety of habitats and shoreline cover, but also high mid-channel velocities. The Riverton station had relatively poor habitat overall and some unstable banks. These two stations show the general



Surplus Canal-North Temple



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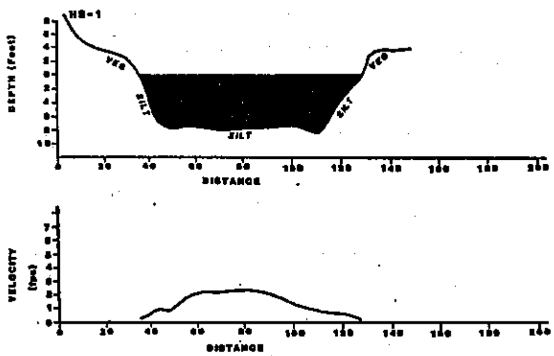

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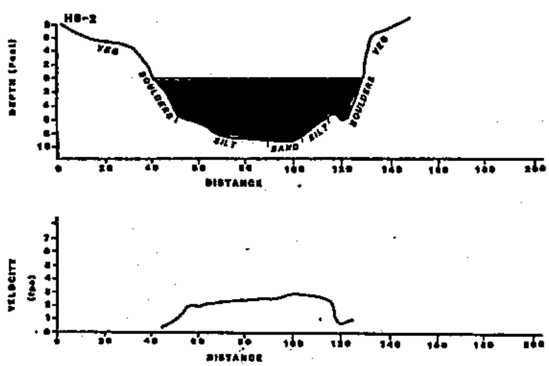

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FIGURE 12. General diagram and cross-sectional profiles for the Surplus Canal station at North Temple.

variability of "natural" portions of the Jordan River and suggest that overall habitat quality in the Jordan before recent dredging may not have been very high.

The stations below Riverton show a variety of man-induced changes. The station at 45th South was probably the most altered, with dredging and rip-rapped banks. A change occurs at the mouth of Mill Creek. The major flow is maintained in a large canal. This canal encompassed the station below Mill Creek and the station above the diversion, and also the two Surplus Canal stations. The lowermost Jordan River stations are in a fairly natural channel, but the flow regime shows little variation due to most of the flow being bypassed to the Surplus Canal. This has caused increased sedimentation further away from the diversion, although scouring near the diversion (17th South) has exposed more coarse substrates. Therefore, the 17th South stations are potentially quite different than the lowermost stations on both the Surplus Canal and the Jordan River.

A major habitat feature lacking at all stations except Bluffdale was mid-channel cover or habitat differentiation. No mid-channel obstructions, sand bars, or depth changes were noted. This is probably a function of the extensive dredging that has occurred, but may also be partially due to the natural form of the Jordan River.

Macroinvertebrates

A total of 81 invertebrate samples were collected from the Jordan River during the study. Samples were collected from the available habitats which included runs, riffles and backwaters and a variety of substrates. The average number of invertebrates per square foot for all samples collected at a study site is shown in Table 3. Results are also tabulated for the various habitats and substrates sampled, although not all habitats and substrates occurred at each study site. Table 4 lists mean invertebrate densities at each habitat sampled in a station. Table 5 shows mean densities of invertebrates in the various substrates that occurred at each study site.

Population Densities

A total of 34 different taxa of invertebrates were identified from the Jordan River and Surplus Canal. Oligochaetes and chironomid larvae were the most commonly occurring organisms though *Hydropsyche* sp. (caddisfly larvae) were also common, especially in the most upstream reaches. Highest mean density and numbers of species of invertebrates occurred in the Jordan River near Bluffdale and at the Riverton station (Table 3). Densities and species occurrence at stations downstream of Riverton were lower and variable. Total densities ranged from 6.6 to 47.1 organisms/ft^2.

Table 3.
MEAN DENSITIES OF BENTHIC INVERTEBRATES (#/Ft)
IN THE JORDAN RIVER, FALL 1986.

STATION*	SC NT	SC 17S	JR 10N	JR 17S	JR AD	JR BMC	JR AMC	JR 45S	JR RT	JR BD
Helobdella stagnalis	.0	.0	.0	.0	.0	.0	.0	.0	1.1	.0
Unidentified Hirudinea	.0	.0	.0	.0	.0	.0	.3	.0	.0	3.1
Oligocheata	3.9	28.8	9.6	25.6	15.9	15.9	35.5	2.9	33.6	8.9
Dubiraphia sp.	.0	.0	.0	.0	.0	.3	.0	.0	.0	.0
Haliplus sp.	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0
Hydrobium sp.	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0
Microcylleopus sp.	.0	.0	.0	.0	.0	.0	.0	.0	.1	.8
Stenelmis sp.	.0	.0	.0	.1	.0	.0	.0	.0	.1	6.3
Asellus sp.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1
Bezzia sp.	.0	.0	.0	.0	.0	.0	.0	.0	2.3	.0
Chironomus sp.	.0	11.0	1.4	7.5	.9	.8	.4	.0	56.0	.8
Dicrotendipes sp.	.0	.0	.0	.1	.0	.0	.0	.0	.0	.0
Parachironomus sp.	.0	.0	.0	.6	.0	.0	.0	.0	6.6	.0
Polypedilium sp.	.0	.0	.0	2.5	6.0	2.5	2.1	6.6	5.6	27.5
Tanytarsus sp.	.0	.0	.0	.0	.0	.0	.1	.0	4.9	.0
Chironomidae pupae	.0	.0	.0	.1	.0	.0	.0	.0	.0	.0
Cricotopus sp.	.1	.2	.1	.6	.3	1.5	1.8	2.4	1.4	4.6
Paratendipes sp.	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0
Unident. Orthocladinae	.5	1.2	.3	.4	.6	1.6	1.9	3.6	3.1	1.8
Orthocladinae pupae	.0	.0	.0	.0	.0	.1	.0	.0	.0	.0
Alotanypus sp.	.0	.0	.0	.1	.0	.0	.0	.0	.0	.0
Cnephia sp.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1
Simulium sp.	.0	.0	.0	.0	.0	.0	.0	.0	.3	2.3
Tricorythodes sp.	.1	.0	.0	.1	.0	.0	1.5	2.6	.4	2.0
Corisella decolor	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1
Corisella tarsalis	.0	.0	.0	.0	.0	.0	.0	.0	.1	.3
Hesperocorixa laevig	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1
Gyraulus sp.	.0	.0	.0	.4	.1	.8	.3	.0	.1	.1
Physa sp.	.0	.0	.0	.3	.5	.4	.0	.0	4.3	.8
Gomphus sp.	.0	.2	.0	.1	.0	.0	.0	.0	.0	.0
Ischnura sp.	.0	.0	.0	.0	.0	.0	.4	.1	.0	.0
Unidentified Nematoda	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0
Hydropsyche sp.	2.0	.2	.0	.4	.0	1.2	3.0	3.6	5.0	52.0
Planaridae	.0	.0	.0	.0	.0	.0	.0	.0	.0	21.4
Total	6.6	41.8	11.4	39.0	24.3	25.1	47.1	22.0	125.3	132.9
Standard Error	1.6	16.6	2.0	9.1	4.2	6.7	10.3	4.6	33.3	50.9
No. Samples	8	5	8	8	8	12	8	8	8	8

*Station Codes: SC-NT= Surplus Canal, North Temple; SC-17S= Surplus Canal, 17th S; JR-10N= Jordan River, 10th N; JR-17S= Jordan River, 17th S; JR-AD= Jordan River, above Diversion; JR-BMC= Jordan River, below Mill Creek; JR-AMC= Jordan River, above Mill Creek; JR-45S= Jordan River, 45th S; JR-RT= Jordan River, Riverton; JR-BD= Jordan River, Bluffdale.

Table 4. BENTHIC MACROINVERTEBRATE DENSITIES ($\#/FT^2$) AT STUDY SITES IN RELATION TO HABITAT.

STATION*	SC NT	SC 17S	JR 10N	JR 17S	JR AD	JR BMC	JR AMC	JR 45S	JR RT	JR BD	JR BD	JR BMC	JR AMC	JR RT
------SPECIES----------	-RUN-										-RIFFLE-	---BACKWATER---		
Helobdella stagnalis	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	2.3
Unidentified Hirudinea	.0	.0	.0	.0	.0	.0	.4	.0	.0	.0	6.3	.0	.0	.0
Oligocheata	3.9	28.8	9.6	16.3	15.9	11.4	29.6	2.9	16.3	6.0	11.8	25.0	45.3	51.0
Dubiraphia sp.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.8	.0	.0
Haliplus sp.	.0	.0	.0	.0	.0	.0	.0	.0	.3	.0	.0	.0	.0	.0
Hydrobium sp.	.0	.0	.0	.0	.0	.0	.0	.0	.3	.0	.0	.0	.0	.0
Microcylleopus sp.	.0	.0	.0	.0	.0	.0	.0	.0	.3	.0	1.5	.0	.0	.0
Stenelmis sp.	.0	.0	.0	.0	.0	.0	.0	.0	.3	.3	12.3	.0	.0	.0
Asellus sp.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.3	.0	.0	.0	.0
Bezzia sp.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	4.5
Chironomus sp.	.0	11.0	1.4	.0	.9	.0	.2	.0	.3	.0	1.5	2.5	.7	111.8
Dicrotendipes sp.	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Parachironomus sp.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	13.3
Polypedilium sp.	.0	.0	.0	4.8	6.0	3.6	2.2	6.5	11.3	1.8	53.5	.3	2.0	.0
Tanytarus sp.	.0	.0	.0	.0	.0	.0	.2	.0	.0	.0	.0	.0	.0	9.8
Chironomidae pupae	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Cricotopus sp.	.1	.2	.1	1.0	.3	2.3	2.6	2.4	1.3	.0	9.3	.0	.3	1.5
Paratendipes sp.	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Unident. Orthocladinae	.5	1.2	.3	.8	.6	2.4	2.8	3.6	4.8	.3	3.3	.0	.3	1.5
Orthocladinae pupae	.0	.0	.0	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0
Alotanypus sp.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Cnephia sp.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.3	.0	.0	.0
Simulium sp.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	4.5	.0	.0	.5
Tricorythodes sp.	.1	.0	.0	.3	.0	.0	2.2	2.6	.8	.0	4.0	.0	.3	.0
Corisella decolor	.0	.0	.0	.0	.0	.0	.0	.0	.0	.3	.0	.0	.0	.0
Corisella tarsalis	.0	.0	.0	.0	.0	.0	.0	.0	.0	.5	.0	.0	.0	.3
Hesperocorixa laevig	.0	.0	.0	.0	.0	.0	.0	.0	.0	.3	.0	.0	.0	.0
Gyraulus sp.	.0	.0	.0	.8	.1	1.1	.4	.0	.3	.0	.3	.3	.0	.0
Physa sp.	.0	.0	.0	.5	.5	.1	.0	.0	.5	1.5	.0	1.0	.0	8.0
Gomphus sp.	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Ischnura sp.	.0	.0	.0	.0	.0	.0	.6	.1	.0	.0	.0	.0	.0	.0
Unidentified Nematoda	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0	.0	.0	.0	.0
Hydropsyche sp.	2.0	.2	.0	.5	.0	1.8	4.6	3.6	10.0	.5	103.5	.0	.3	.0
Planaridae	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	42.8	.0	.0	.0
Total	6.6	41.8	11.4	25.0	24.3	22.8	45.8	22.0	46.3	11.5	254.3	29.8	49.3	204.3
Standard Error	1.6	16.6	2.0	2.9	4.2	6.4	16.1	4.6	22.0	2.6	47.4	17.1	11.1	22.9
No. Samples	8	5	8	4	8	8	5	8	4	4	4	4	3	4

*Station Codes: SC-NT= Surplus Canal, North Temple; SC-17S= Surplus Canal, 17th S; JR-10N= Jordan River, 10th N; JR-17S= Jordan River, 17th S; JR-AD= Jordan River, above Diversion; JR-BMC= Jordan River, below Mill Creek; JR-AMC= Jordan River, above Mill Creek; JR-45S= Jordan River, 45th S; JR-RT= Jordan River, Riverton; JR-BD= Jordan River, Bluffdale.

Table 5. BENTHIC MACROINVERTEBRATE DENSITIES (#/FT^2) AT STUDY SITES IN RELATION TO SUBSTRATE.

STATION*	SC NT	SC 17S	JR 10N	JR 17S	JR AD	JR BMC	JR AMC	JR BD	SC NT	JR 17S	JR BMC	JR AMC	SC NT	JR AD	JR BMC	JR 45S	JR BD	JR BMC	JR RT	JR RT
SPECIES	SILT								SAND				CLAY			COBBLE		GRAVEL		DETRITUS
Helobdella stagnalis	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	2.3
Unidentified Hirudinea	.0	.0	.0	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	6.3	.0	.0	.0
Oligocheata	7.0	28.8	9.6	34.9	17.7	20.0	44.8	6.0	2.5	16.3	.0	7.5	1.7	3.0	13.3	2.9	11.8	17.0	16.3	51.0
Dubiraphia sp.	.0	.0	.0	.0	.0	.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Haliplus sp.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.3	.0
Hydrobium sp.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.3	.0
Microcylleopus sp.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.5	.0	.3	.0
Stenelmis sp.	.0	.0	.0	.3	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	12.3	.0	.3	.0
Asellus sp.	.0	.0	.0	.0	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Bezzia sp.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	4.5
Chironomus sp.	.0	11.0	1.4	15.0	1.0	2.0	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.5	.0	.3	111.8
Dicrotendipes sp.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Parachironomus sp.	.0	.0	.0	1.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	13.0
Polypedilium sp.	.0	.0	.0	.3	6.4	.4	2.5	1.8	.0	4.8	.0	1.0	.0	3.0	.0	6.6	53.3	9.3	11.3	.0
Tanytarus sp.	.0	.0	.0	.0	.0	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	9.8
Chironomidae pupae	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Cricotopus sp.	.0	.2	.1	.3	.3	.0	1.8	.0	.0	1.0	.0	1.5	.3	.0	1.3	2.4	9.3	4.7	1.3	1.5
Paratendipes sp.	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Unident. Orthocladinae	.7	1.2	.3	.0	.7	.2	2.2	.3	1.0	.8	.0	1.0	.0	.0	3.0	3.6	3.3	3.0	4.8	1.5
Orthocladinae pupae	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.3	.0	.0
Alotanypus sp.	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Cnephia sp.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.3	.0	.0	.0
Simulium sp.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	4.5	.0	.0	.5
Tricorythodes sp.	.0	.0	.0	.0	.0	.0	2.0	.0	.0	.3	.0	.0	.3	.0	.0	2.6	4.0	.0	.8	.0
Corisella decolor	.0	.0	.0	.0	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Corisella tarsalis	.0	.0	.0	.0	.0	.0	.0	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.3
Hesperocorixa laevig	.0	.0	.0	.0	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Gyraulus sp.	.0	.0	.0	.0	.1	.4	.3	.0	.0	.8	2.0	.0	.0	.0	2.0	.0	.3	.0	.3	.0
Physa sp.	.0	.0	.0	.0	.6	.8	.0	1.5	.0	.5	1.0	.0	.0	.0	.0	.0	.0	.0	.5	8.0
Gomphus sp.	.0	.2	.0	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Ischnura sp.	.0	.0	.0	.0	.0	.0	.3	.0	.0	.0	.0	.5	.0	.0	.0	.1	.0	.0	.0	.0
Unidentified Nematoda	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0	.0	.0
Hydropsyche sp.	2.0	.2	.0	.3	.0	1.2	3.3	.5	4.0	.5	1.0	2.0	.7	.0	1.3	3.6	103.5	1.0	10.0	.0
Planaridae	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	42.8	.0	.0	.0
Total	9.7	41.8	11.4	52.9	26.9	25.6	58.3	11.5	7.5	25.0	4.0	13.5	3.0	6.0	21.0	22.0	254.3	35.3	46.3	204.3
Standard Error	3.2	16.6	2.0	15.9	3.9	13.8	9.7	2.6	1.5	2.9	.0	6.5	1.2	.0	11.0	4.6	47.4	9.7	22.0	22.9
No. Samples	3	5	8	4	7	5	6	4	2	4	1	2	3	1	3	8	4	3	4	4

*Station Codes: SC-NT= Surplus Canal, North Temple; SC-17S= Surplus Canal, 17th S; JR-10N= Jordan River, 10th N; JR-17S= Jordan River, 17th S; JR-AD= Jordan River, above Diversion; JR-BMC= Jordan River, below Mill Creek; JR-AMC= Jordan River, above Mill Creek; JR-45S= Jordan River, 45th S; JR-RT= Jordan River, Riverton; JR-BD= Jordan River, Bluffdale.

Riffle, run and backwater habitats were sampled within the stations when they were available. A breakdown of invertebrate samples by habitat and station is shown in Table 4. The riffle habitat at Bluffdale, which was the only riffle habitat sampled, exhibited the highest total density of any habitat during this study (254/ft^2). The most abundant species were *Hydropsyche* sp. and the chironomid larvae *Polypedilium* sp., although a number of other larvae occurred in low to moderate densities. Total densities of invertebrates in backwater habitats ranged from 29.8 to 204.3/ft^2. Dominant species in backwaters were Oligochaetes and *Chironomus* sp. Runs were the most common habitats sampled. Total density of invertebrates in run habitats was lower than riffle or backwater habitats and ranged between 6.6 and 46.3 organisms/ft^2. The most commonly occurring taxa in the run habitats were Oligochaetes and Chironomid larvae, particularly *Polypedilium* sp.

Table 5 shows invertebrate densities in relation to the substrates present at each site. Only two sites, Bluffdale and 45th South exhibited rubble substrates. Total densities at these sites ranged from 22.0 to 254.3 organisms/ft^2. Most abundant species at these sites included *Hydropsyche* sp., *Polypedilium* sp., and various Elmid beetle larvae. Gravel substrates occurred in invertebrate samples at only two sites, Riverton and the Jordan River just above Mill Creek. Total densities ranged from 35.3 to 46.3 organisms/ft^2. The only organisms that occurred in these samples were Oligochaetes and several taxa of Chironomid larvae, of which Polypedilium sp. was the most abundant. Silt was the most commonly occurring substrate in the invertebrate samples. Silt substrates occurred at all sites except Riverton and 45th South. Total density of invertebrates in silt substrates ranged from 9.7 to 58.3 organisms/ft^2. Oligochaetes were the most abundant organism in the silt. Chironomus sp. and Polypedilium sp. were also common in some areas. Sand substrates were present in some of the invertebrate samples from the Surplus Canal at North Temple, the Jordan River at 17th South and the Jordan River above Mill Creek. Total densities in these samples were relatively low, ranging from 7.5 to 25.0 organisms/ft^2. The most abundant organism in these samples was oligochaetes. Clay or hardpack silt substrates occurred in invertebrate samples from the Surplus Canal at North Temple, the Jordan River above the Surplus Canal Diversion and the Jordan River below Mill Creek. Sample densities ranged between 3.0 and 21.0 organisms/ft^2. Limited numbers of taxa occurred, with oligochaetes being the most common. Detritus or silt substrates rich in organic material occurred only in a backwater on the Jordan River at Riverton. Total mean density of invertebrates from these samples was 204.3/ft^2. Chironomus sp. was the most abundant organism, followed by oligochaetes.

Species Discussion

Highest overall densities of benthic invertebrates were observed at the two uppermost sites on the Jordan River, Bluffdale and Riverton. Total density of invertebrates was similar at

- highest

these two sites, although species composition was very different. Species composition at Bluffdale was dominated by Hydropsyche sp. and Polypedilium sp. that occurred in the riffle habitat, while the predominate species at Riverton were Chironomus sp. and oligochaetes which were present in a backwater habitat with a rich organic substrate.

Below Riverton invertebrate densities in the Jordan River were much lower and quite variable. Due to the inherent variability within invertebrate samples, the small variability between the lower stations may be real or an artifact of sampling resulting from the relatively small number of samples. The following discussion points out some of the variation and potential reasons for the variation, assuming it is real. The 45th South station had low invertebrate densities (Tables 3 and 4), even though the sampling included a cobble substrate, which is generally very good for high densities of invertebrates. The substrate was unstable, however, and primarily composed of materials brought in for bank stabilization (rip-rap). This may have accounted for the low density of invertebrates.

Some reduction in invertebrate densities occurred below Mill Creek (Tables 3 and 4) although some upstream areas also exhibited reduced densities. Reduced average densities immediately below Mill Creek could be the result of the toxic effects of high chlorine levels in Mill Creek. Samples taken along the right bank of the river, where the effluent from Mill Creek mixes with the Jordan River exhibited a mean density of 15 organisms/ft^2, whereas mean invertebrate densities on the opposite side of the river that were not influenced by any effluent from Mill Creek averaged 30 organisms/ft^2. Mill Creek proper, near its confluence with the Jordan exhibited a density of <2.5 organism/ft^2.

Another reason for the decrease below Mill Creek may be related to substrate. As noted in the Habitat section above, the area below Mill Creek has a finer substrate and reduced gradient. Most of this area is within a canal. However, the Surplus Canal Diversion does create some differentiation by providing higher velocities and scouring below the diversion. Tables 3 and 4 indicate that the 17th South stations on both the Jordan River and Surplus Canal had higher invertebrate densities than the lower stations or the stations just above the diversion. This would indicate that the habitat differences noted above may have a larger effect on invertebrate densities than potential water quality changes near Mill Creek.

Overall density of invertebrates in the Jordan River was low in comparison to many southwestern rivers where samples were collected in relatively stable, usually cobble substrates. Holden and Crist (1981) reported benthic invertebrate densities in the Green and Yampa rivers of Utah and Colorado that were typically in excess of 1,000 organisms per ft^2. Payne (1979) reported benthic invertebrate densities usually in excess of 1500 organisms per ft^2 from the Strawberry River, Utah. In contrast, invertebrate densities for the Jordan River (7-133 organisms/ft^2) were relatively similar to densities reported for some southwestern rivers with unstable substrates dominated by sand and silt. Holden et al. (1980) found densities of invertebrates in the San Juan River near Mexican Hat, Utah, an area of shifting sand substrate, to be typically under 100 organisms per ft^2.

Overall species composition and mean density of invertebrates during this study were similar to that reported by Hinshaw (1966) for the Jordan River, although somewhat more species were collected by Hinshaw due to the larger time period encompassed and larger number of samples collected. The only major difference in taxa collected was the crustaceans *Gammarus* sp. and *Hyallela* sp.. Although Hinshaw found these organisms to be relatively common, none were collected during the course of this study. High density and diversity of benthic invertebrates were observed in this study at the Bluffdale and Riverton sites compared to the lower river and Surplus Canal (Table 3). Hinshaw (1966) observed a similar trend and attributed it primarily to downstream water pollution and degradation of habitat as a result of channelization. However, since 1966 water quality in the Jordan has improved substantially. Large sludge beds observed by Hinshaw were not present in the river sections sampled in this study despite the overall similarity in study areas. Water conductivity and hardness values were lower and dissolved oxygen values higher in this study compared to those reported by Hinshaw. In general, water quality is presently better than in 1966 due to a combination of improved pollution control and higher flows within the Jordan River basin.

During this study, water quality did not appear to exert an overriding effect on populations of benthic invertebrates. High overall benthic invertebrate densities at the Bluffdale and Riverton sites relative to other sites can be attributed to the specific habitats sampled rather than gross differences in water quality. High overall density and diversity at the Bluffdale site was due primarily to the fact that half of the samples collected from this site were from a riffle habitat with cobble substrate. Riffles are typically the most productive areas in a stream and usually support a diverse assemblage of organisms due to the diversity and stability of the substrate and high consistent oxygen levels. No other stations sampled contained riffle habitats. High overall benthic densities at the Riverton site were primarily a result of a large population of *Chironomus* sp. that occurred in a backwater habitat with a rich organic substrate. No similar organic or detritus-laden substrates occurred in other samples taken in the study. Muck or organic substrates can be very productive, though often limited in the number of species that occur (Hynes 1970).

A comparison of samples taken in a similar habitat at each station (runs) is made in Table 4. Runs were the most commonly occurring habitat within the overall study area and were sampled at each site. As such, benthic invertebrate densities in runs provide a means of comparing the different sites along the Jordan River without the complicating factor of differing habitats. Run habitats in the Jordan River supported low densities of macroinvertebrates at all sites on the Jordan River with no apparent trend between upstream and downstream areas. The variations noted below Mill Creek between the 17th South stations and other stations are also seen in the run data of Table 4. The 17th South stations have higher densities than the other stations in this area, probably because of the presence of better substrates due to the scouring caused by the diversion.

Although data are limited, they suggest that variations in densities between the run habitats at different stations may be due to the substrate present in the samples at those stations. Table 5 shows the various substrates that occurred in samples at each station. Cobble substrates in riffles showed the greatest density and diversity of invertebrates of any samples, while cobble substrates in runs showed lower densities, similar to gravel substrates. Silt substrates exhibited variable densities of primarily oligochaetes and chironomid larvae, but generally supported greater densities than sand or clay substrates. Detritus or organic substrates were relatively uncommon but supported high densities of chironomid larvae and oligochaetes.

Higher densities of benthic invertebrates in runs at Riverton, above Mill Creek and the Surplus Canal at 17th South appear to be related to the gravel, cobble, and silt substrates present at those sites. The remaining sites, which exhibited lower densities, were taken from a combination of silt, clay and sand substrates.

Overall mean benthic invertebrate density was greater at the Bluffdale and Riverton sites. Higher benthic invertebrate densities at these sites relative to the rest of the study area was related to the presence of productive riffle and backwater habitats that were not present at other sites. A comparison of benthic invertebrate densities in runs, a habitat that occurred at all study sites, did not show a major difference between upstream and downstream areas. Differences observed in the density of invertebrates between the various run samples appear to have been related to substrates.

Fish

Two general types of sampling were conducted for this study. The first involved sampling within a representative 500 foot section of each station with the intent of determining population levels. The second type of sampling involved sampling outside the 500 foot station, often in rare types of habitats not represented in the 500 station. The first type of sampling involved all habitats within the station without separating out catch per habitat type. The second type of sampling concentrated on individual habitats, rather than a given discrete area. Therefore, the first type of sampling is best suited to describe the general fish populations found at each station and for comparison between stations. The second type is best suited to describe habitats used by the fish and for adding to a list of species found at a given station. Together they provide a very good analysis of the general abundance and distribution of fish in the Jordan River.

Population Studies

Sampling was conducted at each station to determine population size and composition. Mark/recapture population estimates were attempted at all stations except the two most downstream Jordan River stations. At these two stations, 10th North and 17th South, a multiple pass population estimate was used. Table 6 shows the number of fish marked, the number caught during the second collection effort and the number of recaptures, along with the population estimate derived from that data. Multiple pass catches are also shown. Because carp were the only species recaptured at most stations, population estimates could generally be made for this species only. Utah suckers were recaptured at 45th South and Bluffdale, but not at other stations. Other species were generally found in very small numbers only and no marked fish were recaptured. At many of the stations where recapture of carp and Utah sucker occurred, the number of recaptures was very small compared to the total number of fish caught, making population estimates extremely large (Table 6).

Sampling at 10th North and 17th South was efficient enough to allow for population estimates of carp and Utah sucker using the multiple-pass technique, but not rarer species. These estimates are also shown in Table 6 along with the numbers of fish caught.

Population estimates of fish in the Jordan River are nearly impossible due to several factors. First, it appears that the two abundant species, carp and Utah suckers, probably move in and out of the stations fairly commonly, thus violating one of the primary assumptions of mark/recapture studies: that no migration occurs. Second, the deep water of most stations generally reduced the efficiency of electrofishing gear, reducing the percent of the available population that was captured. Population estimates were made only at the two lower Jordan River stations where the river size is much smaller. Third, many of the fish species present in the Jordan River are found only

Table 6. POPULATION ESTIMATES OF FISH CAUGHT DURING POPULATION SAMPLING

METHOD: Mark and Recapture Technique[1]

STATION[2]	SC-NT				SC-17S				JR-AD			
Species	M	N	R	P	M	N	R	P	M	N	R	P
Carp	54	58	6	522	26	10	5	52	43	58	2	1247
White Bass	2	6	0	–	5	1	0	–	8	9	0	–
Utah Sucker	0	0	0	–	0	0	0	–	31	41	0	–
Black Crappie	0	0	0	–	2	0	0	–	1	1	0	–
Walleye	0	0	0	–	2	0	0	–	0	0	0	–
Green Sunfish	0	0	0	–	0	0	0	–	0	0	0	–
Channel Catfish	0	0	0	–	1	0	0	–	0	0	0	–

METHOD: Mark and Recapture Technique

STATION	JR-BMC				JR-AMC				JR-45S			
Species	M	N	R	P	M	N	R	P	M	N	R	P
Carp	34	55	1	1870	47	52	8	306	29	29	12	70
White Bass	0	0	0	–	12	9	0	–	3	1	0	–
Utah Sucker	50	37	0	–	44	32	0	–	93	56	10	521
Black Crappie	0	0	0	–	1	2	0	–	0	0	0	–
Walleye	1	3	0	–	0	0	0	–	1	2	0	–
Green Sunfish	1	0	0	–	0	0	0	–	4	3	0	–
Channel Catfish	0	2	0	–	0	0	0	–	1	1	0	–

METHOD: Mark and Recapture Technique

STATION	JR-RT				JR-BD			
Species	M	N	R	P	M	N	R	P
Carp	5	0	0	–	20	15	1	300
White Bass	2	1	0	–	1	1	0	–
Utah Sucker	14	8	0	–	77	58	3	1489
Black Crappie	0	0	0	–	1	1	0	–
Walleye	0	0	0	–	2	0	0	–
Green Sunfish	0	0	0	–	0	0	0	–
Channel Catfish	0	0	0	–	1	0	0	–
Mountain Sucker	0	0	0	–	1	3	0	–
Largemouth Bass	0	0	0	–	1	0	0	–
Brown Trout	0	0	0	–	0	1	0	–

Table 6. continued

METHOD: Multiple Pass Technique[3]

STATION	JR-10N					JR-17S			
Species	1st	2nd	3rd	4th	P	1st	2nd	3rd	P
Carp	77	32	18	12	148	21	11	2	35
Utah Sucker	1	2	2	0	5	42	26	11	91
Utah Chub	0	1	0	0	1	3	0	0	3
White Bass	0	0	0	0	–	1	0	1	2
Green Sunfish	0	0	0	0	–	1	1	1	3
Cutthroat Trout	0	0	0	0	–	0	1	0	1

[1]M= number of fish marked; N= number of fish caught during recapture efforts; R= number of marked fish recaptured; P= population estimate.

[2]Station codes: SC-NT= Surplus Canal, North Temple; SC-17S= Surplus Canal, 17th S; JR-10N= Jordan River, 10th N; JR-17S= Jordan River, 17th S; JR-AD= Jordan River, above Diversion; JR-BMC= Jordan River, below Mill Creek; JR-AMC= Jordan River, above Mill Creek; JR-45S= Jordan River, 45th S; JR-RT= Jordan River, Riverton; JR-BD= Jordan River, Bluffdale.

[3]1st, 2nd, 3rd and 4th indicate pass number; P= population estimate.

sporadically and in very small numbers, making any type of population estimate impractical. These same problems have affected all past sampling efforts on the Jordan River.

Another method of estimating relative population levels is the use of catch-per-unit-effort (CPUE). At all stations, the initial electrofishing runs covered most of the station. Additional runs were made to increase the number of fish marked, but they were generally less effective than the initial runs. These initial runs were the most consistent between stations and therefore present the best samples to compare for CPUE. Table 7 shows CPUE (number of fish per 1000 seconds of electrofishing) for all the stations and all the species collected during the initial electrofishing runs. This table indicates that carp and Utah sucker were by far the most abundant species at all stations. Carp was generally the most abundant species in the Surplus Canal and in the lower Jordan River, whereas the Utah sucker was the most abundant species in the upper Jordan. The 17th South Jordan River station was the only exception to this trend as Utah sucker was more abundant than carp. Other species were generally rather uncommon.

Total abundance of fish, as reflected by total CPUE, was relatively similar to several other regional rivers. Crist and Holden (1987) found total densities of fish ranging between 16.6 and 132.8 fish/1000 sec in the lower Portneuf and Blackfoot Rivers and in the Snake River at Fort Hall, Idaho. Total CPUE in the Jordan River ranged between 17.8 and 85.5 fish/1000 sec.

Table 7. CPUE[1] FOR THE FIRST TWO ELECTROFISHING RUNS WITHIN EACH 500 FT. STATION.

STATION[2]	SC NT	SC 17S	JR 10N	JR 17S	JR AD	JR BMC	JR AMC	JR 45S	JR RT	JR BD
Carp	60.2	16.3	63.1	24.0	19.8	19.5	27.1	20.1	1.9	10.3
Utah Sucker	2.3	3.0	2.8	47.9	14.3	30.7	37.2	60.5	13.9	31.8
Black Crappie	.0	1.0	.0	.0	.5	.0	.0	.0	.0	.0
White Bass	.0	.0	.0	1.1	4.0	.0	5.0	2.8	1.2	.0
Green Sunfish	.0	.0	.0	1.1	.0	1.3	.0	1.0	.0	.0
Walleye	.0	.0	.0	.0	.0	1.3	.0	1.0	.8	.0
Channel Catfish	.0	.0	.0	.0	.0	.0	.0	.0	.0	.6
Utah Chub	.0	.0	.6	3.4	.0	.0	.0	.0	.0	.0
Total CPUE	62.4	20.3	66.5	77.5	38.6	52.7	69.3	85.5	17.8	42.1
Total # of Species	2	3	3	5	4	4	3	5	4	3

[1]Catch per unit effort (CPUE) is given in #/1000 seconds.
[2]Station Codes: SC-NT= Surplus Canal, North Temple; SC-17S= Surplus Canal, 17th S; JR-10N= Jordan River, 10th N; JR-17S= Jordan River, 17th S; JR-AD= Jordan River, Above Diversion; JR-BMC= Jordan River, below Mill Creek; JR-AMC= Jordan River, above Mill Creek; JR-45S= Jordan River, 45th S; JR-RT= Jordan River, Riverton; JR-BD= Jordan River, Bluffdale.

Utah Suckers were the most abundant species in the lower Portneuf and Blackfoot and Snake Rivers as well as in the mid and upper Jordan River.

Total abundance varied considerably within the Jordan River with no clear pattern as far as differences between the upper and lower river. The general river section with the highest CPUE for both stations was the area just above Mill Creek, the 45th South station and the station above Mill Creek. The river section with the next highest CPUE was the Jordan River below the Surplus Canal diversion, the 10th North and 17th South stations. The station with the lowest total CPUE was Riverton, although the Surplus Canal at 17th South was also quite low.

These comparisons would suggest that overall population trends did not follow a discernable pattern following river section as general fish abundance was high at both upstream and downstream stations, and it was also low at both upstream and downstream stations. It should be remembered that this pattern generally reflects carp and suckers, the dominant species collected.

A comparison of adjacent stations indicates that the Riverton station had a lower catch than either of the adjacent stations. The low catch in the 500 foot station at Riverton is probably due to the poor habitat found at that station. As noted above, this station had a deep, fast run along an eroding bank that afforded very little shelter from high velocities. Both the Bluffdale and 45th South stations had more diversity of habitat and better instream habitat than at Riverton. Bluffdale also showed a fairly low total catch, especially when compared with most downstream stations. Although habitat diversity was good at Bluffdale, main channel velocities were very high (Figure 3) and probably limited use of much of the channel. Most of the fish collected at this site were found near the shore and near cover from the high velocities.

Likewise, the station below Mill Creek and the station above the Diversion had lower catch rates than the station above Mill Creek and the lower Jordan stations, although not greatly lower. Figures 7 and 8 show these stations to have fairly uniform cross-sections. Just above the mouth of Mill Creek the Jordan River channel becomes a typical large canal, straight and uniform rather than a more natural shape. This actually is the beginning of the channelization that continues into the Surplus Canal. Therefore, habitat changes dramatically in these two stations compared to the stations immediately upstream. Silt becomes more common in the substrate of these two stations, probably due to lower velocities caused by the Surplus Canal Diversion. It is also possible that water quality, especially elevated chlorine levels, may be a problem in this area since several Central Valley treatment plants discharge just above these stations. An even lower catch rate was recorded for the 17th South Surplus Canal station, suggesting a potential water quality problem that is worse downstream. However, the 17th South Jordan River station showed a very high catch rate, suggesting that water quality probably could not be the major factor in lower catch below Mill Creek. The higher catch rate at the 17th South Jordan station appears to be due to improved habitat, particularly substrate. Although shown as silt in Figure 9, gravel underlaid the shallow silt. The area just above the station was primarily gravel and cobble. Therefore, it appears that low catch rates just below Mill Creek are probably due to habitat changes rather than water quality since they are not consistent between stations with different habitat characteristics. This same habitat change was noted in the invertebrate discussion as increasing invertebrate densities at 17th South also.

A comparison of the number of species collected during the initial electrofishing runs at each 500 foot station (Table 7) gives a general idea of species richness at each station. Again there is not much of a trend, except perhaps that the Surplus Canal may have a slightly lower number of species than the Jordan River. The 17th South Jordan station again shows a higher number than adjacent stations, strengthening the discussion above for habitat being the most important factor in differences between stations.

General population trends between stations can also be compared using the total numbers of fish collected during all electrofishing runs during the sampling to mark fish or for all the multiple capture runs. This total effort, although somewhat variable between stations, was generally consistent in that each station was thoroughly sampled until catch was diminished considerably or a large number of fish was collected for marking. Table 6 lists the number of each species of fish collected during the population sampling (number marked or total captured in all runs) at each 500 foot station. This information also shows the dominance of carp and Utah sucker, and how these two species change dominance in the upper and lower river. It also indicates that no upstream/downstream trend in abundance is noticeable, and that species richness also did not vary much between upper and lower stations.

Therefore, the data collected are sufficient to show the general population size and structure between the different stations. These data would not support a conclusion that water quality was limiting in the lower section of the river, and appear to support a conclusion that habitat may be limiting at some stations in both the upper and lower river.

Other Sampling

Other sampling conducted outside the 500 foot stations included habitat-specific electrofishing and, at some stations, seining. Individual habitats were electrofished and fish collected were reported separately. This allowed for determination of CPUE for different habitat types. Only three major habitat types were found: runs, backwaters and riffles. These three types were generally differentiated by the type of shoreline that bordered the habitat. Electrofishing generally followed shorelines since the population sampling showed these areas supported most of the fish. The habitats sampled were: runs along grass banks; runs along riparian banks; runs along rip-rapped banks; runs along bare or eroded banks; runs with special habitat or cover features; backwaters with grass banks; backwaters with riparian banks; and riffles with riparian banks.

Table 8 shows the CPUE by habitat type for all stations combined. Although the amount of effort at each habitat type differed considerably due to the varying availability of the habitats, CPUE provides a valid means of comparison between habitat types. The highest CPUE was for backwaters with riparian banks. The lowest CPUE was for riffles, but this habitat type was so rare that only one sample was taken. Within the run categories, which was by far the most common habitat, runs with riparian banks had the highest CPUE, but there was little differentiation between the other types of runs.

A comparison of different habitat types within each station may be more valuable in differentiating different use of habitats. Tables 9-18 show CPUE by habitat type for each station. Generally, only two or three different habitat types were available at most stations. The station just below Mill Creek had only one habitat type that was sampled, although Mill Creek itself was also sampled. The Mill Creek sampling turned up one carp in 1050 seconds of electrofishing, which was not included in any of the tables. The 45th South station had five different habitat types sampled, the highest of any station and an indication of the diversity of habitat in that general area.

Table 8. CPUE[1] BY HABITAT TYPE FOR ALL SAMPLING OUTSIDE OF THE 500 FT. STATIONS

	COVER CODES[2]							
Species	RNGB	RNRB	RNRR	RNCB	RNSP	BAGB	BARB	RIRB
Carp	31.9	50.9	26.4	22.3	40.9	23.9	58.8	7.8
Utah Sucker	8.4	30.4	18.4	17.7	4.9	29.2	132.6	22.6
Mountain Sucker	.0	.0	.0	.0	.7	.0	.0	.0
Black Crappie	.1	.3	.0	.0	.3	1.2	.0	.0
White Bass	1.4	1.3	1.4	.0	2.0	15.0	.0	.4
Green Sunfish	.1	1.3	.7	.2	2.3	.3	.0	.0
Walleye	.3	.1	.2	.2	1.0	.3	.9	.0
Rainbow Trout	.0	.0	.0	.7	.7	.0	.0	.0
Cutthroat Trout	.0	.4	.0	.0	.3	.0	.0	.0
Brown Trout	.3	.0	.0	.0	.0	.0	.0	.4
Channel Catfish	.0	.3	.0	.0	.3	.0	.4	.4
Utah Chub	.0	1.8	.0	.6	1.3	.0	.0	.0
Total CPUE	42.5	86.8	47.1	41.6	54.8	69.7	192.9	31.6
Standard Error	13.4	17.9	9.4	11.4	15.9	15.8	19.2	.0
No. Samples	9	12	6	8	6	5	2	1

[1]Catch per unit effort (CPUE) is given in #/1000 seconds.
[2]Cover codes: RN = run; BA = backwater; RI = riffle.
GB = grassy bank; RB = riparian bank; RR = rip-rap bank;
CB = cut (eroding) bank; SP = special cover.

Table 9. CPUE[1] BY HABITAT TYPE FOR STATION JR-10N

	COVER CODES[2]							
Species	RNGB	RNRB	RNRR	RNCB	RNSP	BAGB	BARB	RIRB
Carp	104.0	178.4	-	57.8	-	-	-	-
Utah Sucker	1.0	10.0	-	15.6	-	-	-	-
Mountain Sucker	.0	.0	-	.0	-	-	-	-
Black Crappie	.0	.0	-	.0	-	-	-	-
White Bass	.0	.0	-	.0	-	-	-	-
Green Sunfish	.0	.0	-	.0	-	-	-	-
Walleye	.0	.0	-	.0	-	-	-	-
Rainbow Trout	.0	.0	-	.0	-	-	-	-
Cutthroat Trout	.0	.0	-	.0	-	-	-	-
Brown Trout	.0	.0	-	.0	-	-	-	-
Channel Catfish	.0	.0	-	.0	-	-	-	-
Utah Chub	.0	4.7	-	4.4	-	-	-	-
Total CPUE	105.0	193.0	-	77.8	-	-	-	-
Standard Error	6.9	47.0	-	.0	-	-	-	-
No. Samples	2	2	-	1	-	-	-	-

[1]Catch per unit effort (CPUE) is given in #/1000 seconds.
[2]Cover codes: RN=run; BA=backwater; RI= riffle.
GB= grassy bank; RB= riparian bank; RR= rip-rap bank;
CB= cut (eroding) bank; SP= special cover.

Table 10. CPUE[1] BY HABITAT TYPE FOR STATION JR-17S.

	COVER CODES[2]							
Species	RNGB	RNRB	RNRR	RNCB	RNSP	BAGB	BARB	RIRB
Carp	–	47.1	–	17.1	24.0	–	–	–
Utah Sucker	–	51.4	–	40.0	22.0	–	–	–
Mountain Sucker	–	.0	–	.0	4.0	–	–	–
Black Crappie	–	.0	–	.0	.0	–	–	–
White Bass	–	.0	–	.0	.0	–	–	–
Green Sunfish	–	3.8	–	.0	14.0	–	–	–
Walleye	–	.0	–	.0	.0	–	–	–
Rainbow Trout	–	.0	–	5.7	4.0	–	–	–
Cutthroat Trout	–	1.6	–	.0	2.0	–	–	–
Brown Trout	–	.0	–	.0	.0	–	–	–
Channel Catfish	–	.0	–	.0	2.0	–	–	–
Utah Chub	–	4.1	–	.0	8.0	–	–	–
Total CPUE	–	108.1	–	62.8	80.0	–	–	–
Standard Error	–	12.7	–	.0	.0	–	–	–
No. Samples	0	3	0	1	1	0	0	0

[1]Catch per unit effort (CPUE) is given in #/1000 seconds.
[2]Cover codes: RN = run; BA = backwater; RI = riffle.
GB = grassy bank; RB = riparian bank; RR = rip-rap bank;
CB = cut (eroding) bank; SP = special cover.

Table 11. CPUE[1] BY HABITAT TYPE FOR STATION JR-AD.

Species	RNGB	RNRB	RNRR	RNCB	RNSP	BAGB	BARB	RIRB
	COVER CODES[2]							
Carp	14.4	–	49.6	–	–	–	–	–
Utah Sucker	43.1	–	28.9	–	–	–	–	–
Mountain Sucker	.0	–	.0	–	–	–	–	–
Black Crappie	.0	–	.0	–	–	–	–	–
White Bass	5.7	–	.0	–	–	–	–	–
Green Sunfish	.0	–	.0	–	–	–	–	–
Walleye	.0	–	.0	–	–	–	–	–
Rainbow Trout	.0	–	.0	–	–	–	–	–
Cutthroat Trout	.0	–	.0	–	–	–	–	–
Brown Trout	.0	–	.0	–	–	–	–	–
Channel Catfish	.0	–	.0	–	–	–	–	–
Utah Chub	.0	–	.0	–	–	–	–	–
Total CPUE	63.2	–	78.5	–	–	–	–	–
Standard Error	.0	–	.0	–	–	–	–	–
No. Samples	1	0	1	0	0	0	0	0

[1]Catch per unit effort (CPUE) is given in #/1000 seconds.
[2]Cover codes: RN = run; BA = backwater; RI = riffle.
GB = grassy bank; RB = riparian bank; RR = rip-rap bank;
CB = cut (eroding) bank; SP = special cover.

Table 12. CPUE[1] BY HABITAT TYPE FOR STATION JR-BMC.

	COVER CODES[2]							
Species	RNGB	RNRB	RNRR	RNCB	RNSP	BAGB	BARB	RIRB
Carp	–	–	–	–	–	34.9	–	–
Utah Sucker	–	–	–	–	–	1.6	–	–
Mountain Sucker	–	–	–	–	–	.0	–	–
Black Crappie	–	–	–	–	–	.0	–	–
White Bass	–	–	–	–	–	4.8	–	–
Green Sunfish	–	–	–	–	–	1.6	–	–
Walleye	–	–	–	–	–	1.6	–	–
Rainbow Trout	–	–	–	–	–	.0	–	–
Cutthroat Trout	–	–	–	–	–	.0	–	–
Brown Trout	–	–	–	–	–	.0	–	–
Channel Catfish	–	–	–	–	–	.0	–	–
Utah Chub	–	–	–	–	–	.0	–	–
Total CPUE	–	–	–	–	–	44.5	–	–
Standard Error	–	–	–	–	–	.0	–	–
No. Samples	0	0	0	0	0	1	.0	0

[1]Catch per unit effort (CPUE) is given in #/1000 seconds.
[2]Cover codes: RN = run; BA = backwater; RI = riffle.
GB = grassy bank; RB = riparian bank; RR = rip-rap bank;
CB = cut (eroding) bank; SP = special cover.

Table 13. CPUE[1] BY HABITAT TYPE FOR STATION JR-AMC.

	COVER CODES[2]							
Species	RNGS	RNRB	RNRR	RNCB	RNSP	BAGB	BARB	RIRB
Carp	9.3	17.2	20.7	12.1	-	34.8	-	-
Utah Sucker	21.8	42.3	13.8	12.7	-	19.3	-	-
Mountain Sucker	.0	.0	.0	.0	-	.0	-	-
Black Crappie	.0	.0	.0	.0	-	3.0	-	-
White Bass	.0	.0	2.1	.0	-	21.6	-	-
Green Sunfish	.0	.0	1.0	.0	-	.0	-	-
Walleye	.0	.0	.0	.0	-	.0	-	-
Rainbow Trout	.0	.0	.0	.0	-	.0	-	-
Cutthroat Trout	.0	.0	.0	.0	-	.0	-	-
Brown Trout	3.1	.0	.0	.0	-	.0	-	-
Channel Catfish	.0	1.5	.0	.0	-	.0	-	-
Utah Chub	.0	.0	.0	.0	-	.0	-	-
Total CPUE	34.2	61.0	37.7	24.8	-	78.6	-	-
Standard Error	.0	4.8	10.3	14.1	-	42.6	-	-
No. Samples	1	2	4	3	0	2	0	0

[1]Catch per unit effort (CPUE) is given in #/1000 seconds.
[2]Cover codes: RN = run; BA = backwater; RI = riffle.
GB = grassy bank; RB = riparian bank; RR = rip-rap bank;
CB = cut (eroding) bank; SP = special cover.

HABITAT IS PRINCIPAL
CONSTRAINT TO FISH
DENSITY / DIVERSITY

Table 14. CPUE[1] BY HABITAT TYPE FOR STATION JR-45S.

	COVER CODES[2]							
Species	RNGB	RNRB	RNRR	RNCB	RNSP	BAGB	BARB	RIRB
Carp	–	–	26.1	31.7	–	–	58.8	–
Utah Sucker	–	–	26.1	47.6	–	–	132.6	–
Mountain Sucker	–	–	.0	.0	–	–	.0	–
Black Crappie	–	–	.0	.0	–	–	.0	–
White Bass	–	–	.0	.0	–	–	.0	–
Green Sunfish	–	–	.0	1.6	–	–	.0	–
Walleye	–	–	1.3	1.6	–	–	.9	–
Rainbow Trout	–	–	.0	.0	–	–	.0	–
Cutthroat Trout	–	–	.0	.0	–	–	.0	–
Brown Trout	–	–	.0	.0	–	–	.0	–
Channel Catfish	–	–	.0	.0	–	–	.4	–
Utah Chub	–	–	.0	.0	–	–	.0	–
Total CPUE	–	–	53.5	82.5	–	–	192.9	–
Standard Error	–	–	.0	.0	–	–	19.2	–
No. Samples	0	0	1	1	0	0	2	0

[1]Catch per unit effort (CPUE) is given in #/1000 seconds.
[2]Cover codes: RN = run; BA = backwater; RI = riffle.
GB = grassy bank; RB = riparian bank; RR = rip-rap bank;
CB = cut (eroding) bank; SP = special cover.

Table 15. CPUE[1] BY HABITAT FOR STATION JR-RT.

Species	RNGB	RNRB	RNRR	RNCB	RNSP	BAGB	BARB	RIRB
	COVER CODES[2]							
Carp	.0	–	–	–	–	7.5	–	–
Utah Sucker	.0	–	–	–	–	52.8	–	–
Mountain Sucker	.0	–	–	–	–	.0	–	–
Black Crappie	.0	–	–	–	–	.0	–	–
White Bass	3.3	–	–	–	–	13.5	–	–
Green Sunfish	.0	–	–	–	–	.0	–	–
Walleye	.0	–	–	–	–	.0	–	–
Rainbow Trout	.0	–	–	–	–	.0	–	–
Cutthroat Trout	.0	–	–	–	–	.0	–	–
Brown Trout	.0	–	–	–	–	.0	–	–
Channel Catfish	.0	–	–	–	–	.0	–	–
Utah Chub	.0	–	–	–	–	.0	–	–
Total CPUE	3.3	–	–	–	–	73.9	–	–
Standard Error	.0	–	–	–	–	16.2	–	–
No. Samples	1	0	0	0	0	2	0	0

1Catch per unit effort (CPUE) is given in #/1000 seconds.
2Cover codes: RN = run; BA = backwater; RI = riffle.
GB = grassy bank; RB = riparian bank; RR = rip-rap bank;
CB = cut (eroding) bank; SP = special cover.

Table 16. CPUE[1] BY HABITAT FOR STATION JR-BD.

	COVER CODES[2]							
Species	RNGB	RNRB	RNRR	RNCB	RNSP	BAGB	BARB	RIRB
Carp	–	10.1	–	–	–	–	–	7.8
Utah Sucker	–	45.7	–	–	–	–	–	22.6
Mountain Sucker	–	.0	–	–	–	–	–	.0
Black Crappie	–	1.7	–	–	–	–	–	.0
White Bass	–	1.7	–	–	–	–	–	.4
Green Sunfish	–	.0	–	–	–	–	–	.0
Walleye	–	.9	–	–	–	–	–	.0
Rainbow Trout	–	.0	–	–	–	–	–	.0
Cutthroat Trout	–	.0	–	–	–	–	–	.0
Brown Trout	–	.0	–	–	–	–	–	.4
Channel Catfish	–	.0	–	–	–	–	–	.4
Utah Chub	–	.0	–	–	–	–	–	.0
Total CPUE	–	61.0	–	–	–	–	–	31.6
Standard Error	–	14.2	–	–	–	–	–	.0
No. Samples	0	2	0	0	0	0	0	1

[1]Catch per unit effort (CPUE) is given in #/1000 seconds.
[2]Cover codes: RN = run; BA = backwater; RI = riffle.
GB = grassy bank; RB = riparian bank; RR = rip-rap bank;
CB = cut (eroding) bank; SP = special cover.

Table 17. CPUE[1] BY HABITAT TYPE FOR STATION SC-NT.

	COVER CODES[2]							
Species	RNGB	RNRB	RNRR	RNCB	RNSP	BAGB	BARB	RIRB
Carp	35.8	–	–	35.0	55.4	–	–	–
Utah Sucker	2.3	–	–	.0	.8	–	–	–
Mountain Sucker	.0	–	–	.0	.0	–	–	–
Black Crappie	.0	–	–	.0	.5	–	–	–
White Bass	.0	–	–	.0	3.0	–	–	–
Green Sunfish	.0	–	–	.0	.0	–	–	–
Walleye	2.3	–	–	.0	1.5	–	–	–
Rainbow Trout	.0	–	–	.0	.0	–	–	–
Cutthroat Trout	.0	–	–	.0	.0	–	–	–
Brown Trout	.0	–	–	.0	.0	–	–	–
Channel Catfish	.0	–	–	.0	.0	–	–	–
Utah Chub	.0	–	–	.0	.0	–	–	–
Total CPUE	40.4	–	–	35.0	61.2	–	–	–
Standard Error	.0	–	–	.0	18.6	–	–	–
No. Samples	1	0	0	1	4	0	0	0

[1]Catch per unit effort (CPUE) is given in #/1000 seconds.
[2]Cover codes: RN = run; BA = backwater; RI = riffle.
GB = grassy bank; RB = riparian bank; RR = rip-rap bank;
CB = cut (eroding) bank; SP = special cover.

Table 18. CPUE[1] BY HABITAT TYPE FOR STATION SC-17S.

Species	COVER CODES[2] RNGB	RNRB	RNRR	RNCB	RNSP	BAGB	BARB	RIRB
Carp	6.4	19.3	-	.0	.0	-	-	-
Utah Sucker	2.1	5.0	-	.0	4.2	-	-	-
Mountain Sucker	.0	.0	-	.0	.0	-	-	-
Black Crappie	.4	.0	-	.0	.0	-	-	-
White Bass	1.1	4.1	-	.0	.0	-	-	-
Green Sunfish	.4	1.2	-	.0	.0	-	-	-
Walleye	.0	.0	-	.0	.0	-	-	-
Rainbow Trout	.0	.0	-	.0	.0	-	-	-
Cutthroat Trout	.0	.0	-	.0	.0	-	-	-
Brown Trout	.0	.0	-	.0	.0	-	-	-
Channel Catfish	.0	.0	-	.0	.0	-	-	-
Utah Chub	.0	.0	-	.0	.0	-	-	-
Total CPUE	10.5	29.6	-	.0	4.2	-	-	-
Standard Error	2.7	3.2	-	.0	.0	-	-	-
No. Samples	3	3	0	1	1	0	0	0

[1]Catch per unit effort (CPUE) is given in #/1000 seconds.
[2]Cover codes: RN = run; BA = backwater; RI = riffle.
GB = grassy bank; RB = riparian bank; RR = rip-rap bank;
CB = cut (eroding) bank; SP = special cover.

A habitat comparison of interest is that between runs with stable banks, either covered with grass or riparian vegetation such as willows, and runs with unstable or eroding banks. Stations on the Surplus Canal, as well as 10th North, and 17th South all had samples from these two types of run. In all cases, the eroding banks had lower CPUE than the stable bank areas. Runs with special cover also had higher CPUE than runs with eroding banks in the three stations where they could be compared (Surplus Canal stations and 17th South). These within-station comparisons tend to support the conclusion that the better habitats supported the most fish as suggested by the data in Table 8.

These observations also tend to support the discussion above concerning differences in catch rates between stations and that stations with low catch rates generally had poorer habitat than stations with high catch rates. The data (Tables 9-18) indicate that the poorest habitats within stations had lower catch rates than the better habitats in that same station, and that poor habitats generally had lower overall catch than better habitats for all stations combined (Table 8). Therefore, habitat quality appears to be a major factor in fish distribution and abundance in the Jordan system.

Table 19 shows the total number of fish caught electro-fishing at each station during the other sampling. Distribution and abundance follows very closely with that shown in Tables 6 and 7. Numbers of fish are generally low at Bluffdale and

Table 19. NUMBERS OF FISH CAUGHT DURING SAMPLING BY ELECTROFISHING OUTSIDE OF THE 500 FT. STATIONS

STATION*	SC NT	SC 17S	JR 10N	JR 17S	JR AD	JR BMC	JR AMC	JR 45S	JR RT	JR BD
Carp	149	28	353	57	27	22	97	139	6	12
Utah Sucker	2	10	19	70	28	1	91	184	69	55
Utah Chub	0	0	8	8	0	0	0	0	0	0
Green Sunfish	0	1	0	10	0	1	1	1	0	0
White Bass	6	6	0	0	2	3	8	0	16	2
Mountain Sucker	0	0	0	2	0	0	0	0	0	1
Rainbow Trout	0	0	0	3	0	0	0	0	0	0
Cutthroat Trout	0	0	0	3	0	0	0	0	0	0
Black Bullhead	0	0	0	1	0	0	0	0	0	0
Channel Catfish	0	0	0	1	0	0	1	1	0	0
Yellow Perch	0	0	0	0	0	0	0	0	1	0
Black Crappie	1	0	0	0	0	0	2	0	0	2
Bluegill	0	0	0	0	0	0	0	1	0	0
Walleye	3	0	0	0	0	1	0	4	0	0
Gambusia	0	1	0	0	0	0	0	0	0	0
Largemouth Bass	0	0	0	0	0	0	0	0	0	1
Brown Trout	0	0	0	0	0	0	1	0	0	0
TOTAL # SPECIES	5	5	3	9	3	5	7	5	4	6
TOTAL # INDIVIDUALS	161	46	380	155	57	28	201	329	92	73

*Station Codes: SC-NT= Surplus Canal, North Temple; SC-17S= Surplus Canal, 17th S; JR-10N= Jordan River, 10th N; JR- 17S= Jordan River, 17th S; JR-AD= Jordan River, above Diversion; JR- BMC= Jordan River, below Mill Creek; JR- AMC= Jordan River, above Mill Creek; JR-45S= Jordan River, 45th S; JR-RT= Jordan River, Riverton; JR-BD= Jordan River, Bluffdale.

Riverton, and again at the two stations immediately below Mill Creek, but numbers increase in the lower Jordan stations and at the lower Surplus Canal station. Carp are generally more abundant below Mill Creek than Utah sucker, except at 17th South. It should be remembered that these numbers reflect the fish caught in habitats outside the 500 foot stations and that sampling effort varied considerably.

Table 20 shows the stations that were sampled with seines and the numbers of fish caught with this sampling technique. Seining at most stations was not possible due to high water conditions and limited beaches or other areas on which to pull seines. Seining at Bluffdale was primarily conducted in runs and riffles. At Riverton, runs, riffles and a large backwater were seined. At 45th South, a backwater, the ponded mouth of Little Cottonwood Creek, and some runs were seined. At 17th South, only one backwater was seined. Therefore, the amount of seining, and the types of habitat sampled, varied between these four stations.

Seining was conducted to catch smaller fish not efficiently captured with electrofishing. Relatively few fish were caught in seines, and many seine hauls were empty. As can be seen in Table 20, 12 total species were collected with seines, but only 147 individual fish were caught. It is suspected that small fish are more abundant than shown in our catch, but they were unavailable to our sampling because they were using deeper areas of the river. This same phenomenon of disappearance from shallow areas as temperatures drop was noticed by Holden and Crist (1981) in

Table 20. NUMBERS OF FISH COLLECTED BY SEINING.

STATION*	JR 17S	JR AMC	JR RT	JR BD
Carp	15	21	0	0
Utah Sucker	3	1	1	0
Utah Chub	2	3	0	0
Bluegill Sunfish	1	0	0	0
Flathead Minnow	0	37	10	6
White Bass	6	13	1	1
Black Crappie	0	1	6	1
Black Bullhead	0	1	1	0
Green Sunfish	0	1	0	0
Gambusia	0	1	0	0
Mountain Sucker	0	0	6	7
Redside Shiner	0	0	1	0
TOTAL # SPECIES	5	9	7	4
TOTAL # INDIVIDUALS	27	79	26	15
# OF HAULS	2	10	7	9

*Station Codes: SC-NT= Surplus Canal, North Temple; SC-17S= Surplus Canal, 17th S; JR-10N= Jordan River, 10th N; JR-17S= Jordan River, 17th S; JR-AD= Jordan River, above Diversion; JR-BMC= Jordan River, below Mill Creek; JR- AMC= Jordan River, above Mill Creek; JR-45S= Jordan River, 45th S; JR-RT= Jordan River, Riverton; JR-BD= Jordan River, Bluffdale.

1. NOT ENOUGH SEINING
2. COLD WATER TEMPS.
3. WRONG TIME OF YEAR

the Green and Yampa rivers. It is also possible that there are relatively few small fish in the Jordan River due to lack of proper spawning or rearing habitat.

Of the 4 Utah suckers collected with seines, only one was a young-of-the-year. Species that were represented by what appeared to be young-of-the-year included carp, Utah sucker, fathead minnow, white bass, green sunfish, black bullhead and gambusia. All of these young fish were found above Mill Creek, but only young of carp were found below Mill Creek.

More young fish were caught at the station above Mill Creek than in the other three stations combined. This is related to sampling conducted at one backwater that was about 2^{o}C warmer than the river and perhaps also to the slightly greater number of seine hauls made at this station (Table 20). The 17th South station had the greatest catch per seine haul, again this was in a backwater. The two uppermost stations had more shallow riffle and run habitat and they were seined fairly intensively, but very little was found as can be seen by comparing effort and catch in Table 20. This information may indicate that the availability of backwater habitats, which were quite rare in the river, may be a major factor in the low numbers of small fish caught during the study.

The relatively few young fish collected makes it very difficult to determine which species may be reproducing in the Jordan River. It is possible that all of the young fish found were washed down from Utah Lake or the Jordan above the Narrows.

This is doubtful, especially for native species such as Utah chub that were found only in the lower Jordan River. But so few young of most of the other species were found that determining reproduction from the present data is not possible. Therefore, several factors may explain the paucity of young fish, including: 1. reproduction in the lower Jordan River is limited to a very few species; 2. young fish were not available to the sampling gear during the study; 3. most of the young fish are washed down from Utah Lake; and 4. habitat in the lower Jordan River for young fish is lacking and limiting numbers of young fish that can survive. In reality, probably all or several of these factors are probably effecting the Jordan River.

Species Discussions

This section deals with the individual species found during the study, primarily common species and species of importance for management and water quality concerns. A total of 18 species were collected in the river, but as noted above, only carp and Utah sucker were abundant. Most of the other 16 species were relatively uncommon. Table 21 lists the total number of each species of fish collected at each station combining all of the sampling.

Carp. One of the codominant species, carp were collected at all stations (Table 22) and in all habitat types (Table 8). As noted in Table 21, 472 carp were collected above Mill Creek, 1162 below Mill Creek, 325 in the Surplus Canal and 598 in the Jordan

Table 21. Total numbers of fish collected at BIO/WEST study sites.

STATION*	SC NT	SC 17S	JR 10N	JR 17S	JR AD	JR BMC	JR AMC	JR 45S	JR RT	JR BD
Carp	261	64	492	106	128	111	217	197	11	47
Utah sucker	2	10	24	150	100	88	168	204	92	190
Mountain sucker	0	0	0	0	0	0	0	0	6	12
Utah chub	0	0	9	13	0	0	3	0	0	0
Black crappie	1	2	0	13	2	0	6	0	6	5
White bass	14	12	0	8	19	3	42	4	20	5
Bluegill sunfish	0	0	0	1	0	0	0	?	0	0
Green sunfish	0	1	0	10	0	2	2	8	0	0
Walleye	4	2	0	0	0	5	0	7	3	0
Rainbow trout	0	0	0	3	0	0	0	0	0	0
Cutthroat trout	0	0	0	4	0	0	0	3	0	0
Brown trout	0	0	0	0	0	0	1	0	0	1
Channel catfish	0	1	0	1	0	2	1	3	0	1
Black bullhead	0	0	0	1	0	0	1	0	1	0
Yellow perch	0	0	0	0	0	0	0	0	1	0
Largemouth bass	0	0	0	0	0	0	0	0	0	1
Fathead minnow	0	0	0	0	0	0	37	0	10	6
Redside shiner	0	0	0	0	0	0	0	0	1	0
Gambusia	0	1	0	0	0	0	1	0	0	0

*SC-NT= Surplus Canal, North Temple; SC-17S= Surplus Canal, 17thS; JR-10N= Jordan River, 10th N; JR-17S= Jordan River, 17th South; JR-AD= Jordan River, above diversion; JR-BMC= Jordan River, below Mill Creek, JR-AMC= Jordan River, above Mill Creek; JR-45S = Jordan River, 45th S; JR-RT= Jordan River, Riverton; JR-BD= Jordan River, Bluffdale.

Table 22. SPECIES PRESENCE IN EACH STATION AS DETERMINED BY ALL THE SAMPLING COMBINED

STATION*	SC NT	SC 17S	JR 10N	JR 17S	JR AD	JR BMC	JR AMC	JR 45S	JR RT	JR BD	SPECIES OCCURRENCE (# OF STATIONS)
Carp	X	X	X	X	X	X	X	X	X	X	10
Utah Sucker	X	X	X	X	X	X	X	X	X	X	10
Utah Chub			X	X			X				3
Green Sunfish		X		X		X	X	X			5
White Bass	X	X		X	X	X	X	X	X	X	9
Mountain Sucker									X	X	2
Rainbow Trout				X							1
Cutthroat Trout				X							1
Brown Trout							X			X	2
Black Bullhead				X			X		X		3
Channel Catfish		X		X		X	X	X		X	6
Yellow Perch									X		1
Black Crappie	X	X		X	X		X		X	X	7
Walleye	X	X				X		X	X		5
Gambusia		X					X				2
Largemouth Bass										X	1
Bluegill				X				X			2
Flathead Minnow							X		X	X	3
Redside Shiner									X		1
TOTAL	5	8	3	11	4	6	11	7	10	9	

*Station Codes: SC-NT= Surplus Canal, North Temple; SC-17S= Surplus Canal, 17th S; JR-10N= Jordan River, 10th N; JR- 17S= Jordan River, 17th S; JR-AD= Jordan River, above Diversion; JR- BMC= Jordan River, below Mill Creek; JR-AMC= Jordan River, above Mill Creek; JR-45S= Jordan River, 45th S; JR-RT= Jordan River, Riverton; JR-BD= Jordan River, Bluffdale.

River below the Surplus Canal diversion. They were least abundant at the Riverton station, and generally increased in abundance in the downstream stations. Young-of-the-year were found in both the area above and below Mill Creek.

Their higher abundance in downstream stations may be due to preference for finer substrates, reduced velocities and warmer temperatures, but may also have been a reflection of decreased Utah sucker abundance. There is also the possibility that water quality in the lower river limited Utah sucker to the benefit of carp. This is doubtful because Utah sucker were more abundant at 17th South, the only station in the lower area to show sucker dominance, and water quality concerns should have reduced suckers there also. [A comparison of the station figures shows that the stations where carp dominated had predominately a silt bottom. The stations where suckers dominated had predominately gravel, cobble bottoms.] The exception is 17th South. The 17th South area, especially upstream from the station, had gravel and cobble substrates caused by the higher velocities nearer the diversion. Also, substrate at the station was silt over gravel. This suggests that the 17th South station was considerably different in substrate than other downstream stations in that coarser materials were more available at 17th South. It is further hypothesized that Utah sucker dominate in areas with coarser substrate and probably outcompete carp for bottom food organisms. Carp, on the other hand, fill the bottom feeding niche in areas with fine substrates that Utah sucker do not utilize. If this hypothesis is correct, differences in CPUE noted between stations near Mill Creek, which primarily reflect carp and/or sucker abundance, are mainly explained by habitat differences.

Utah Sucker. Utah sucker were also taken in all stations and all habitat types. As noted in Table 21, 654 Utah sucker were collected above Mill Creek, 374 below Mill Creek, 12 in the Surplus Canal, and 174 in the Jordan River below the Surplus Canal diversion. Table 8 indicates a strong preference for backwaters, but this is probably due to a high catch rate in backwaters only at the 45th South and Riverton stations (Tables 14 and 15). At the station above Mill Creek (Table 13), back-water catch was not higher than catch in run habitats. Utah sucker declines in the lower stations, and the suspected reasons for lower numbers were included in the discussion under Carp above. A few young Utah sucker were found during the study, but not in the numbers expected with the large adult populations encountered. Their overall abundance decreased dramatically there and no young were found at 17th South.

White Bass. White bass were generally found throughout the river and at all stations except 10th North (Table 22). Numbers collected included 71 above Mill Creek, 56 below Mill Creek, 26 in the Surplus Canal and 8 in the Jordan below the diversion. They were never very abundant except in certain backwater habitats. Table 8 indicates a preference for backwaters for this species. They were generally found associated with some type of cover in runs when they were not found in backwaters. Largest numbers, and highest CPUE, were found at the station above Mill Creek and at the Riverton station (Tables 13 and 15), both of which had a major backwater that was sampled. The highest CPUE in runs came from the Surplus Canal station at 17th South and the station above the Diversion (Tables 18 and 11). No white bass were found in runs with cut banks (Table 8), indicative of little cover. Juvenile white bass were taken in several stations, including 45th South and 17th South. Young of the year were found only at 45th South.

Black Crappie. Black crappie were found in 7 of the 10 stations, and in all river sections except the Jordan below the Surplus Canal Diversion (Table 22). Numbers collected included 17 above Mill Creek, 18 below Mill Creek, 3 in the Surplus Canal and 13 in the Jordan below the diversion (Table 21). Most were juveniles or adults. They were generally found in runs with cover or in backwaters. Relatively few were taken in any one place, with the largest single collection being six taken by seine (Table 20) from a large backwater at the Riverton station.

Green Sunfish. Green sunfish were found in low numbers in 5 of the 10 stations, and in all sections except the upper one (Table 22). As noted in Table 21, 10 were collected above Mill Creek, 13 below Mill Creek, 1 in the Surplus Canal, and 10 in the Jordan below the diversion. They were most abundant in runs with special cover, indicating a preference for cover. Green sunfish are typically found in slow water habitats, lakes, ponds and slow rivers, but are found in relatively low numbers in slow portions of swifter rivers in the West. Young were found in a backwater in the Jordan River at 45th South.

Walleye. Walleye were found in 5 of the stations. Numbers were generally low, with the largest numbers collected at the station below Mill Creek and at the 45th South station (Table 21). Numbers collected included 10 above Mill Creek, 11 below Mill Creek, 6 in the Surplus Canal, and none in the lower Jordan below the diversion. Walleye were found in all habitat types except riffles, and had the highest CPUE in runs with special cover (Table 8). Samples from the Surplus Canal station at North Temple were divided into run with grass bank and run with special cover, but both were in an area with wing dams that apparently attracted the walleye. No walleye were collected in areas not adjacent to the wing dams. Some of the fish taken at 45th South were found in a run along a cut bank, others in a backwater. Therefore, walleye were generally found in stations with better habitat, and more than one was usually collected at those stations. This suggests that walleye were distributed due to physical habitat preferences rather than water quality or some other factor. Walleye are typically riverine species but prefer dropoffs or other structural changes in the channel that are relatively rare in the Jordan River. Two juvenile walleye were taken at 45th South, all the others were adults.

Channel Catfish. Channel catfish were collected in 6 stations, and in all river sections (Table 22). Numbers collected, however, were low. Five were collected in the area upstream of

Mill Creek, 2 below Mill Creek, 1 in the Surplus Canal, and 1 in the Jordan below the diversion. They were collected in back-waters and runs but the low numbers seen did not indicate a preference for habitat or portion of the river. Catfish are often collected in smaller numbers than their actual density, especially during cold months of the year. They are typically found in riverine environments, preferring deep, slow pools and cover for resting and often forage in riffle areas. Cover is a necessary ingredient for reproduction and often is a major reason for their poor reproduction in new environments. The scarcity of habitat diversity in the Jordan River may be the major reason for the low numbers collected.

Trout. Brown, rainbow and cutthroat trout were taken during the study, but in small numbers except at 17th South where rain-bow and cutthroat were somewhat concentrated. Numbers of total trout collected included 5 from areas upstream of Mill Creek and 7 below Mill Creek, all in the Jordan at 17th South (Table 21). The trout were located just below the Surplus Canal Diversion where the water was swift and turbulent. CPUE was fairly high at this station (Table 10). These fish were probably individuals that had been stocked or had moved down from tributaries or upstream sites. One small juvenile rainbow was collected at 17th South. Rainbow were stocked in the Jordan near Bluffdale for several years in the late 1970's, and occasionally in the lower Jordan for special events.

Other Species. The other species collected were very uncommon, or restricted to only one capture at one station. Species such as fathead minnow and gambusia are probably more common, but were not found due to limitations discussed above for seining. Distribution of Utah chub was interesting in that this species was only found below 45th South in the Jordan River. Largemouth bass, bluegill and perch are all lake or pond species that were obviously out of their element in the Jordan River.

The presence of young fish for some of the warmwater game species such as white bass may indicate reproduction. But it could also be indicative of fish washing down from Utah Lake during the recent high flows as discussed above. We do not think the data available presently are sufficient to address reproduction in the Jordan River except for carp, gambusia and fathead minnow, and this makes it difficult to address which fish are actually residents. Therefore, the fish found in the river during this study have been divided into three main groups, Group 1 includes species with large populations, had young of the year collected or are native species that have been found in the Jordan for many years; Group 2 includes those species with several year classes but no young were collected; and Group 3 includes species present in very small numbers and only due to their presence in Utah Lake. Table 23 lists the species in these three groups for the Jordan River above and below Mill Creek based on samples by the DOW and BIO/WEST in 1985 and 1986.

Table 23. PRESENT STATUS OF THE FISHES OF THE JORDAN RIVER

Species	Above Mill Creek Group 1	Above Mill Creek Group 2	Above Mill Creek Group 3	Below Mill Creek Group 1	Below Mill Creek Group 2	Below Mill Creek Group 3
Carp	X			X		
Utah chub		X		X		
Fathead minnow	X			X		
Redside shiner	?					X
Speckled dace	?			-------Not Found-------		
Utah sucker	X			?		
Mountain sucker	X				?	
Rainbow trout			X			X
Brown trout			X			X
Cutthroat trout						X
Channel catfish		X			X	
Black bullhead	X					X
White bass	X			?		
Black crappie		X			X	
Green sunfish	X				X	
Bluegill			X			X
Largemouth bass			X			
Walleye		X			X	
Yellow perch			X	-------Not Found-------		
Gambusia	X				X	

Group 1 = species with large populations, young of the year, or native species that have been found in the Jordan River for many years.
Group 2 = species with several year classes but no young were collected.
Group 3 = species present in very small numbers and due to their presence in Utah Lake.

"HABITAT BIGGEST FISHERY LIMITATION"

LOW WATER VELOCITY MAY IMPROVE HABITAT

Comparisons with Past Studies

Several studies of fish in the Jordan River have been conducted in the past. Perhaps the earliest was that of David Starr Jordan in the summer of 1889. He sampled the Jordan "below a dam 4 miles southwest of Salt Lake City" (Jordan 1891). He described the river in this area as being "2 rods wide and 2 to 5 feet deep, the bottom being of adobe". He generally characterized the river as somewhat turbid, with a moderate current and sand and adobe bottom. Fish were described as plentiful, but not trout which had been "excluded by the dams of the irrigating ditches". The fishes he noted as being in the river included the Utah sucker ("young are very abundant"), mountain sucker, speckled dace, redside shiner, and Utah chub. Mountain whitefish were described as "occasional".

This report (Jordan 1891) indicates that the native fish fauna was comprised of only 6 species, but they were abundant in the river except for the whitefish. He also indicates that many of the present limiting factors to fish in the Jordan River were present in 1889, mainly dewatering for irrigation. His description of the river, especially its substrate, is very similar to what was noted in this study. All of the species collected in 1889 were collected in 1986 except for the mountain whitefish and speckled dace. We suspect that the dace may be present but was unavailable to the seines due to use of habitats that could not be seined. Mountain whitefish probably have been extirpated by increasing temperatures and turbidity from Utah Lake, which harbored an excellent cutthroat trout population in 1889.

More recent studies of the Jordan include a study by the EPA in 1972 that was described in Way (1980), a survey by the Utah Division of Wildlife (DOW) in 1976, a DOW survey in 1985 and a DOW survey in 1986. Not all of the surveys sampled the same sites, but in general many of the stations used in this study were also sampled by one or more of these previous studies. It appears that all of these studies used electrofishing as the primary collection tool, although the fish species caught by the EPA study suggests seines were also used. The amount of effort undoubtedly differed but could not be determined. In general, it would appear that the greatest effort at each station was expended in the present study. The studies also varied in time of year that the sampling occurred, the EPA study was conducted in the summer, the 1986 DOW study in September, the 1985 DOW study in October, the 1977 DOW study in December and the present study in November.

Table 24 compares the various studies for all similar stations. Total fish collected for the BIO/WEST study includes all electrofishing and all seine captures in the four stations where it occurred. In general, the various studies show many of the same trends. Carp and Utah sucker are the codominant species, and the sucker is generally more abundant until near Mill Creek and below where the carp dominates, except for 17th South. Carp tended to be more common in relation to sucker in

Table 24. COMPARISON OF BIO\WEST'S 1986 DATA WITH PAST FISHERIES STUDIES OF THE JORDAN RIVER.

STATION[1]	JR-BD			JR-RT			JR-90S		JR-45S				JR-AMC		JR-AD		JR-17S			JR-18N	JR-10N
AGENCY[2] YEAR SAMPLED	EPA 1972	DOW 1986	B/W 1986	EPA 1972	DOW 1976	B/W 1986	EPA 1972	DOW 1986	EPA 1972	DOW 1976	DOW 1985	B/W 1986	EPA 1972	B/W 1986	EPA 1972	B/W 1986	DOW 1976	DOW 1985	B/W 1986	EPA 1972	B/W 1986
Carp	10	0	47	56	10	11	16	20	40	63	13	197	150	217	60	128	2	58	105	64	462
Utah Sucker	37	37	190	16	59	92	13	14	50	35	22	204	75	168	1	100	14	58	150	0	22
Mountain Sucker	82	0	12	66	1	5	27	0	5	0	0	0	10	0	0	0	0	2	0	0	0
Black Crappie	0	0	5	0	0	6	0	0	0	0	0	0	0	6	0	2	0	0	13	0	0
White Bass	0	0	5	1	0	20	0	3	0	0	4	4	0	42	0	19	0	2	8	0	0
Green Sunfish	0	0	0	0	0	0	1	0	0	0	0	8	0	2	0	0	0	7	10	0	0
Walleye	0	1	0	0	0	3	0	0	0	0	1	7	0	0	0	0	0	1	0	0	0
Rainbow Trout	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	3	0	0
Brown Trout	0	0	0	0	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Channel Catfish	0	2	1	0	0	0	0	0	0	0	0	3	0	1	0	0	0	0	1	0	0
Utah Chub	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	20	13	20	9
Black Bullhead	0	4	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
Bluegill	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Largemouth Bass	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gambusia	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Flathead Minnow	0	0	6	0	0	10	0	0	0	0	0	0	0	37	0	0	0	0	0	0	0
Yellow Perch	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dace	26	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Redside Shiner	0	0	0	9	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0
Cutthroat Trout	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0

[1]Station Codes: JR-BD= Jordan River,below diversion; JR-RT= Jordan River,Riverton; JR-90S= Jordan River, 90S; JR-45S= Jordn River, 45S; JR-AMC= Jordan River, above Mill Creek; JR-AD= Jordan River above diversion; JR-17S= Jordan River, 17S; JR-18N= Jordan River,18N; JR-10N= Jordan River, 10N.

[2]Agency Codes: EPA= Environmental Protection Agency; DOW= Utah Division of Wildlife; B/W= BIO/WEST Inc.

DIVERSION DAMS HAVE
BLOCKED UPSTREAM MIGRATION

1960's LOW D.O.
1970's MID D.O. &
HIGH CHLORINE

the past studies above Mill Creek, which may indicate that reduced velocities and poorer water quality during those years favored carp further up the river than at present. Trout were scarce and sporadic in occurrence. Utah chub were only taken in the lower Jordan River, below 45th South.

Several differences are evident, especially between the 1972 and later studies. Dace, mountain sucker and redside shiner were predominate species in the 1972 study, especially at Riverton and Bluffdale, and the shiners again in the lower Jordan. All of these species are small as adults and are generally not effectively sampled with electrofishing gear. Therefore, their presence in the 1972 study may be due to seining, and because the sampling occurred in the summer, seining during warm portions of the year. The only other seining we know of in these studies was by BIO/WEST, which occurred in a colder month and did not see any dace, considerably fewer mountain suckers and only one redside shiner. It is possible that these species have actually been reduced substantially in the river since 1972, but that is doubtful. Differences between years is probably a reflection of sampling and time of the year. The other major difference between the 1972 results and more recent studies is the lack of walleye and channel catfish in 1972, and the lack of white bass from 45th South and downstream. Walleye and channel catfish were caught above Bluffdale in 1976, the catfish in very high numbers (110). This 1976 sample was above a major irrigation dam and later samples were below the dam. White bass were still not found at 45th South or below until 1985. In 1985 and 1986, white bass, walleye and channel catfish were all found at 17th South and above. Black crappie, largemouth bass and bluegill sunfish were not reported from the Jordan River in Salt Lake County until the present study in 1986. Fathead minnow, gambusia, yellow perch and cutthroat trout were also not reported until the present study in 1986.

Sigler and Miller (1963) indicate that most of the species noted in the preceding paragraph that are apparently recent additions to the Jordan River fauna had been introduced into Utah Lake prior to 1960. The exception is the fathead minnow, which was not known from the Utah Lake area in the early 1960's. It is possible that past collections missed them due to rarity of these species because of a lack of reproduction or other limiting factor, such as poor water quality. It is also possible that the warm water species planted in Utah Lake are recent additions to the lower Jordan River due to the unusually high river flows that occurred during the last few years.

It would appear that the recent high flows have had an effect on the distribution and abundance of fish in the Jordan River. Discussions with Charlie Thompson, DOW Fishery Biologist for this area and a member of the 1976 and later DOW sampling crews, indicates that most species from Utah Lake had access to the lower Jordan River for many years. The dams in the Narrows obviously were a block to downstream movement during most normal flow years since no water was passed by the lower dam near

Bluffdale except during spring runoff. A DOW creel census near Riverton in 1979 reported a few white bass, walleye and channel catfish were caught by fishermen, along with nearly a hundred stocked rainbow trout, in April and May. Therefore these game species had restricted access to the lower Jordan River ever since their introduction into Utah Lake. During the last few years of high flow, the dams in the narrows passed water all months of the year. This provided considerably improved access for these species to the lower river. Therefore, the absence of these fish from earlier collections was probably due in part to the very small numbers that came down the river due to limited access. It should be understood that none of the warmwater game species now found in the lower Jordan have been stocked there. According to DOW records, only trout have been stocked in the Jordan.

Water quality may also have been a concern in the lower river in the past. Data in Hinshaw (1966) show very low dissolved oxygen and other water quality parameters indicating very degraded water quality. Way (1980) suggests that water quality in the late 1970's would have limited most game fish populations. This position was also suggested by Charlie Thompson who indicated that water quality conditions in the lower Jordan during the 1976 sampling were very poor. Hydroqual (1987) modeled the water quality of the Jordan River in the mid 1970's and showed that very high levels of chlorine, approaching if not exceeding acute fish toxicity thresholds, frequently occurred. Therefore, even if these game species had gained access to the lower Jordan, population increases due to reproduction would have been unlikely due to poor water quality.

Water quality as measured during the present field study (Appendix A) and as has been measured during recent years, does not appear to be limiting fish populations in the Jordan. The distribution and abundance of fish and macroinvertebrates could not be directly related to present water quality, but appeared to be well correlated with physical habitat. Species that may be sensitive to poor water quality such as walleye and channel catfish showed trends that were best explained by habitat availability.

The data collected in 1986 in this study indicate that the Jordan River varies considerably in terms of macroinvertebrate species composition, or density, and in fish composition and abundance in the areas studied. Differences between stations were generally best explained by differences in physical habitat such as substrate, cover, velocity and diversity of habitats. A comparison with past studies indicated that invertebrate density and species composition have not changed dramatically since the 1960's, but reasons for differences between stations may have changed. Hinshaw (1966) indicated water quality and channelization were the major factors affecting invertebrate populations. The present study indicated substrate and habitat differences to be the major factor creating differences in invertebrates between stations. Water quality was not a major limiting factor in 1986.

Fish populations have changed considerably in the lower Jordan River in the last 20 years and even the Riverton and Bluffdale areas have seen some changes. The major change has been an increase in the number of species, especially warm water game species common in Utah Lake, in the river.

The data collected in this study has indicated that most of the fish in the river except carp and Utah sucker are found sporadically and generally in rarer habitats. The Jordan River at all stations except Bluffdale provided very little in the way of diverse cover or habitat in the main channel, and Bluffdale had very high velocities. Since many of the gamefish are of fairly recent origin to much of the lower Jordan, due both to restricted access and water quality, their actual ability to utilize the available habitat is questionable.

It is suspected that as flows are reduced back down to "normal" levels, the number of fish moving down the river from Utah Lake will decrease. Habitat in the river will increase since slower water habitats will become more common and more diversity of flows across a channel will also occur. The actual amount of habitat change is not known but will probably vary considerably between portions of river. Areas that are fairly natural and presently have a diversity of habitat, such as 45th South, will probably have increased habitat diversity. Areas that are very canal-like, such as the Surplus Canal and Jordan River immediately below Mill Creek, will probably not change as much because of the flat, broad channel and homogeneity of the present habitat. The Jordan River below the diversion will probably change the least because it is presently highly regulated in flow and that will not change appreciably. These habitat changes will increase the amount of habitat for the warmwater game species such as white bass, walleye and channel catfish, especially at stations like 45th South where habitat is presently fairly diverse, but habitat in poorer stations may not change appreciably from present conditions. The major question remains whether sufficient numbers of these species exist to start a population, and whether habitat will be sufficient, especially for reproduction. We suspect the numbers of fish may be too low and habitat also may be too marginal.

CONCLUSIONS

The information developed from this study, both the field data and the literature review, indicate that fish and macroinvertebrate populations have changed in the fairly recent past. During the 1960's and 1970's water quality was very poor in the lower Jordan River as evidenced by several reports (Hinshaw 1966, Way 1980, Hydroqual 1987). This poor water quality, along with relatively limited access from Utah Lake, restricted the potential for buildup of macroinvertebrate and warmwater gamefish populations. In fact, the water quality, especially chlorine levels, probably also limited the populations of all fish. Any deficiencies in physical habitat quality were masked by the water quality problems.

Water quality has improved recently as a result of improved wastewater treatment. In addition, high flows have been the norm in recent years, creating even better water quality due to dilution. Physical habitat has not been improved and may have been reduced in quality by recent dredging and channelization. This is especially true of the area below Mill Creek where the river has been essentially put in a large canal, the Surplus Canal. Fish access from Utah Lake has improved with year-round flows through the Narrows irrigation dams. Warmwater gamefish have become more abundant, along with other species including trout that get into the river. Survival of these fish is no longer a problem in the lower Jordan since water quality is adequate for their survival. Limiting factors at present, therefore, are related to physical habitat. The habitat information collected during this study indicates that the lack of productive riffle habitats is limiting macroinvertebrate populations. Also, habitat for fish such as walleye, channel catfish and white bass is generally quite poor. All of these species require more habitat diversity and structure than presently found in the river. This is evidenced by collection of these species, especially white bass and walleye, in certain rare types of habitats. Backwaters in the case of white bass, and near instream cover for walleye. Whether or not reproductive habitat is available is not known but it is likely that little presently exists.

In the future, as the high flows subside, fish access from Utah Lake will decrease. However, water quality should be acceptable for the species presently found there as noted in the Hydroqual information, except for the trouts that only occur occasionally and would be limited by summer water temperatures. Without habitat improvement, and perhaps substantial habitat improvement, it is doubtful the warmwater gamefish will be able to become self-sustaining in the river. This, along with decreased access from Utah Lake, will probably decrease density of these species below that at present. It should be noted that the descriptions of the river by Jordan (1891) suggest the river has always been fairly poor for fish such as walleye, channel catfish and white bass. High velocities, lack of cover and sandy substrates all contribute to this. Dredging and channelization has made an impact, but based on the data collected during this study, it is not necessarily negative. Stations at 45th South, Above Mill Creek and 17th South had all been recently dredged but still had the largest and most diverse fish populations. As discussed in this report, these stations also were the most diverse in habitat, and apparently dredging did not change that dramatically.

Therefore, water quality at the levels predicted by Hydroqual should not be the primary limiting factor to fish and invertebrates in the lower Jordan River in the future. The lack of diverse physical habitat will be the major limiting factor that will need to be altered before warmwater gamefish can be expected to have a chance at providing reasonable recreational opportunities. Without this habitat improvement, it is our opinion that water quality improvements would not produce changes in the fish composition of the lower Jordan River.