THE IMPACT OF CATTLE GRAZING
ON SURFACE WATER QUALITY
OF A LOW FLOW FRONT RANGE STREAM

by

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INTRODUCTION

Cattle grazing has been and will continue to be an important land use in the Colorado Front Range. 122,000 head grazed the Front Range Counties in 19 (personal communication with H. L. Gary). Both seasonal and rotational grazing patterns are used, depending on the land productivity. While some areas require transportation of water, most areas have sufficient surface water to support a grazing population in excess of an available forage population. These cattle are normally granted unlimited access to their water supplies. When cows are located in or near the surface water sources, there is a possibility of a physical, chemical, or biological impact upon the quality of the water. These potential impacts are especially serious in low-flow streams common to the Colorado Front Range.

The objective of the first phase of this study was to evaluate the impact on stream water quality of grazing with unlimited stream access. I felt that by studying and comparing selected water quality parameters, variations in water quality could be measured as the stream traveled through non-grazed and grazed areas. Anticipated results were that mean concentrations of the water quality parameters would be low, but that occasional concentrations of certain parameters might reach levels which would suggest potential problems.

This paper summarizes the procedures and results of the first year's (phase 1) data collection (2 June - 12 November) and makes recommendations for the second sampling season.

STUDY AREA

The Colorado Front Range, generally regarded as the eastern foothills region of the Rocky Mountains, extends from roughly southern Wyoming to Canon City, Colorado. The region is bounded on the east by the plains and on the west by the crest of the Continental Divide. Land features along the Front Range include steep rocky canyons, narrow mountain valleys, foothills, ridges, and large openings or parks. Over 90 percent of the Front Range soils have been derived from the granite bedrock that underlies these geologic features.

The low elevation (6000-9000 ft) forests and grasslands of this Front Range are generally termed the ponderosa pine zone. The chief characteristics of this zone are its infertile and potentially unstable soils, and its sparse tree cover (Gary, 1975).

The Manitou Experimental Forest was established in 1936 to study land use problems in this ponderosa pine zone. Located about 40 mi. northwest of Colorado Springs, Colorado, the Experimental Forest has an area of just over 26 square mi. Extensive cattle grazing research has been accomplished at the Experimental Forest during the last few years (U.S.F.S., 1969).

Trout Creek is the only perennial stream in the Experimental Forest. This stream flows in a northerly direction from its origin near Divide, Colorado until it merges with West Creek to form Horse Creek. The stream passes through the Experimental Forest just east of Colorado State Highway 67 about half-way between these two points (fig. 1). As Figure 1 indicates, Trout Creek flows through two adjacent grazing pastures within the Experimental Forest boundaries. These two pastures and the associated sampling

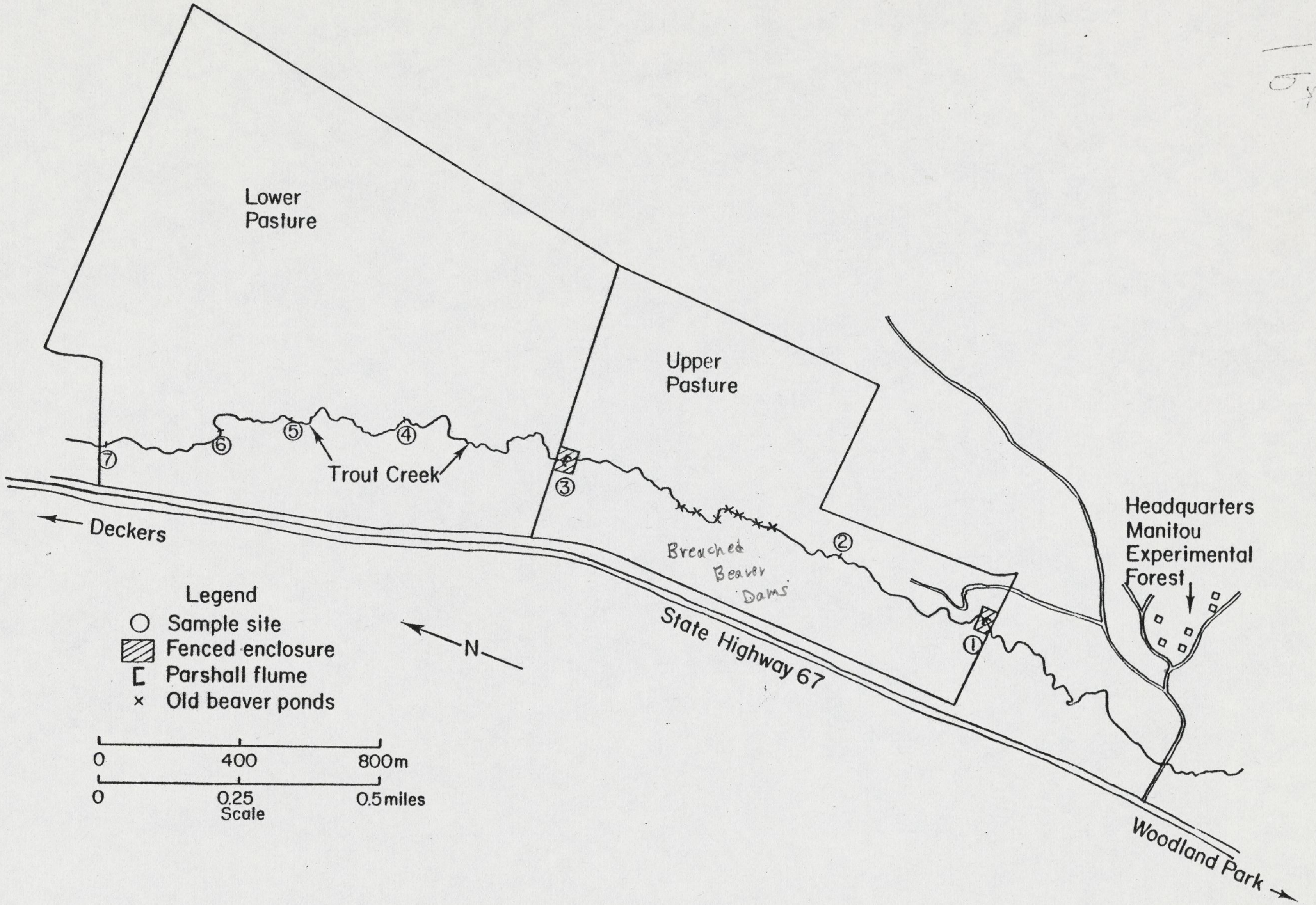

Figure 1. Trout Creek Grazing Study Area (Johnson, et. al, 1978).

sites make up the study reach used in this study.

Characteristic of streams located in alluvial areas, Trout Creek has occupied many positions within a broad floodplain. Upland areas of this floodplain consist of more coarse textured granitic alluvium while lower areas consist of more finely textured alluvium. Both alluvial deposits are derived from the disintegration of Pikes Peak granite, a coarse textured rock made up of quartz, orthoclase, microcline, and biotite (Cretzer, 1949).

Lower floodplain vegetation in the study section included willows, sedges, rushes, buttercups, iris, Kentucky bluegrass, white clover, common dandelion and various stages of weed succession. Upland vegetation in the study area was mainly bunchgrass such as Arizona fescue, mountain muhly or open ponderosa pine stands. Approximately ten percent of the study area was contained within the floodplain, the remainder being in the drier and less productive alluvial fans above the floodplain (Johnson, et, al., 1978).

A meteorological station located at the Experimental Forest Headquarters provided climatological information about the study area as well as the ponderosa pine zone. The climate of the area is sub-humid with wide diurnal and annual temperature ranges and great variation in the occurrence and distribution of rainfall. Average annual precipitation at this location is 15.4 in/yr with nearly three-fourths of this amount occurring from April to August. Most of the summer precipitation falls during thunderstorms of widely varying intensities (Gary, 1975). Mean annual temperature at this station is 40.6°F with occasional 90°F summer readings and extended winter periods of below 0°F (Berndt, 1958). The snow season extends from late September until May but snows commonly melt from southern exposures and valleys within a few days of occurrence (Gary, 1975). The moisture regime of the upland areas is characterized by a surplus of soil moisture through the winter and a summer period of moisture deficit when evapotranspiration depletes soil storage (Berndt, 1958).

Characteristic of Front Range streams, the Trout Creek hydrograph typically demonstrates a spring snowmelt peak and a recession limb sporadically interrupted by peaks from summer storm runoff. Following high intensity thunderstorms, these secondary peaks are occasionally higher than the spring peak. The meandering pattern of the stream course reflects the inherent erosivity of the underlying strata. The stream has cut through this alluvium in some places to a depth of six feet, leaving unstable and easily erodable banks. Average streamflow for Trout Creek is about 1 cfs.

METHODS

The study was conducted along a two mile section of Trout Creek which flowed through two adjacent fenced pastures. The four treatments involved in the study involved both numbers and placements of cows in these two pastures.

Prior to sampling, seven stream sites were selected, three in the 210 acre upper pasture and four in the 400 acre lower pasture (fig. 1). Site 1 is located within a fenced enclosure at the upper pasture boundary. Site 2 is located about midway between sites 1 and 3, just above an area of breached beaver dams. Site 3 in the upper pasture bottom is also located within a fenced enclosure. Sites 4, 5, 6 and 7 are located approximately equi-distant from each other in the lower pasture. Site 7 is located just above the lower pasture bottom fence.

For the past several years both pastures have been used as spring holding areas for cattle and have been heavily stocked from mid-April to early June. The cattle were then removed, leaving the pastures ungrazed until the following spring.

The beaver occupying the ponds between sites 2 and 3 were removed prior to the first sampling season. Their dams were destroyed and the ponds allowed to drain. Any additional beaver that attempted to build dams during the study period were live trapped and removed.

Phase one of this study involved four separate treatment periods. These periods included variable numbers and locations of grazing cattle.

In early April 1977, 150 head of cows and calves were placed in the lower pasture, leaving the upper pasture ungrazed. Measurements of water quality were begun at all seven sites on 2 June, nearly 1.5 months after grazing had begun. The cows remained in this area until 15 June. From 15 June until 25 June, both pastures were left ungrazed. Then, from 25 June until 14 October, 40 cows and calves were allowed to graze the upper pasture with the lower pasture remaining ungrazed. After 14 October, no grazing was permitted in either pasture.

Normal sampling frequency varied from every other day during early June to monthly in late fall. Two storm and one diurnal samples were attempted in mid-summer using only sites 1, 2 and 3.

Grab samples were collected in sterilized polyethylene bottles the same approximate time each sampling day (7-8 a.m.). The order of sample collection was Site 7 through Site 1, working upstream. The samples were kept iced from collection until arrival at the Experimental Forest Lab (within 1.5 hours of Site 7 sampling) and all analysis were accomplished the same day as collection.

Water quality parameters analyzed in this study include the following: stream discharge, electrical conductivity, dissolved oxygen, stream temperature, nitrate-nitrogen, ammonia-nitrogen, orthophosphates, suspended and total dissolved solids, pH, turbidity, and fecal coliform and fecal strep bacteria. Cattle activities and locations were observed and recorded on many non-sampling days. Climatological data was obtained from records kept at the Experiment Forest Headquarters.

Analytical procedures and techniques used to measure and analyze the data are individually summarized as follows.

Stream Discharge

Stream discharge values were determined from the depth-discharge relationship at the two Parshall Flumes at sites 1 and 3. Stream height recorders were installed in mid June and maintained until October.

Stream Temperature

Temperature was measured with the probe on the Y.S.I. dissolved oxygen meter and recorded to the nearest 0.5°C (1°F). Stream temperature recorders were installed in mid summer and maintained until October.

Electrical Conductivity

Electrical conductance (EC) was measured in the field with a Beckman EC Meter using the temperature from the Y.S.I. DO Meter. EC was recorded to the nearest 5 μmhos with the temperature dial set to the nearest 0.5°C (1°F).

Suspended Solids and Total Dissolved Solids

Suspended solids (SS) and total dissolved solids (TDS) were both made gravimetrically following procedures in Standard Methods (APHA, 1974). 200 ml samples were filtered with 100 ml being evaporated in the TDS analysis. GF/C grade filters were used for the suspendeds and porcelain crucibles for the TDS analysis. All weighing was done with a Mettler H-balance to four decimal places.

Turbidity

Turbidity was measured with a Hach Model 2100 A Turbidity Meter. Turbidities less than 10 were recorded to the nearest 0.1 NTU and readings above 10 to the nearest 1.0 NTU.

pH

Hydrogen ion activity was measured in the lab with a Hach pH meter. pH was recorded to the nearest 0.1 unit with the temperature compensation dial set to the nearest 1.0°C (2°F).

Dissolved Oxygen

Dissolved oxygen (DO) was measured in the field with a Y.S.I. DO Meter with automatic temperature compensation. Oxygen concentration was recorded to the nearest 0.5 mg/l following an immersion stabilization period of three to four minutes. The meter was calibrated in the air prior to each reading.

Nitrate-Nitrogen, Ammonia-Nitrogen and Orthophosphates

These were made colorimetrically using Bausch and Lomb Spec 70 following procedures outlined in the Hach Procedures Manual (Hach Chem. Co., 1975). Premeasured powdered pillows and the Nessler Reagent used in these tests were supplied by the Hach Chemical Company.

As the principle involved in these tests is light impedence (ideally only by a reaction - induced color), the remaining 100 ml of filtrate from the SS-TDS analysis was used. Measured light-impedence values were compared to standard curves to get actual concentrations. These standard curves were prepared using known concentrations and their recorded impedence values using the same procedures as in the sample analysis.

Concentrations were recorded as µg/l of NH_3-N, NO_3-N and PO_4.

Fecal Coliform and Fecal Strep Bacteria

Fecal coliform (FC) and fecal strep (FS) analysis were made using the membrane filtration technique with several dilutions per sample being made to assure a countable range (Millipore, 1973). Total elapsed time from sample collection at Site 7 until the last dish incubation was routinely two hours or less. Bacteria counts were reported as colonies per 100 ml of sample.

Statistical analysis and comparisons for this study were made using paired "t" tests. Comparisons were made between sites and study reaches for all four treatment periods. Minimum level for a significant difference between means was .05.

RESULTS

During the study period 8.72 in. of precipitation occurred which was 93 percent of normal for this time period. Several short duration-high intensity storms were recorded (24 July, 16 August, 21 August, and 12 September), each resulting in a substantial increase in streamflow.

Cattle locations and activities varied according to both season and time of day. Treatment 1 (lower pasture grazing) found most cows favoring the early season grasses near the stream during the day while dispersing over the entire pasture at night. In Treatment 3, however, with less cows in the smaller upper pasture, the cows remained fairly concentrated but did not seem to favor any particular area or grazing trend. Cows in both Treatments, as well as in other studies (Dwyer, 1961), spent less than 1 % of their time actually watering or resting in the stream channel.

The results of the routine sampling are given in Appendix C and summarized in Table 1. In general, average concentration of the various constituents were quite low. Those parameters closely associated with streamflow (i.e. SS, turbidity, nutrients, fecal coliforms and fecal strep. bacterial densities) illustrate a high degree of variability. This was to be expected since data following a time series has been averaged. The most significant differences between sites and reaches were found among the same parameters, further indicating a discharge correlation.

Since the primary objective of this project was to evaluate differences between treatments, the Discussion section will be concerned primarily with differences between sites 1, 3, and 7. Sites 1 and 3 constitute the upper reach while sites 3 and 7 constitue the lower reach. Intermediate sites (2, 4, 5, 6) were not employed in the statistical analysis but were used to

Table 1. n, $\bar{x}$, s, C.V. for all sites 2 June – 12 Nov 1977

Site		Q cfs	SS mg/l	Turb. NTU's	Temp. °C	EC µmhos/cm	TDS mg/l	pH	NO_3-N µg/l	NH_3-N µg/l	PO_4 µg/l	FC colonies/100 ml	FS colonies/100 ml
Site 1	n	23	23	9	24	23	22	13	24	23	23	23	24
	$\bar{x}$	2.92	9.00	6.06	13.98	236.30	145.05	8.03	217.92	285.22	233.48	33.91	118.54
	s	1.92	6.46	0.73	4.74	27.93	11.35	0.06	129.21	66.39	140.21	42.40	206.59
	C.V.	65.86	71.79	12.03	33.87	11.82	7.82	0.79	59.29	23.28	60.01	125.03	109.57
Site 2	n		23	9	24	23	22	13	24	23	23	23	24
	$\bar{x}$		9.39	5.32	13.85	235.00	144.41	8.11	193.75	255.65	204.78	55.52	155.88
	s		8.46	0.82	4.78	27.30	12.56	0.08	136.12	76.09	80.90	85.05	161.69
	C.V.		90.05	15.40	34.51	11.62	8.70	0.94	70.26	29.76	39.50	153.18	103.73
Site 3	n	23	23	9	24	24	23	13	24	23	23	23	24
	$\bar{x}$	2.51	27.17	8.19	13.54	237.29	145.17	8.05	249.79	303.75	218.70	90.35	223.75
	s	1.74	31.94	3.15	4.93	26.25	12.86	0.09	217.15	104.87	63.63	136.17	224.85
	C.V.	69.24	117.54	38.43	36.44	11.06	8.86	1.09	86.93	34.57	29.09	150.71	100.49
Site 4	n		23	9	24	24	23	13	24	23	23	23	24
	$\bar{x}$		25.09	9.40	12.54	240.63	147.70	7.96	235.00	342.39	195.65	76.52	238.00
	s		31.72	2.57	4.80	27.16	14.04	0.07	153.25	74.47	89.33	80.74	230.50
	C.V.		126.46	27.29	38.24	11.29	9.50	0.82	65.21	21.75	45.66	105.51	96.85
Site 5	n		23	9	24	24	22	13	24	23	23	23	24
	$\bar{x}$		22.7	8.27	12.29	237.5	146.68	8.08	177.92	288.70	209.57	84.65	244.58
	s		34.79	2.90	4.76	27.82	10.12	0.09	117.66	115.22	80.54	98.49	213.97
	C.V.		153.27	35.06	38.74	11.71	6.90	1.11	66.13	39.91	38.43	116.35	87.48
Site 6	n		23	9	24	24	23	13	24	23	23	23	24
	$\bar{x}$		28.43	8.04	12.02	237.92	145.52	8.10	240.83	280.65	329.61	81.22	225.50
	s		44.48	3.25	4.61	26.66	11.09	0.10	129.58	78.57	431.81	87.26	195.50
	C.V.		156.43	40.45	38.31	11.21	7.62	1.23	53.80	28.00	131.01	107.44	86.70
Site 7	n		23	9	24	24	23	13	24	23	23	23	24
	$\bar{x}$		18.87	7.67	11.98	234.38	146.22	8.06	215.83	300.87	242.17	88.00	227.58
	s		32.41	3.26	4.32	25.76	11.78	0.10	166.73	76.92	135.21	99.72	201.38
	C.V.		171.75	42.46	36.04	10.99	8.06	1.19	77.25	25.57	55.83	113.32	88.48

aid in the interpretation of data trends and help identify constituent sources.

DISCUSSION

The study consisted of four separate treatments that occurred sequentially throughout the summer. To enhance clarity, each treatment is discussed separately. Two of the treatments involved grazing on one pasture while the other remained ungrazed and the other two treatments involved no grazing on either pasture. Emphasis is placed on those parameters demonstrating positive or negative grazing impacts.

During the period of 2 June through 14 June, 150 cows and calves grazed the lower pasture while the upper pasture remained unoccupied. Appendix B contains the statistical results of the five samples analyzed during this period.

Sites 1 and 3 were compared first to obtain an indication of the natural variability in the control pasture. Significant differences were found between discharge, suspended solids, and fecal coliform densities. These results indicate a fairly high background variation for these parameters in the absence of cattle.

The significant difference in discharge was due to the alluvial nature of the soil material. The apparent mean loss of 0.66 cfs between the two flumes (Appendix A) was due to increased intragravellar flow at the lower site. The total of surface discharge and intragravellar flow were probably nearly the same at both sites. Surface discharge for this period ranged from 3.8 cfs to nearly 9.0 cfs while the apparent discharge loss between flumes ranged from 0.3 cfs to 1.2 cfs. Highest losses occurred on days of highest flow (Fig. 3; Appendix A).

Suspended solids concentrations (Fig. 2) closely followed the stream discharge trend (Fig. 3) with peaks occurring on days immediately following precipitation. Site 3 was much higher than Site 1 on all sampling days with mean values of 16.0 and 66.8 mg/l, respectively. Site 2 data revealed that this significant increase occurred below site 2. It was apparent from field observation that this increase in SS loads was derived from the area of breached beaver dams between sites 2 and 3 (Fig. 1). The breaching of these dams and the draining of their associated ponds left broad areas of accumulated silt and organic deposits. This area contributed silt and sediment directly to the stream as the streamcourse now traverses the once ponded area. Channel location is a dynamic process in alluvial areas such as this but the exposure of this easily erodable material following years of deposition caused the significant difference in SS between these two sites.

Fecal coliform densities were significantly different with site 3 supporting consistently higher counts (Fig. 4a). However, both counts were relatively low; the mean values for sites 1 and 3, were, respectively, 13 and 22 colonies per 100 ml. The count at site 1 indicates an upstream FC source while the increase downstream possibly indicates a residual effect from this pastures' past grazing history. Other possibilities include a groundwater addition or an up-watershed impact from a human activity.

Statistical comparisons were then made between sites 3 and 7 to examine grazing effects. Significant differences were found between stream temperature, fecal coliform and fecal strep bacterial densities (Appendix B).

Temperature differences can best be explained by the time delay in sampling. Average time between the data collection at sites 3 and 7 was 40 minutes, enough time to allow the more 2°C (4°F) mean temperature increase at the upper site. A cold groundwater or spring addition above the lower site is another possible explanation.

Bacterial densities indicate a possible cattle grazing impact. Mean fecal coliform counts for sites 1, 3 and 7 respectively, were 13, 22 and 156 colonies while mean FS counts for the same sites were 75, 69 and 234 colonies (Appendix A). FS differences were significant only between sites 3 and 7. Site 7 was consistently highest in both counts with both FC and FS graphs demonstrating similar trends for the period (Fig. 4a, 4b).

FS counts seem to correlate closely with discharge and precipitation events. The peak count for the period of 465 on 14 June followed 0.21 in. of precipitation on the afternoon and evening of the 13th. Discharge was decreasing but still above 4 cfs (Fig. 3).

Possible explanations for the increased bacterial densities in the grazed pasture include direct stream deposition of fecal material or the transmission of the bacteria through the soil by normal percolation and infiltration. With the increased numbers of bacteria in the grazed pasture due to the cattle fecal material, normal bacterial die-off rates would still leave much larger bacterial counts in the grazed pasture, as the data indicates. Another possible explanation for these bacterial counts is a groundwater addition from a up-watershed human activity. The extreme permeability of these alluvial soils might allow bacteria to travel great distances without total die-off.

The final statistical comparison for this treatment was made between pastures, or specifically the <u>differences</u> between sites 1 and 3 were compared to the <u>differences</u> between sites 3 and 7. Thus the grazed and ungrazed pastures were compared in the same fashion that sites 1, 3, and 7 had been compared.

Significant differences were found in suspended solids, stream temperature and fecal coliform counts (Appendix B).

The SS differences were probably due to the breached beaver dam area in the upper pasture as differences were greatest in this ungrazed pasture. Site 7 had the highest concentration of SS on two occasions, possibly indicating a further scouring effect by the material picked up in the beaver dam areas.

Stream temperature differences were once again due to the time delay in sampling or from a groundwater or cold spring addition.

The significant differences between FC means indicate a cattle grazing impact but the lack of a significant difference in FS means weakens this argument. As FS bacteria are more numerous than FC bacteria in cattle intestines (approximately 2 to 10 times) a higher FS count is needed before a cattle impact can be concluded. Therefore, some form of outside fecal pollution (up-watershed homes, recreationists, etc.) must be included in possible explanations of the higher downstream counts.

Neither TDS nor EC were significantly different, either between sites or between reaches (Appendix B). Mean TDS for the three main sites was 152 mg/l while mean EC was 209 (Appendix A). Mean EC for all sites began an upward trend that continued throughout the study. EC and TDS variability and trends depend upon an inter-relationship between baseflow, stream temperature, and possibly runoff resulting from precipitation events. These are all factors which effect sites more or less uniformly, hence the similarity of the site means.

None of the nutrients (NO_3-N, NH_3-N, or PO_4) displayed any significant differences either between sites or between reaches (Appendix B). Means for NO_3-N and NH_3-N demonstrated slight increases in the downstream direction.

For sites 1, 3, and 7, respectively, mean NO_3-N concentrations were 298, 354 and 427 µg/l while mean NH_3-N concentrations were 273, 294 and 308 µg/l (Appendix A). Mean PO_4 concentrations differed only slightly in the upper pasture (207 µg/l mean for the two sites) while a substantial increase is exhibited in the lower pasture (203 to 252 µg/l).

These were the highest NO_3-N concentrations for the entire study period, possibly suggesting a "nitrate flush" from a source area. Deposition of decaying organic material in slack water pools and during the winter might have allowed a build up of nitrogenous compounds. Then, after these materials were flushed into the stream during high discharge periods, a high nitrate concentration would be followed by lower values, just as the data indicate.

Figures 5, 6 and 7 illustrate the trends for nitrate, ammonia and phosphate during this treatment period.

Variations in nutrient levels may be due to an interaction between stream discharge and stream temperature, as well as the fact that low concentrations, such as these, allow natural variation to become a significant factor. The degree of accuracy involved in these tests and analytical procedures allow natural background levels and natural variation to possibly become the predominant cause of experimental variation. Addition of nutrients from groundwater and/or land use activities may also be responsible for some of this nutrient variation.

While FS counts were significantly different only between sites 3 and 7, the mean count of 72 in the upper pasture is apparently the background concentration. Beaver activity or a residual effect from past grazing history are possible causes for this concentration. The precipitation events which seem to be involved in the significant differences between sites 3 and

7 had no effect here, apparently due to the lack of cattle to provide the bacterial source.

In summary of Treatment 1, cattle impacts are implied only in the fecal coliform bacteria densities. Most significant differences were due probably to sampling technique, inherent background variation coupled with low concentrations, and interactions with streamflow. An interaction between discharge and precipitation events may have masked differences in some comparisons between pastures.

Treatment 2

Between the 15th and 24th of June all cows were removed from grazing in the study pastures. Sampling continued just as in Treatment 1 with five samples being drawn and analyzed.

In comparing sites 1 and 3, significant differences were found between discharge and suspended solids (Appendix B). The significant difference in FC means from Treatment 1 has disappeared, further indicating a grazing impact in Treatment 1.

Significant differences in discharge was once again due to increased intragravellar flow at the lower flume. Mean streamflow for the period was about 2 cfs and the mean apparent loss between flumes was 0.36 cfs (Appendix A).

The significant differences in the SS analysis was once again due to higher concentrations at site 3 from the breached beaver dam area. Mean values for sites 1, 3 and 7, respectively, were 7.5, 15.5 and 5.1 mg/l (Appendix A). Sites 3 and 7 both recorded mean decreases of about 51 mg/l over Treatment 1 means. SS measurements still follow the discharge trend but no precipitation impact is indicated. The lower flow characteristic of the stream apparently influenced the expected precipitation impacts following storms on the 17th and 23rd. Evidently a "threshold value" in discharge must be reached before the stream begins to transport sediment. Figure 2 illustrates the variation and trend in SS concentrations for these sites.

The only significant difference between sites 3 and 7 was in stream temperature (Appendix B). Once again, this was due to the time delay in sampling these two sites. The time delay between sites 1 and 3 was much less, hence its lack of a significant difference.

The only significant difference between stream reaches was in the Ammonia-Nitrogen (NH_3-N) concentration (Appendix B). As Figure 6 indicates, this period had the peak value for the entire study, 530 μg/l, which occurred at site 3 on 22 June. However, no clear pattern or trend between sites is apparent. All three sites seem to vary independently. Mean concentrations of NH_3-N for sites 1, 3 and 7, were, respectively, 250, 332 and 284 μg/l. Possible explanations for the site 3 concentration include groundwater addition or a beaver visit between sites 1 and 3. Nitrate measurements contradict this explanation, however, as I would expect higher NO_3-N concentrations from the same sources.

An explanation of the significant differences in NH_3-N between reaches is difficult, particularly when site comparisons demonstrated no significant differences. The greater difference between upper pasture sites (1 and 3) compared to the lower pasture sites (3 and 7) indicate more uniformity among lower pasture concentrations. This indicates no additive or cumulative effects as the water travels through the lower pasture but suggests the opposite in the upper pasture. Beaver activities and/or groundwater additions seem to be the only possible explanation at this time.

EC and TDS still demonstrated no significant differences either between site or between reaches. TDS averages for each site were all within 3 mg/l of a 140 mg/l mean and EC values were within 3 units of a 222 μmhos/cm mean (Appendix A). The upward trend in EC concentration continued, apparently in response to a falling hydrograph.

Stream temperature differences were significant only between sites 3 and 7, not between sites 1 and 3 or between reaches. A significant time delay in sampling is only present between sites 3 and 7 while the low-flow characteristic of the stream tends toward a uniform stream temperature.

Suspended solids (SS) demonstrated no significant differences either between sites 3 and 7 or between reaches. Low streamflow, no major precipitation events and absence of beaver dam silt flats in the lower pasture led to this result.

As mentioned earlier, only the Ammonia-Nitrogen difference between reaches was significant. Phosphate concentrations were very uniform on most days but the site 1 measurement of 440 μg/l on 24 June resulted in it having the highest mean for the period (Fig. 7). PO_4 means for sites 1, 3, and 7, respectively were 228, 190 and 194 μg/l (Appendix A).

The PO_4 peak on the 24th at site 1 was preceded by the 0.17 in. precipitation event on the 23rd. This indicates that an upstream phosphate source was flushed into the stream but utilized before site 2. This result would appear to further indicate a lack of residual grazing effects.

Nitrate-Nitrogen (NO_3-N) concentrations were relatively low with mean values of 158, 110 and 84 μg/l for sites 1, 3 and 7, respectively. These are the lowest NO_3-N concentrations for the entire study and demonstrate reductions over Treatment 1 means of from 100% to almost 500% (427 μg/l to 84 μg/l for site 7).

This NO_3-N reduction in the downstream direction indicates a nitrate addition from an unknown upstream source which is consumptively used. The reduction in mean NO_3-N at all sites, and particularly site 1, indicate a reduced level of contamination from this upstream source.

While none of the FC or FS comparisons demonstrated any significant differences, the FC analysis indicates a grazing impact (Appendix B). The mean FC density at site 7 decresed from 150 to 44 colonies while sites 1 and 3 registered higher counts for this treatment period as compared to the previous Treatment (Appendix A). This decrease in the FC density at site 7 following removal of the cattle indicates a grazing impact while the increased densities at sites 3 and 7 indicate an increasing amount of upstream FC contamination. Possible sources of this upstream contamination include beaver activities or human activities.

The increasing downstream trend in the FC counts may be due to a residual effect from grazing, both from Treatment 1 and from the past grazing histories of both pastures. The increases in FC counts on days immediately following precipitation were slight.

FS counts demonstrated large increases during this treatment but site 7 had the smallest increse, indicating a grazing impact. The mean FS count at site 1 was 230 colonies per 100 ml (up 155), 235 colonies per 100 ml at site 3 (up 166), while site 3 had a mean of 282 colonies per 100 ml, an increase of 48 colonies per 100 ml over treatment 1 (Appendix A). These results indicate a grazing impact partially masked by an increase in FS contamination by an unknown upstream source. Once again, possible explanations include beaver or human activities.

Even more than the FC counts, FS densities seem to correlate closely with precipitation events. The 0.17 in of precipitation on the 23rd preceded a mean FS count of over 670 colonies/100 ml for the three main sites. The precipitation event on the 18th led to a similar count.

These increases in both FC and FS counts following precipitation suggest a "soil flushing effect" by the infiltration and percolation of this moisture. Discharge did not increase significantly on these occasions indicating that surface runoff was negligible. The increased soil humidity following this precipitation might have been more conducive to bacterial growth, hence a lower than normal die-off.

Figure 4A and B illustrates the variation involved in the bacterial densities.

Summarizing Treatment 2, reduced bacterial densities following removal of the cattle further indicates a grazing impact. Unknown upstream additions of both nutrients and bacteria had a masking effect on possible significant differences. Most significant differences were due to sampling technique and the breached beaver dam area.

Treatment 3

During the period of 25 June to 13 October, 40 cows and calves grazed the upper pasture while the lower pasture remained ungrazed. pH and turbidity analysis were added to the list of measured parameters.

Statistical analysis indicated no significant differences between reaches for any parameter but several differences were significant within a reach (Appendix B).

Discharge, turbidity, stream temperature, and FC means were significantly different between sites 1 and 3. The mean loss in discharge of 0.24 cfs between the two flumes was due to increased intragravellar flow at the lower site (Appendix A). Turbidity measurements were highest at site 3, once again due to the breached beaver dams (Appendix A). This area contributed silt and organic debris which were measured in the turbidity analysis. Stream temperature was significantly different here, as well as between sites 3 and 7, due to an interaction between discharge and sampling delay (Appendix B). The low flow trend in discharge, storms excepted, accentuated the time delay between samples. The comparison between sites 1 and 3 was significantly different for the first time while the comparison between sites 3 and 7 continued a trend of significant differences.

Suspended solids differences were significant only between sites 1 and 3. SS values closely correlated with stream discharge with mean concentrations of 6.55, 13.15, and 6.45 mg/l for sites 1, 3 and 7, respectively (Appendix A).

Mean fecal coliform densities were significantly different only in the upper pasture with mean counts of 62, 197 and 94 colonies per 100 ml for sites 1, 3 and 7, respectively (Appendix A). This indicates a grazing impact for this treatment as site 3 increased 168 colonies while the other two sites increased less than 50 colonies per 100 ml. FC counts also followed discharge and precipitation trends for this period.

While differences were not significant during any comparison, the FS trend was similar to the FC trend and both indicate a grazing impact. Site 3 was highest for both bacterial types while sites 1 and 3 both registered increases during this period. FS counts for this treatment were the highest of the entire study with means of 278, 362 and 257 colonies per 100 ml for sites 1, 3 and 7, respectively (Appendix A).

Both FC and FS increases indicate an increasing amount of bacterial contamination from an unknown upstream source. This contamination is having a masking effect on the grazing impacts. The 6.5 in of precipitation which occurred during this period also caused increases which had a masking effect.

Nutrients (NO_3-N, NH_3-N and PO_4) were not significantly different either between or within reaches (Appendix B). NH_3-N and NO_3-N indicate a possible grazing impact, however.

The mean NH_3-N concentration at site 3 was higher than sites 1 or 7 (311 compared to 286 and 281 μg/l, respectively) indicating a grazing impact as well as an upstream ammonia contamination source (Appendix A). Measurements in general were highly variable (Fig. 6) but the date of lowest concentrations (16 August) was also the date of lowest discharge on a sampling day. Other data from this period demonstrate the opposite, however. NH_3-N variations are probably due to an interaction between stream temperature and discharge. Figure 6 illustrates this variation measured during this treatment.

As in the NH_3-N analysis, mean NO_3-N was highest at site 3. Means for sites 1, 3 and 7 were 187, 234 and 164 μg/l, respectively, with all three sites demonstrating increases for the treatment (Appendix A). This indicates a grazing impact partially masked by upstream nitrate contamination. No clear trend among sites was found during this Treatment as Figure 5 illustrates.

Mean PO_4 concentration also increased during this period but site 3 registered the lowest level. Mean concentration at site 3 was 242 μg/l while sites 1 and 7 had means of 287 and 294 µg/l, respectively (Appendix A). Natural variation at low concentrations is the best explanation for the results in Figure 7.

pH differences were not significantly different as pH was very uniform between all sites. pH values varied slightly in a 7.8 - 8.2 range. TDS and EC differences were small and not significant but the trend towards increasing EC continued. Mean EC for the sites was 248 µmhos/cm while mean TDS was 148 mg/l (Appendix A). TDS and EC variation are probably a result of a temperature-discharge interaction.

In summarizing Treatment 3, FC and FS bacterial densities as well as NH_3-N and NO_3-N imply a grazing impact. Contamination from upstream sources for all these parameters, however, had a masking effect on the grazing impact analysis. The lack of any significant differences between reaches for this period of highest sample number weakens any conclusions of cattle grazing impacts.

Treatment 4

The 40 cows and calves were removed from the upper pasture on 14 October, leaving both pastures ungrazed. Three samples were collected and analyzed, leading to significant differences between only two parameters.

Suspended solids and turbidity differences between sites 3 and 7 were found to be significantly different (Appendix B). The site 3 SS concentration was still highest (mean of 6.50 mg/l) while the means of sites 1 and 3 were very similar (4.33 and 4.67 mg/l, respectively) (Appendix A). Low streamflows kept these concentrations small but the breached beaver dam addition is still apparent. The deposition of this transported sediment between sites 3 and 7 created the significant difference. Mean turbidity differences were small but significant and increased in the downstream direction (Appendix A). No explanation is available at this time to explain this trend. Both SS and turbidity closely followed the discharge trend (fig. 3), but the low flow condition led to the uniformity in data.

Neither bacteria type, FC or FS, demonstrated any significant differences but both demonstrated dramatic decreases in numbers. These decreases, apparently in response to an increasingly hostile climate, masked any grazing impact that might have occurred. Mean FS counts for sites 1, 3 and 7, respectively, were 51, 43 and 72 colonies per 100 ml while mean FC counts were 7, 10 and 8 colonies per 100 ml (Appendix A). The climatic changes experienced during this period, primarily temperature, led to an increased die-off of the bacterial populations.

Stream temperature also responded to this climatic change as the mean stream temperature for the three sites dropped to almost 4°C (39°F) (Appendix A). EC and TDS responded to the stream temperature and discharge trends by becoming very uniform between the sites. Mean TDS was 130 mg/l and mean EC was 279 µmhos/cm (Appendix A).

pH differences were not significant as pH was almost constant on any sampling day. pH values varied slightly in a 7.8 - 8.2 range.

Mean loss in discharge was 0.42 cfs, but the difference was not significant due to the low number of samples (Appendix A).

Nutrient differences were not significant but measurements demonstrated varying trends. Ammonia concentrations were the highest of the study but the means were very similar between all three sites (367, 343 and 373 µg/l for sites 1, 3 and 7, respectively) (Appendix A). This uniformity in mean concentrations continued a trend which began in mid-August. The upstream NH_3-N contamination is still evident, possibly from beaver activities.

Nitrates increased at all sites for this Treatment while site 3 was highest on all sampling days. Mean concentrations of NO_3-N were 260, 327 and 187 μg/l for sites 1, 3 and 7, respectively (Appendix A). The concentration at site 1 indicates an increase in the upstream NO_3-N contamination while the site 3 measurement implies a residual effect from the grazing period. Apparently the NO_3-N is utilized by vegetation in the lower pasture, hence the reduction in NO_3-N concentration at site 7. A groundwater addition above site 3 is another possible explanation for the NO_3-N trend. Figure 5 illustrates the variation in NO_3-N concentration for the period.

Mean phosphate concentrations decreased during this period but site 3 had the highest values. Mean PO_4 concentrations for sites 1, 3 and 7, respectively, were 130, 227 and 147 μg/l (Appendix A). The upstream PO_4 source has decreased but no trend among sites is apparent, as illustrated in Figure 7.

To summarize Treatment 4, only the NO_3-N indicated a grazing impact. Decreases in both FC and FS bacterial populations due to climatic changes masked any possible grazing impacts. Nutrient trends were highly variable with the highest NH_3-N and the lowest PO_4 measurements for the entire study occurring during this period.

Conclusions

Only the results of the FC analysis indicate an impact by grazing cattle. Mean FC densities were highest in the grazed pasture bottoms for both grazed treatments. These same sites were also highest in the non-grazed Treatments, indicating a residual effect.

Nutrients (NH_3-N, NO_3-N and PO_4) demonstrated a high degree of internal variation but also implied a grazing impact in some instances. As with FC counts, mean NO_3-N concentrations were always highest in the grazed pasture bottoms for the two grazed Treatments. NH_3-N concentrations were high or highest at these same grazed pasture bottoms. Upstream nutrient contamination possibly masked the grazing impact for these nutrients.

Several physical parameters demonstrated significant differences but none implied a grazing impact. Time delay in sampling, stream channel conditions, and soil characteristics created these significant differences.

Comments in Preparation of 2nd Season Data Collection

1. It has been decided that the cause of the upstream contamination need not be determined, at least by this paper.
2. A discharge measuring device should be installed at site 7, in the lower pasture bottom.
3. If extensive bank sloughing analysis is deemed necessary, a sag-tape analysis (U.S.F.S. procedure) will be used.
4. Another site in the beaver dam area will be added.
5. A diurnal examination is not needed.
6. At least one major storm event, plus spring run-off needs to be sampled and analyzed.
7. 2nd season data collection began on 4-5 March and will continue every other weekend until summer begins. Sampling will then be done on a weekly basis.
8. Filtering action of the soil will be examined. Varying lengths of soil columns will be used in a FC-FS analysis.
9. 2-3 replications will be made of samples whenever possible. 2nd and 3rd samples will be analyzed after the 1st set, not as an enlarged first set.

Suspended Solids (SS)

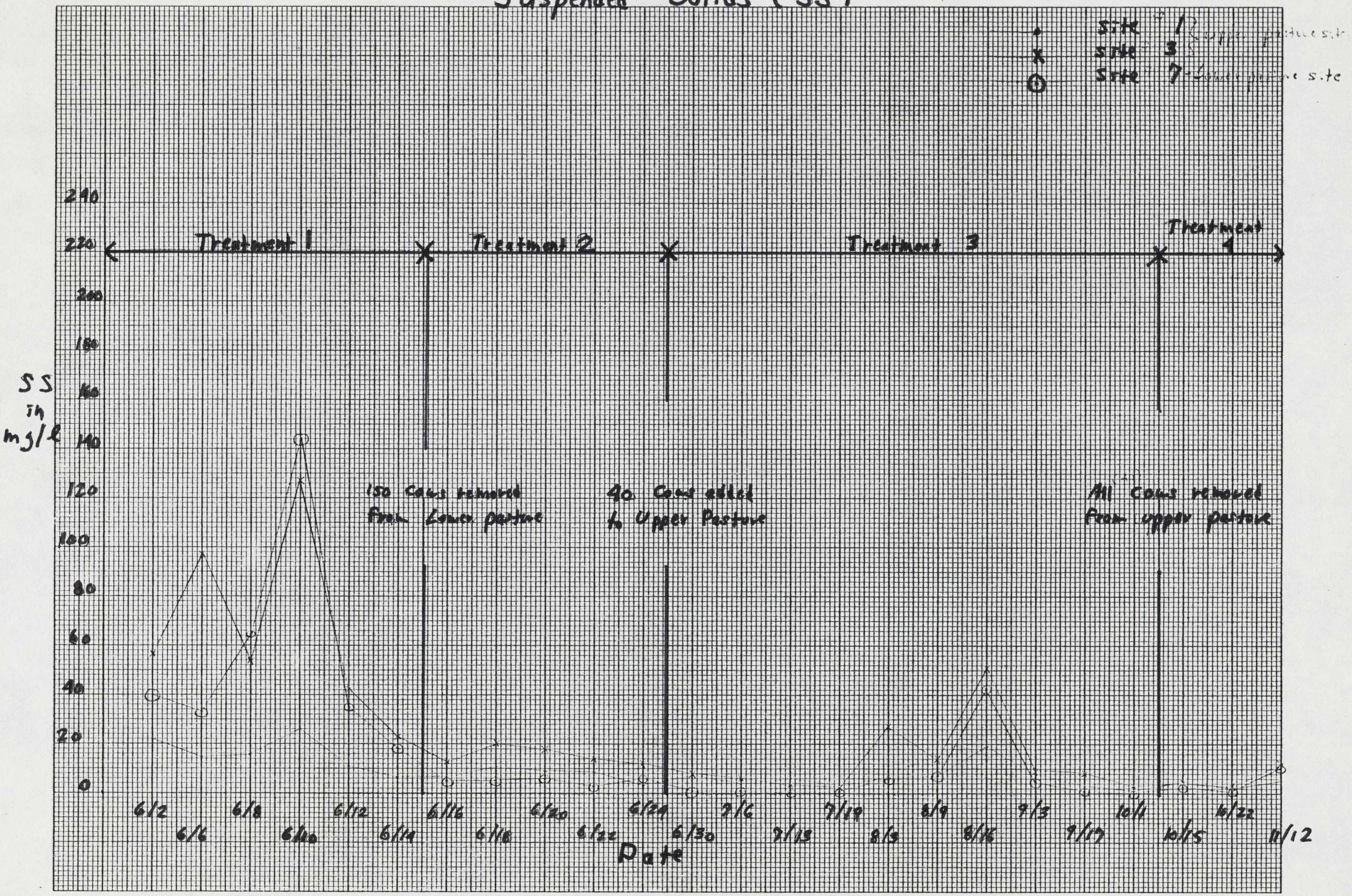

Fig. 2 Suspended Solids Determination

K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

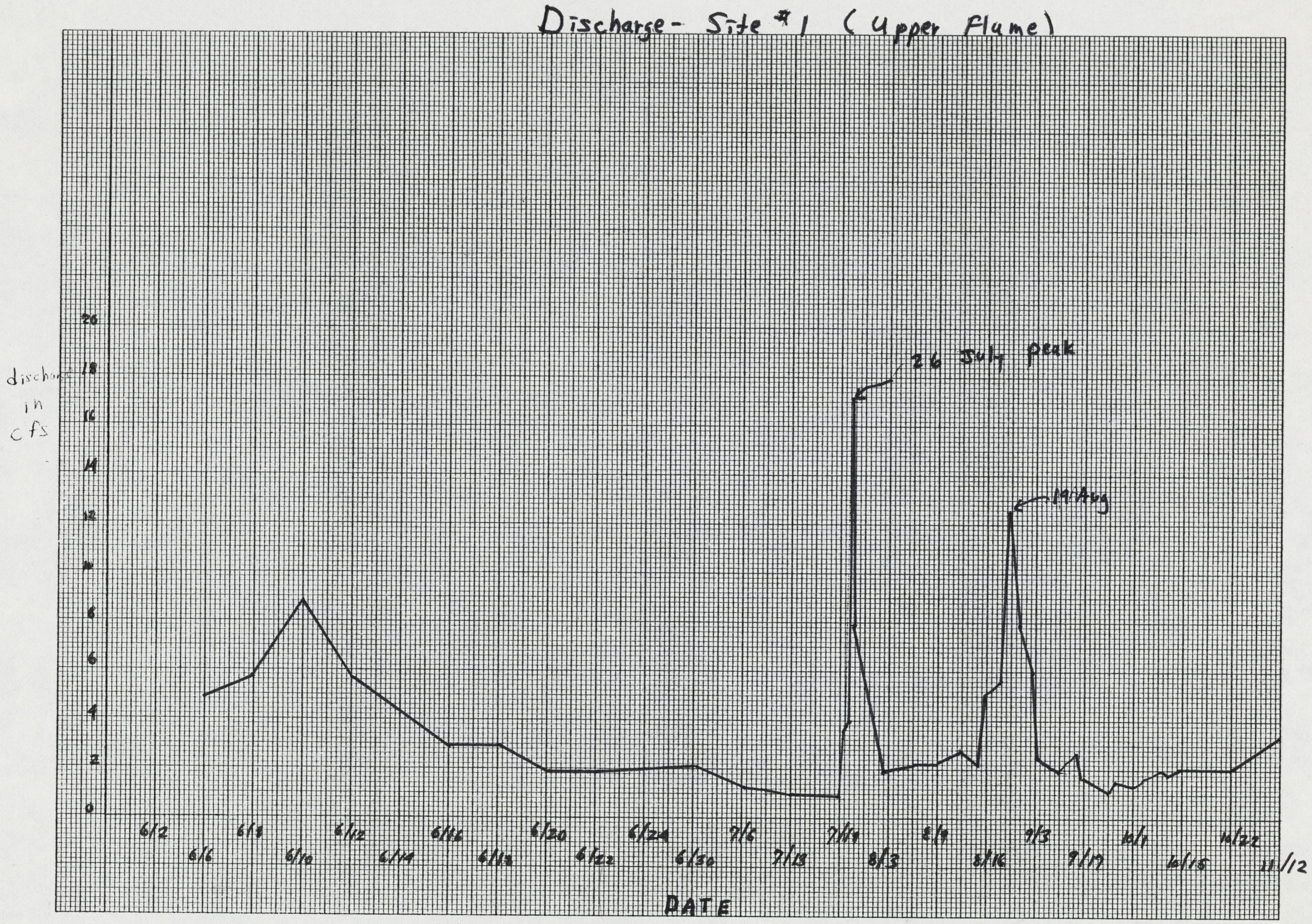

Fig. 3 Stream Discharge

FC, FS Bacteria Counts

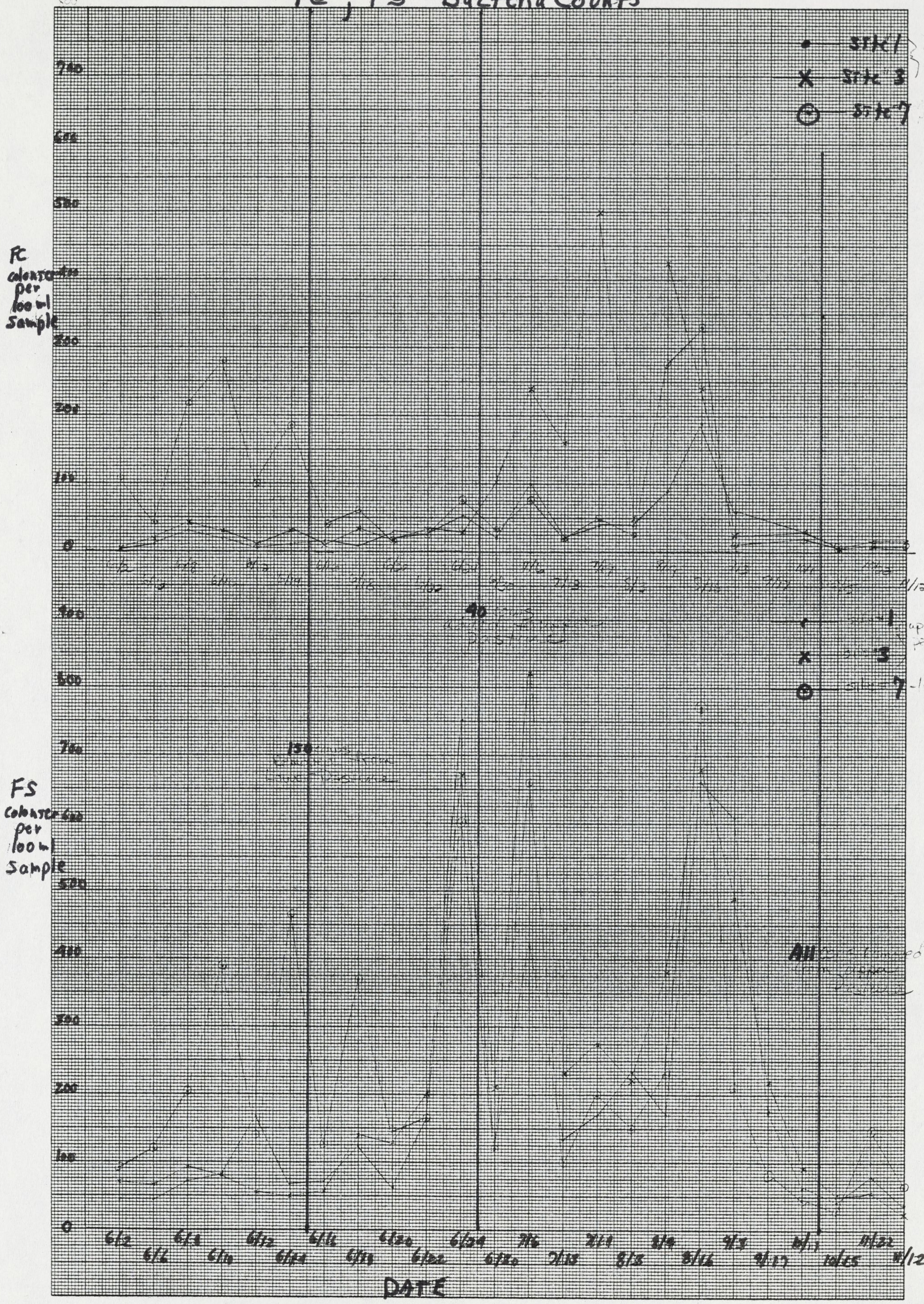

Fig. 4a, FC and 4b, FS Bacteria Counts /100 ml.

K+E 10 X 10 TO THE CENTIMETER 18 X 25 CM. 46 1513 MADE IN U.S.A. KEUFFEL & ESSER CO.

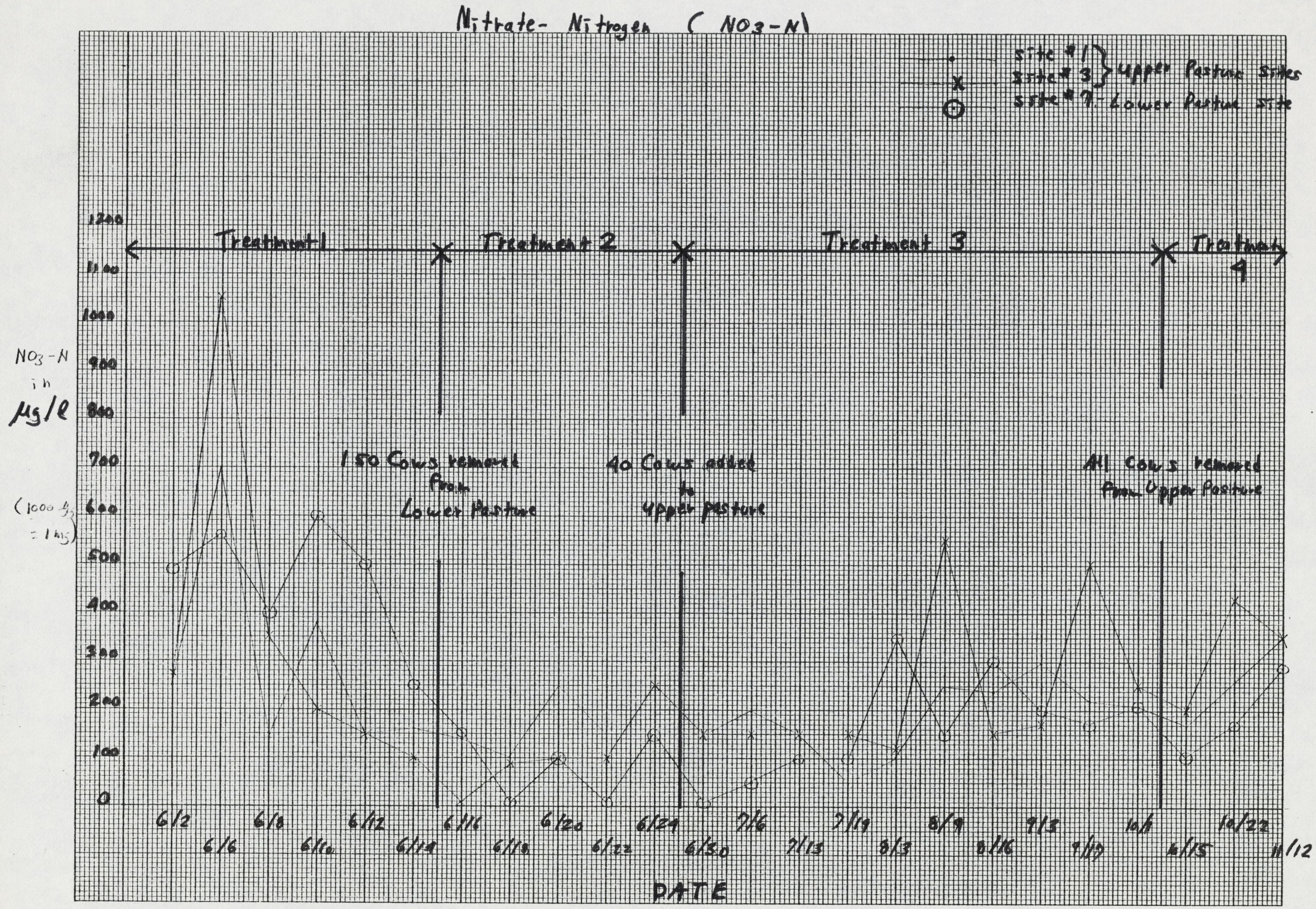

Fig. 5 Nitrate-Nitrogen (NO_3-N)

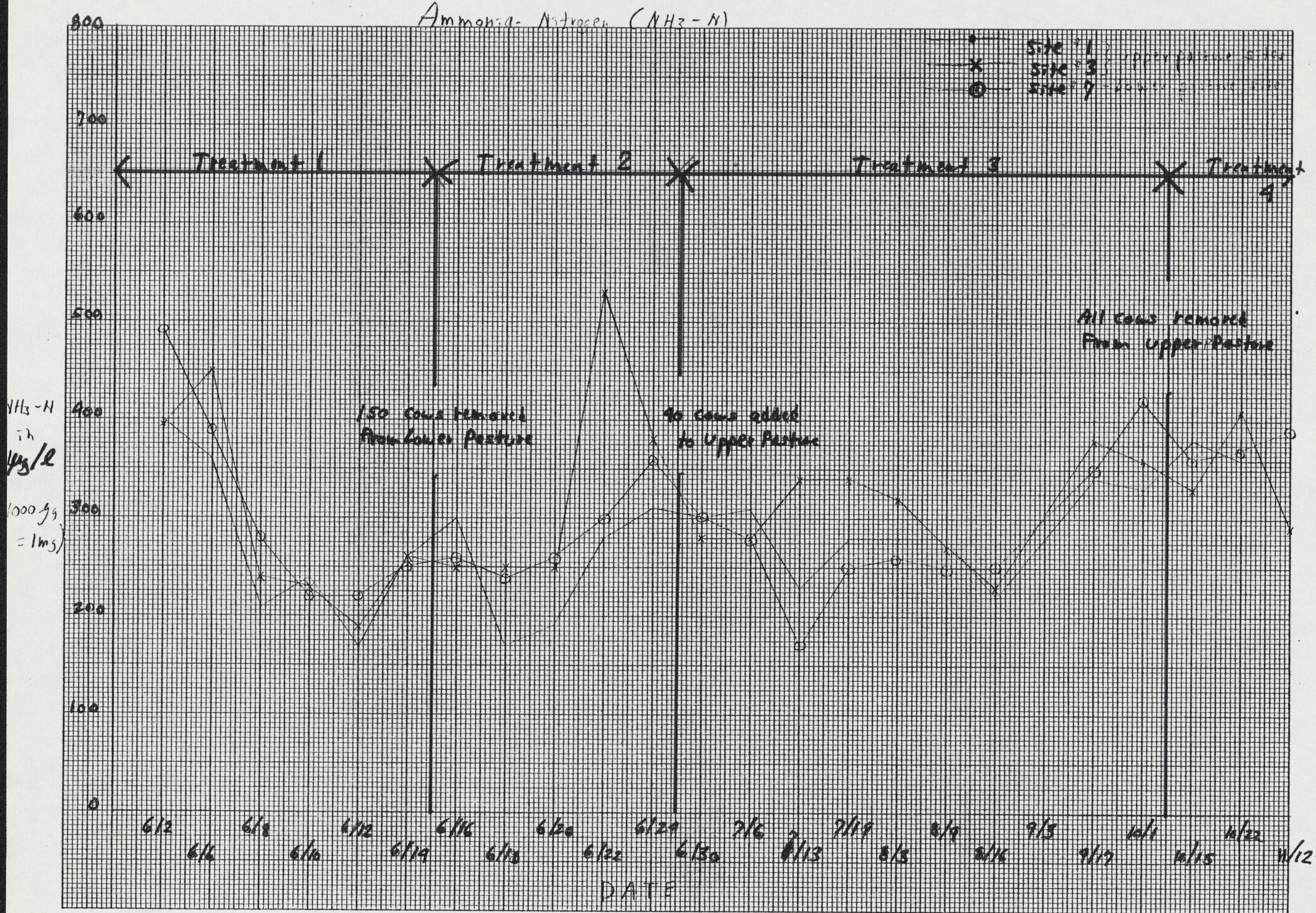

Figure 6 Ammonia- Nitrogen (NH_3-N)

K+E 10 X 10 TO THE CENTIMETER 46 1513
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

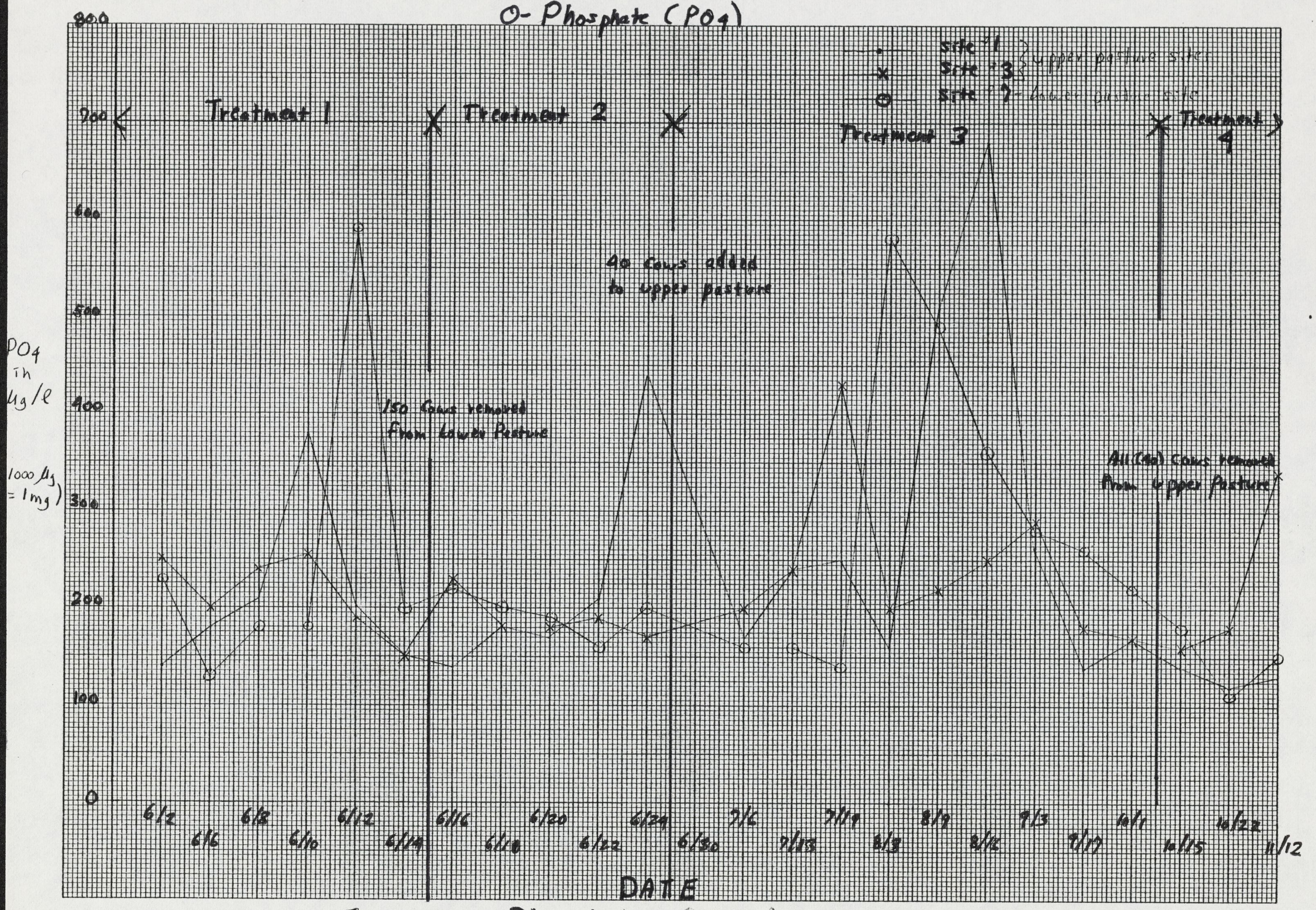

Figure 7 O-Phosphate (PO4)

Discharge - Site #3 (Lower Flume)

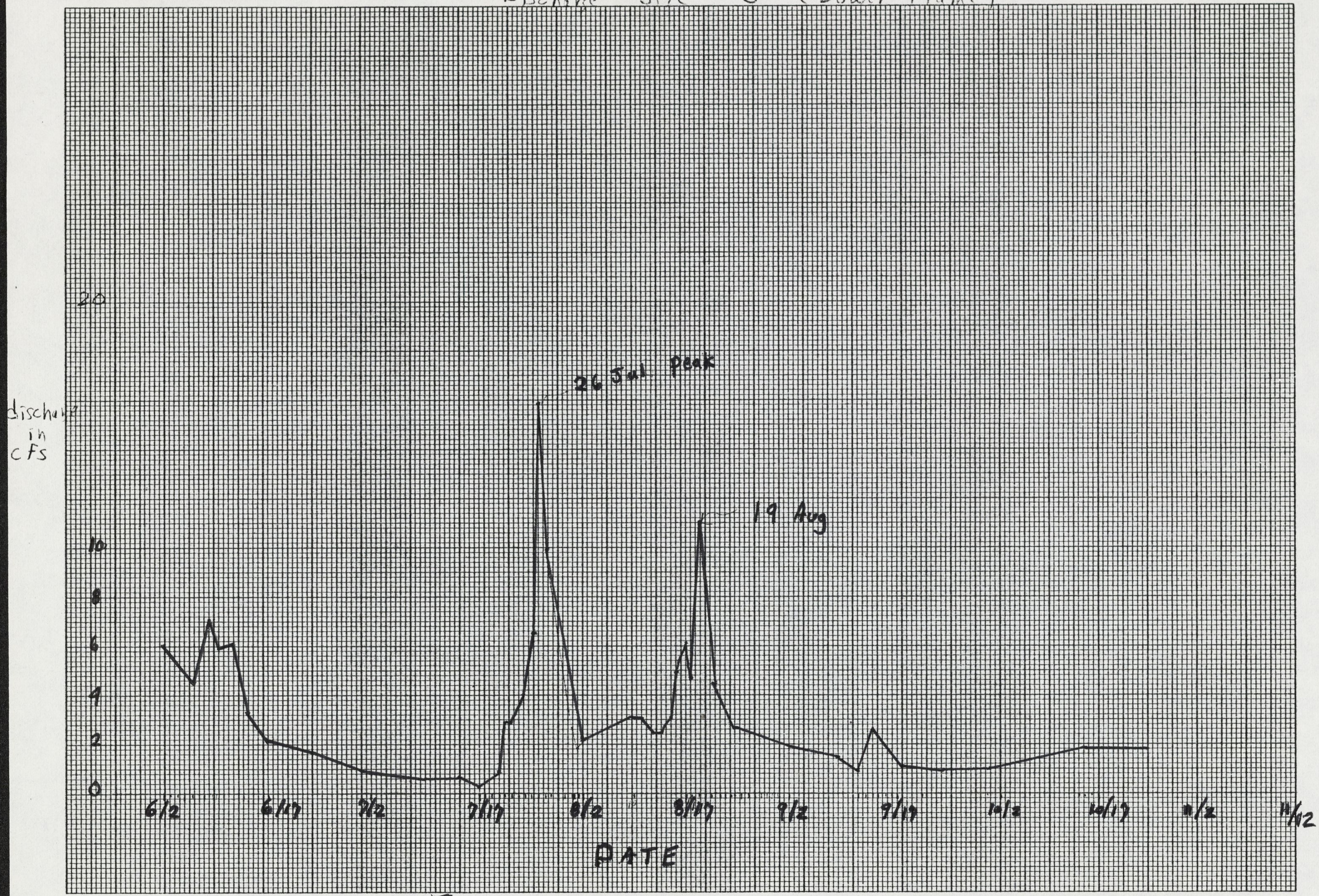

Fig. 8

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Appendix A

Mean Values for sites 1, 3, and 7 for each Treatment

TDS (mg/l)	Treatment 1	2	3	4
Site 1	150	138	148	136
2	154	139	146	130
3	152	143	149	125

EC (µmhos/cm)	Treatment 1	2	3	4
Site 1	208	221	251	285
3	208	225	248	280
7	211	220	245	272

Turbidity (NTU's)	Treatment 1	2	3	4
Site 1	/	/	6.03	6.07
3	/	/	9.20	6.17
7	/	/	8.08	6.83

Temp (°C)	Treatment 1	2	3	4
Site 1	17.25	16.20	13.80	4.33
3	17.00	16.30	12.95	4.00
7	14.92	14.40	11.30	4.33

NO_3-N (µg/l)	Treatment 1	2	3	4
Site 1	298	158	187	260
3	354	110	234	327
7	427	84	164	187

NH_3-N (µg/l)	Treatment 1	2	3	4
Site 1	273	250	286	367
3	294	332	311	343
7	308	284	291	373

PO_4 (µg/l)	Treatment 1	2	3	4
Site 1	210	228	287	130
3	203	190	242	227
7	252	194	294	147

SS (mg/l)	Treatment 1	2	3	4
Site 1	16.00	7.50	6.55	4.33
3	66.83	15.50	13.15	6.50
7	56.00	5.10	6.45	4.67

FC (counts/100 ml)	Treatment 1	2	3	4
Site 1	13	26	62	7
3	22	29	197	10
7	56	44	94	8

FS	Treatment 1	2	3	4
Site 1	75	230	278	51
3	69	235	362	43
7	234	282	257	72

Q*	Treatment 1	2	3	4
Site 1	5.91	2.34	1.86	2.42
3	5.25	1.98	1.62	2.00
loss btw 1 and 3	0.66	0.36	0.24	0.42

* CFS at time of sample collection

Appendix B Paired t-test Comparisons

Sites	Treatment	Date	Statistic	S.S	Turbidity	Temp.	E C	TDS	pH	NO_3-N	NH_3-N	PO_4	FC	FS	Q
Paired comparisons between sites 1 and 3															
1 and 3	1	6/2-6/14	df	5		5	5	4		5	5	5	5	5	4
			t	-3.725*		1.464	0.000	-0.492		-0.720	-1.372	0.195	-3.391*	0.281	4.516*
	2	6/15-6/24	df	4		4	4	4		4	4	4	4	4	4
			t	-9.396**		-1.000	-1.372	-0.278		1.357	-1.705	0.624	0.424	-0.393	21.909**
	3	6/25-10/13	df	9	5	9	9	9	9	9	8	8	8	9	9
			t	-1.874	-2.706*	4.295**	1.406	-0.869	-1.809	-1.034	-1.746	0.702	-2.511*	-1.897	6.535**
	4	10/14-11/12	df	2	2	2	1	2	2	2	2	2	2	2	2
			t	-0.991	-1.512	2.000	0.000	3.464	-1.732	-1.273	0.629	-1.672	-1.512	0.700	2.211
Paired comparisons between sites 3 and 7															
3 and 7	1	6/2-6/14	df	5		5	5	5		5	5	5	5	5	
			t	0.953		7.679**	-1.168	0.532		-0.552	-1.320	-0.339	-4.266**	-2.580*	
	2	6/15-6/24	df	4		4	4	4		4	4	4	4	4	
			t	2.353		5.729**	1.195	-2.157		0.556	1.218	-0.371	-2.015	-0.808	
	3	6/25-10/13	df	9	5	9**	9	9	9	9	8	8	8	9	
			t	3.666**	1.092	7.359	0.938	-1.520	-0.818	1.152	1.302	-0.801	2.008	1.868	
	4	10/14-11/12	df	2	2	2	2	2	2	2	2	2	2	2	
			t	11.000**	-4.131*	-2.000	1.890	0.558	4.000	2.291	-0.742	1.694	2.646	-0.827	
Paired comparisons to compare differences between upper and lower Reaches															
1, 3 \ 3, 7	1	6/2-6/14	df	5		5	5	4		5	5	5	5	5	
			t	2.789*		-4.824**	-1.031	-0.574		-1.529	-1.309	-0.709	-4.149**	-1.832	
	2	6/15-6/24	df	4		4	4	4		4	4	4	4	4	
			t	-1.571		0.090	-1.093	-0.847		0.158	5.662**	1.205	-0.943	-0.920	
	3	6/25-10/13	df	9	5	9	9	9	9	9	8	8	8	9	
			t	0.240	1.664	-2.182	0.051	0.880	-0.318	-1.812	-1.540	-0.527	0.638	-0.366	
	4	10/14-11/12	df	2	2	2	1	2	2	2	2	2	2	2	
			t	0.347	-1.941	0.000	-3.000	-0.910	-0.378	-2.357	0.000	0.378	0.378	-1.437	

* - Sig. Diff. at .05 level

** Sig. Diff. at .01 level

Xii [illegible]

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FC - FS [illegible]

	°C Temp	EC	mg/l DO	mg/l TDS	mg/l SS	mg/l Ammonia Nitrate	mg/l Nitrogen Ammonia	mg/l Phosphate	FC ml	FC 100 ml	FS ml	FS 100 ml		
LP#1 ⑦ 9:00	14	205	7/5	152	40	.250 1.1 mg/l NO3	.410 .60 mg/l NH3	.225 .23	9	138 109	14	90		
LP#2 6 [illegible]	14	210	8/25	147	41	.450 1.98	.455 .56	.225 .23	4	56	11	70	x̄ = 130	
LP#3 5 [illegible]	15	205	8/05	148	54.5	.400 1.76	.530 .65	.150 15	3	33	10	69 190		
LP#4 4 [illegible]	15	210	7/35	185	70	.500 2.2	.325 .40	.252	1-2 diff count	17	2	187		
#1 ③ 10:00	17	200	7/80	165	56.5	.275 1.21	.375 .48	.250	0	5	1	70		
#2 2 [illegible]	17	205	7/70	139	31	.600 2.64	.300 .37	.255 .26	0	3	1	40		
#3 ①	17	205	7/60	~~222~~	22	.250 1.1	.400 .49	.140	0	5	4	45		
	15.5	205	↑ all values in excess of expt. max DO for temp given				.51							

FC, FS Delay w/in 2 hours after collection

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	°C Temp	Ec	DO	TDS	S.S	Nitrate	Nitrogen Ammonia	Phosph.	FC 50ml	FC 100ml	FS 50ml	FS 100ml
LP#1 9:20	16	210	8.30	159	33.5	.56 2.46 mg/l NO3	.39 .48 mg/l NH3	.13	13	44	104	120
LP#2 9:30	17	210	8.10	149	42	.50 2.2	.06 .07	.17	20	34	55	98
LP#3 9:40	17	210	7.70	151	47	.10 .44	.38 .46	.18	14	25	42	73
LP#4 9:50	17	210	7.70	149	73	.54 2.38	.43 .52	.13	22	39	22	— 44
#1 10:05	18	210	7.45	162	97.5	1.05 4.62	.45 .55	.20	9	17	33	39 66
Ht: 0.45 = 4.54 cfs												
#2 10:20	18	210	7.85	153	16.5	.35 1.54	.43 .52	.13	2	14	24	26 48
#3 10:30	18	210	7.65	157	14.5	.70 3.08	.36 .44	.18	3	11	25	43
Ht: 4.70 / 0.47 = 4.86 cfs	17.5	210	↑ all values in excess of max possible				.43					

FC, FS tests done by 12:00

69
2
138
61
137

Following filtration   8 JUN 77

	Temp	EC	DO	TDS	SS	Nitrate	Nitrogen Ammonia	Phosph.	FC 50 ml	FC 100	FS ml 50	FS ml 100
LP#1 08:40	14	215	8.8	144	65	.40 1.76 mg/l NO_3	.28 .54 mg/l NH_3	.18	143	217*	103 206	140
LP#2 08:50	14	210	8.7	140	59	.35 1.54	.25 .31	.23	41 82	—	66	139
LP#3 09:00	15	210	8.5	140	66.5	.35 1.54	.18 .22	.17	90	206*	86 172	117 - overgrown
LP#4 09:10	15	215	8.35	147	76	.90 1.76	.21 .26	.15	43 86	—	54 108	86 - overgrown
#1 09:30	16	210	8.2	147	59	.35 1.54	.24 .29	.20	21 42	—	46 92	61
0.49 = 5.20 cfs												
#2 09:45	17	210	8.35	142	19.5	.15 .66	.19 .23	.16	20*	41*	69* 138	61
#3 09:55	17	215	8.15	141	16	.15 .66	.21 .26	.21	16*	31*	22*	71*
0.52 = 5.70 cfs												
	15.5	210	↑ All values in excess of max possible				.27			* Ideal growth count		

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	Temp	EC	DO	TDS	SS	Nitrate (following filtration)	Ammonia (following filtration)	Phosph (following filtration)	FC 20ml	FC 100ml	FS ml 20	FS 100
LP1 0910	16	205	~~7.80~~	154	144	.60 2.64 mg/l NO_3	.22 .27 mg/l NH_3	.18	56*	231* 280	78	238 390
LP2 0920	16	200	~~7.65~~ ~~7.45~~ max	162	182.5	.50 2.2	.26 .32	.21	33	195* 165	51	149 255
LP3 0930	16	195	~~7.55~~	148	152	.38 1.67	.28 .34	.15	30	<u>166</u>	41	140 205
LP4 0940	16	205	~~7.50~~	158	121	.50 2.2	.27 .33	.19	27*	<u>129*</u>	27	— 135
									50ml	100ml	50	100
1 0955	17	210	~~7.40~~	145	127.5	.20 .88	.23 .28	.23	15	<u>31</u>	36	<u>79</u> ~~[illegible]~~
Ht <u>0.63</u> = 7.72 cfs												
2 1010	17	210	~~7.70~~	175	3.0.	.15 .66	.15 .18	.20	36*	53* <u>72</u>	37	46* <u>74</u>
3 1015	17.5	210	~~7.50~~	157	26.	.38 1.67	.24 .29	.38	7*	<u>19*</u>	39	58 <u>78</u>
Ht <u>0.69</u> = 8.91 cfs			↑ all values in excess of max possible				.29		* ideal growth pattern			
	16.5	205										

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	Temp	EC	DO	TDS	SS	Nitrate (following filtration)	Ammonia	Phosph	FC 20	FC 50	FS 20	FS 50
LP1 0940	15	210	7.70 7.61	153	35.5	.50 2.2 mg/l NO_3	.22 .27 mg/l NH_3	.59	16* 100	50*	30 142	71*
LP2 0920	15	215	7.50	151	50	.15 .66	.21 .26	.55	9* 44	22*	27* 135	47*
LP3 0930	15.5	220	7.40	142	51.5	.10 .44	.15 .18	.33	12* 58	29	15 724	62*
LP4 0940	16	210	7.30	137	49	.12 .53	.21 .26	.26	- 24	12*	17* 84	42
									50ml	100ml	50	100
1 0950	17	210	7.30 7.22	141	42.5	.15 .66	.19 .23	.19	5* 10	4	27* 54	36
Ht 0.48	= 5.03 cfs											
2 1005	17	210	~~7.50~~	141	11.5	.10 .44	.12 .15	.15	3*	9*	22*	42*
3 1015	17	200	~~7.45~~	142	11.0	.15 .66	.17 .21	.20	1*	3*	8*	156* 168
Ht 0.52	= 5.70 cfs											
	16	210	↑ some values in excess of max possible				.22					

* ideal growth pattern

14 JUN 77

	Temp	EC	DO	TDS	SS	NO_3-N (following filtration)	Ammon (following filtration)	Phos (following filtration)	FC 20 ml	FC 50 ml	FS 20 ml	FS 50 ml
LP1 0850	14.5	220	7.10	147	18	.25 1-1 mg/l NO_3	.25 .31	.20	28*	93* 186	93*	201* 465
LP2 0900	15	220	6.85	149	20	.15 .67	.26 .32	.18	24*	92* 184	73	200* 365
LP3 0910	15	215	6.70	154	18.5	.14 .62	.29 .31	.19	10	41 82	63*	91 315
LP4 0920	16	215	6.65	160	23.5	.10 .44	.28 .34	.14	18	26 90	37*	64 185
1 0935	17	210	6.60	164	23	.10 .44	.26 .32	.15	100 29		100 50	
Ht. 0.40 = 3.77 cfs												
2 0945	16.5	215	6.90	~~166~~	10.5	.05 .22	.22 .27	.18	24*		105	
3 0955	17	210	6.80	152	6.5	.16 .70	.26 .32	.15	9		43	
Ht: 0.44 = 4.38 cfs												
	16	215					.31					

*ideal growth characteristics

1 st measurement after removal of cattle

16 JUN 77

	Temp	EC	DO	TDS	SS	Nitrate (following filtration)	Ammonia (following filtration)	Phosph.	FC 20	FC 50	FS 20	FS 50
LP1 0855	13	210	8.4	158	5	.15 .66 mg/l NO_3	.26 .32	.22 mg/l NH_3	6	19* 38	23	64* 128
LP2 0905	13	225	8.15	153	9	.10 .44	.26 .32	.21	7	15* 30	31	73* 146
LP3 0910	14	225	8.0	151	8	.09 .40	.24 .29	.19	7*	27* 54	21*	104* 208
LP4 0920	14.5	225	7.80 7.7	153	9	.14 .62	.31 .38	.18	6*	15* 30	16*	39 78
									50 ml	100	50 ml	100
1 0945 0.31 = 2.52 CFS	16	225	7.50 7.45	148	13	<.01 <.04	.25 .31	.23	4*	7*	14	58
2 1000	16	210	7.45	148	5	<.01 <.04	.22 .27	.14	0	1	14*	34
3 1005 0.34 = 2.92 CFS	16	210	7.80	150	6.5	.14 .62	.30 .37	.14	9	14	23* 46	36*
	14.5	220	↑ several values in excess of max possible				.32					

} 177

18 JUN

	Temp	EC	DO	TDS	SS	following filtration Nitrate	Ammon	Phos	FC 50	FC 100	FS 50	FS 100
LP1 0930	17	225	8.5	133	5.5	<.01 <.04 mg/l NO3	.24 .29 mg/l NH3	.20	33	62	198	371
LP2 0940	17	220	7.8	133	7.0	.15 .66	.28 .34	.20	37	69	260	410
LP3 0950	17.5	215	7.6	132	9.5	<.01 <.04	.21 .26	.19	30	62	280 560	06
LP4 0955	18	220	7.4	134	13.0	.10 .44	.30 .37	.09	37	117	401 800	06
1 1010	19	220	7.3	131	20.5	.09 .40	.25 .31	.18	9	36	69	115 140
0.31 = 2.52 cfs												
2 1020	19	205	7.85	131	9.0	<.01 <.04	.23 .28	.28	6	6 12	64	[illegible]5 128
3 1025	19	220	7.5	132	10.5	.10 .44	.17 .21	.18	5	10	63	110 126
0.34 = 2.92 cfs												
	18	220					.29					

DW blank check had 0 FS in 100 ml.

20 Jun 77

	°C Temp	mhos/e EC	mg/e DO	mg/e TDS	mg/e SS	following filtration mg/e Nitrate	Ammon	Phosph	FC 20 ml	FC 50	FS 20	FS 50
LP1 0905	16	220	7.2	141	6.0	.10 .44 mg/e NO3	.26 .32 mg/e NH3	.19	0	9 18	29	70 145
LP2 0915	16	215	7.05	138	10	.25 1.1	.28 .34	.19	3	4 15	35	71 175
LP3 0925	17	225	Instr failure	141	12	.10 .44	.25 .31	.20	4	8 30	25	58 125
LP4 0930	17	220		139	11	.15 .66	.28 .34	.21	7	19 38	39 195	67
									50 ml	100	50 ml	100
1 0940 0.23	17.5 = 1.58 cfs	220		135	18	.10 .44	.25 .31	.18	9	16	64	106 128
2 0950	17	220		137	7	.10 .44	.20 .24	.18	5	8 10	42	89
3 1000 0.26	17 = 1.41 cfs	220		138	9	.25 1.1	.19 .23	.17	1	14 28	31	90 62
	17	220					.30					

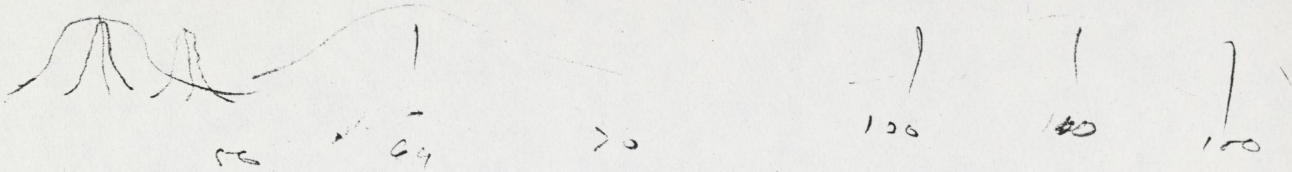
★ 1st DO readings suspect

22 JUN

	Temp	EC	DO	TDS	SS	Nitrates (following filtration)	Ammon (following filtration)	Phos (following filtration)	FC 20 ml	FC 50	FS 20 ml	FS 50
LP1 0845	13	215	~~8.35~~	152	3	<.01 <.04 mg/l NO_3	.30 .37 mg/l NH_3	.16	5	14 __25__	33	62 __165__
LP2 0850	13.5	230	~~8.40~~	147	6.5	.25 1.1	.35 .43	.18	3	10 __15__	38	91 __190__
LP3 0100	14	225	~~8.45~~	156	11	.12 .53	.30 .57	.16	4	12 __20__	38	85 __190__
LP4 0910	14	235	~~8.25~~	150	9.5	.17 .75	.35 .43	.16	4	11 __20__	42	94 __208__
									50 ml	100	50 ml	100
1 0920	15	230	~~8.0~~	146	14	.10 .44	.53 .65	.19	16	26 __32__	100	181 __200__
0.23	=	1.58	cfs									
2 0930	15	220	~~8.3~~	150	7.5	.25 1.1	.25 .31	.18	4	2 __8__	56	109 __112__
3 0940	15	230	~~8.0~~	146	8.5	.15 .66	.28 .34	.21	11	11 __22__	82	155 __164__
0.26	=	1.91	cfs ↑ all values in excess of theoret max									
	14	225					.41					

24 JUN

	Temp	EC	DO	TDS	SS	following filtration: Nitrates	Ammon.	Phosph	FC 20	FC 50	FS 20	FS 50
LP1 0825	13	230	7.85	132	6	.15 .66 mg/l NO_3	.36 .44 mg/l NH_3	.20	15 14 75	44	120	260 600
LP2 0830	13	230	8.00 7.91 max	132	4.5	.25 1.1	.32 .39	.23	9 22 45	24	118	306 590
LP3 0840	13	235	7.95 7.91 max	89*	3.0	.25 1.1	.32 .39	.19	7 37 (5 wet) 38	19	98	244 560
LP4 0850	13	235	7.80	136	9	.10 .44	.41 .50	.19	9 48	24	122	274 610
									50 ml	100	50	100
1 0900	14	230	7.40	134	12	.25 1.1	.38 ~~.39~~ .46	.17		53	333	TNC 670
0.24	=1.64 cfs											
2 0910	14.5	225	7.90 7.7 max	129	3	.24 1.06	.26 .32	.19		16	205	418 410
3 0915	14	225	7.60	125	3	.15 .66	.31 .38	.44		54	380	TNC 750
0.27	= 2.03 cfs											
		230										
	13.5						.43					



30 Jun 77

	Temp	EC	DO	SS	TDS	Following filtration: Nitrate	Ammon	Phosph	FC 20 ml	FC 50	FS 20	FS 50	pH
LP1 0850	14	210	7.9 7.76	1	131	<.01 <.04 mg/l NO_3	.30 .37 mg/l NH_3		6	16 32/100 ml	22	60 120	8.10
LP2 0900	14	220	~~8.0~~ 7	3	127	.15 .66	.25 .31		30	65 150	24	60 120	8.20
LP3 0905	14	230	~~8.05~~	2.5	130	.13 .57	.26 .32	not sampled	13	41 82	34	71 170	8.15 8.2
LP4 0915	14	230	7.80 7.76	4	131	.15 .66	.31 .38		32	73 140	34	94 190	8.00
1 0925	15	210	7.53	8	124	.15 .66	.28 .34		10 ml → 8	20 ml → 13 50 ml → 51 102	10 25	20 30 50 90 210	8.10
0.25 = 1.80 cfs													
2 0935	15.5	225	7.6 7.5	5	125	.10 .44	.25 .31		10 ml → 4	20 ml → 12 50 ml → 21 42	10 → 14	20 → 44 50 → 61 150	8.05 8.1
									20 ml	50	20 ml	50	
3 0945	16	220	7.3	7	126	.15 .66	.30 .37		4	12 20	22	69 140	7.95 8.0
0.27 = 2.03 cfs													
mean of LP2 + LP3	14	225		2.75	129	.62	.32		116		145		8.17

FS means up 167
down 148

FC means up 55
down 103

6 JULY 77

	°C Temp	EC	DO	mg/l TDS	mg/l SS	following filtration: Nitrate	following filtration: Ammonia Nitrogen	following filtration: Phosphate	FS /ml 20	FS /ml 50	FC /ml 10	FC /ml 20	pH
LP1 0900	15	230	7.15	150	1.5	.05 .22 mg/l NO_3	.28 .34 mg/l NH_3	.16	8 76	38	66 660	124	8.10
LP2 0910	15.5	210	7.10	148	2.5	.15 .66	.30 .37	.18	10 60	30	64 640	110	8.10
LP3 0915	16	230	7.25	151	4	.05 .22	.25 .31	.14	11 34	17	65 650	112	8.20
LP4 0925	16.5	240	7.35	151	3.5	.10 .44	.31 .38	.17	14 54	27	69 690	115	7.95 8.0
1 0935	18	235	6.95	145	6	.15 .66	.28 .34	.20	38 240	121	82 820	133	8.20
0.17 = 0.95 cfs													
2 0945	18	220	6.90	149	3	.21 .92	.23 .28	.15	18 192	96	50 500	88	8.15 8.2
3 0955	18	230	7.00	148	4	.20 .88	.31 .38	.17	16 100	49	42 420	105	8.10
0.20 = 1.26 cfs													
mean of LP2 + LP3	15.75	226	7.20	150	3.3	.44	.34	.16	47		645		8.15

FS means up 580
down 665

FC means up 177
down 59

13 July 77

	Temp	EC	DO	SS	TDS	following filtration: Nitrate	Phosp	Ammonia	FC 50	FC 100	FS 20	FS 50	pH
LP1	13	210	7.3	.5	158	.10	.16	.17	8	19	20	47	8.2
0830						.44 mg/l NO_3		.21 mg/l NH_3	19 /100ml		100 /100ml		
LP2	13	245	7.45	.5	161	.05	.27	.19	20	43	17	46	8.25
0840						.22		.23	40		92		
LP3	13	220	7.55	1	156	<.01	.31	.20	19	49	22	55	8.20
0845						<.04		.24	40		110		
LP4	13.5	220	7.20	3	156	<.01	.15	.31	30	51		56	8.00
0852						<.04		.38	60		112		
1	15	240	7.10	3.5	148	.15	.24	.34	20ml 32	50ml 56	46	75	8.15
0900						.66		.41	100 132 160		250		
0.14	=0.66 cfs												
2	15.5	240	7.25	1.5	149	.10	.19	.22	32	50	38	56	8.20
0915						.44		.27	64		190		
3	15	240	6.90	6	155	.15	.24	.23	7	15	27	67	8.10
0925						.66		.28	15		135		
0.17	=0.95 cfs												
Mean of LP2 + LP3	13	233	7.50	.75	159	.12	.29	.24	40		101		8.23

FS means up 185
down 104
FC means up 80
down 40

19 July
8 AM sample
(portion diurnal)

	Temp	EC	DO	SS	TDS	Following Filtration: Nitrate	Phosph	Ammonia	FC 50	FC 100	FS [illegible]	FS 50	pH
LP1 0705	12	250	7.15	1	157	.10 .44 mg/l NO3	.14	.25 .31 mg/l NH3	25	49 49	40	97 200	8.10
LP2	12	250	7.30	1	148	.30 1.32	.30	.25 .31	60	114 120	33	110 170	8.20
LP3	12	220	7.25	0	150	.05 .22	.20	.28 .34	62	125 124	37	93 185	8.20
LP4	12	255	7.10	1.5	160	.20 .88	.47	.42 .51	64	125 128	35	75 160	8.06
1	13.5	240	6.95	2.5	151	.15 .66	.43	.34 .41	259	417 500	55	125 275	8.10
Ht. 0.12 = 0.51 cfs 2	14.5	245	6.80	3.0	151	.10 .44	.37	.23 .28	63	112 125	57	139 285	8.20
3 0755 Ht 0.16 = 0.90 cfs	15	245	6.40	3.5	155	.05 .22	.25	.28 .34	18	47 40	30	101 170	8.10
mean of LP2+LP3	12	235	7.30	.5	149	.77	.25	.33		122		178	8.2

FS means	up	243
	down	179
FC means	up	222
	down	100

3 Aug

	Temp	EC	DO	SS	TDS	Nitrate (following filtration)	Phosph (following filtration)	Ammon (following filtration)	FC 20	FC 50	FS 10	FS 20	pH	Turb
LP1 0730	11.5	250	7.60	6	162	.35 1.54 mg/l NO3	.58	.26 .32 mg/l NH3	4	13 26	14	31 150	8.2	7.3
LP2 0740	11.5	250	7.60	11.5	169	.12 .53	2.23	.37 .45	21	36 105	26	38 230	8.15	9.2
LP3 0745	11.5	250	7.45	12	166	.15 .66	.47	.36 .44	30	68 150	31	42 310	7.95	10.1
LP4 0755	12	255	7.35	17.5	164	.25 1.1	.26	.38 .46	16	48 85	36	40 360	7.80	12
1 0810 Ht 0.25 = 1.80 cfs	13	245	7.10	27.5	164	.12 .53	.20	.32 .39	8	25 50	12	44 220	7.90	12
2 0820	13.5	250	7.40	6	160	.14 .62	.19	.25 .31	8	24 48	19	35 190	7.95	61
3 0830 Ht 0.26 = 1.91 cfs	14	245	7.10	6.5	161	.10 ~~.04~~ .44	.16	.28 .34	3	19 38	8	47 235	7.95	6.[illegible]
Mean of LP2+LP3	11.5	250	7.53	11.75	168	.60	1.35	.45		128		270	8.05	9.[illegible]

FS means up 215
down 260
FC means up 45
down 80

9 August

	Temp	EC	DO	SS	TDS	following filtration Nitrate	Phosph.	Ammonia	FC 20 ml	FC 50 ml	FS 10 ml	FS 20 ml	pH	turb.
LP1	12	235	7.20	7	156	.15	.49	.25	57	136	18	55	8.05	7.
0735						.66 mg/l NO_3		.31 mg/l NH_3	285		230			
LP2	12.5	250	7.00	8	158	.45	.51	.26	63	126	37	53	8.00	7.
						1.98		.32	315		315			
LP3	12.5	250	6.80	9	158	.35	.19	.31	60	155	31	58	8.00	3.
						1.54		.38	300		310			
LP4	13	255	7.00	11.5	161	.35	.20	.37	56	142	30	51	7.90	9.
						1.54		.45	280		300			
1	14	250	7.00	14	156	.55	.22	.27	85	273	38	42	8.00	7.
						2.42		.33	425		380			
Ht 0.26 = 1.91 cfs														
2	15	250	7.25	5.5	156	.40	.37	.18	67	194	17	36	8.05	5.
						1.76		.22	335		175			
3	15	250	6.95	7	157	.25	.51	.28	17	45	17	34	7.95	6.
0845						1.1		.34	~~45~~ 90		170			
Ht 0.30 = 2.39 cfs														
mean of LP2 + LP3	12.5	250	6.90	8.5	158	1.76	.35	.35	307		312		8.00	7.

FS means up 242
down 281

FC means up 283
down 291

16 August

	Temp	EC	DO	SS	TDS	Following Filtration: Nitrate	Phosph	Ammon	FC 10 ml	FC 20	FS 1 ml	FS 10	pH	turb
LP1	15.5	245	6.9	41.5	144	.30 1.32 mg/l NO3	.36	.25 .31 mg/l NH3	36 330	61	5 770	77	8.05	16
LP2	15.5	245	6.9	45.5	143	.24 1.06	.49	.23 .28	23 290	70	9 740	74	8.05	16
LP3	15.5	250	6.85	45	152	.26 1.14	.33	.24 .29	40 385	75	7 910	91	8.10	15
LP4	16	250	6.80	41.5	143	.30 1.32	.80	.27 .33	27 300	67	8 720	72	8.00	15
1	16	250	6.80	51	147	.15 .66	.25	.23 .28	14 240	48	2 680	68	8.10	14
0.39 water ht = 3.62 cfs				0.35 ppt										
2	16.5	250	6.90	20	143	.25 1.1	.41	.23 .28	22 220	45	3 630	63	8.15	6.4
3	16.5	250	6.65	19	147	.24 1.06	.68	.22 .27	17 190	38	3 660	66	8.10	6.[illegible]
water ht 0.43 = 4.22 cfs ppt = 0.50														
mean of LP2 + LP3	15.5	248	6.88	45.5	148	1.10	.41	.29	340		825		8.08	15.[illegible]

means

FC	up	217
	down	323
Fs	up	657
	down	835

3 Sept 77

	Temp	EC	DO	SS	TDS	Nitrate (following filtration)	Phosph (following filtration)	Ammon (following filtration)	FC ml 10	FC ml 20	FS ml 1	FS ml 10	pH	turb
LP1	11	260	7.8	5	157	.20	.28		1	0	0	21	8.05	5.0
						.88 mg/l NO3		Brk. down	10		210			
LP2	11.5	260	7.7	6.5	156	.26	.25	of	1	0	2	20	8.00	5.
						1.14		Nesler Reagent	10		200			
LP3	12.0	260	7.7	6.5	154	.15	.27		0	6	1	19	8.05	5.5
						.66			30		190			
LP4	12	260	7.6	7.5	151	.18	.40		2	2	0	28	7.95	6.
						.79			15		280			
1	13	265	7.45	8.5	153	.17	.29		1	5	1	49	8.10	4.
						.75			25		490			
0.26	= 1.91 cfs													
2	13.5	260	7.7	6	155	.10	.23		2	3	7	55	8.10	4.
						.44			18		550			
3	14	260	7.1	8	155	.30	.26		3	7	7	61	8.00	4.
0.27	2.03 cfs					1.32			35		610			
mean of LP2 + LP3	11.75	260	7.7	6.5	155	.90	.26		20		195		8.05	5.

FS means up 550
down 228
FC means up 26
down 15

17 Sept 77

	Temp	EC	DO	SS	TDS	Following filtration: Nitrate	Following filtration: Phosph	Following filtration: Ammonia	FC	FS 10	FS 20	pH	turbidity
LP1	6	275	8.45	1	143	.17 .75 mg/l NO3	.26	.35 .43 mg/l NH3	0	15	16 80	7.95	6.[illegible]
LP2	6.5	275	8.55	1.5	142	.20 .88	.23	.35 .43	0	13	16 80	8.00	6.4
LP3	6.5	280	8.50	1	147	.30 1.32	.16	.36 .44	0	14	40 200	8.00	6.[illegible]
LP4	7	270	8.30	5	141	.25 1.1	.17	.43 .52	0	15	24 30	7.85	3.[illegible]
1	8	270	7.90	8	134	.50 2.2	.18	.38 .46	0	19	48 220	7.90	10.[illegible]
Ht. 0.21 = 1.36 cfs 2	8.5	270	8.40	4	139	.30 1.32	.18	.30 .37	0	9	29 145	8.05	4.[illegible]
3 Ht 0.24 = 1.?9 cfs	8.5	280	7.75	3	142	.22 .97	.14	.34 .41	0	8	35 175	7.95	5.[illegible]
mean of LP2 + LP3	6.5	277	8.55	1.25	145	1.10	.20	.44			140	8.00	6.[illegible]

↑ (DO) 5 beaver dams between #1 and #2

↑ (FC) problems with waterbath

FS means: up 180; down 113.3

1 october
Some leaf-fall

	Temp	EC	DO	SS	TDS	Following Filtration: Nitrate	Following Filtration: Phosph.	Following Filtration: Ammonia	FC 50	FC 100	FS 20	FS 50	pH	turb
LP1	3 °c	280	8.70	0	132	.21	.22	.42	10	18	11	22	7.90	6.0
						.92 mg/l NO3		.51 mg/l NH3	20		44			
LP2	3	280	8.70	0	128	.10	.18	.33	7	7	23	36	8.00	5.
						.44		.41	14		92			
LP3	3	285	8.65	1	128	.15	.20	.29	1	5	12	27	8.00	6.4
						.66		.35	5		54			
LP4	3	285	8.55	1.5	131	.15	.20	.45	7	10	14	27	7.90	8.8
						.66		.55	14		54			
1	4	275	8.10	2.5	140	.25	.17	.36	14	30	21	41	7.95	6.
0.18 = 1.00 cfs						1.1		.44	30		92			
2	5	290	8.90	1	138	.13	.16	.30	4	3	11	21	8.00	4.9
						.57		.37	8		42			
3	6	290	8.10	1.5	134	.21	.17	.33	16	26	15	31	7.95	5.
0.20 = 1.26 cfs						.92		.41	26		62			
mean of LP2 + LP3	3	285	8.70	.5	128	.55	.19	.38	10		71		8.00	6.

FS means up 65.33
down 56.33

FC means up 21.33
down 14.7

15 Oct 77

	Temp	EC	DO	SS	TDS	Following filtration: Nitrate	Phosph.	Ammonia	FC 50	FC 100	FS 20	FS 50	pH	Turb.
LP1	5°C	270	9.00	3	127	.10	.18	.36	0	1	3	14	8.20	6.
						.44 mg/l NO_3		.44 mg/l NH_3			28			
LP2	4	280	8.95	4.5	132	.13	.19	.39	0	1	6	16	8.05	6.9
						.57		.48			32			
LP3	4	285	8.70	5	135	.13	.15	.39	1	0	10	12	8.00	7.
						.57		.48			35			
LP4	4	296	8.40	5	131	.29	.12	.47	2	2	4	11	8.00	8.
						1.28		.57			21			
1	4.5	280	8.85	4.5	131	.20	.16	.33	1	0	8	26	8.05	6.
0.25 = 1.80 cfs						.88		.40	2		52			
2	5	280	8.80	4	132	.21	.15	.30	2	2	5	12	8.10	5.
						.92		.37	3		24			
3	5	285	8.40	5	137	.17	.14	.38	0	2	8	20	8.00	6.
0.27 = 2.03 cfs						.75		.46	2		40			
Mean of LP2 + LP3	4	282	8.80			.57	.17	.48	2		33		8.05	7.

22 Oct 77

	Temp	EC	DO	SS	TDS	Nitrate (following filtration)	Phosphate (following filtration)	Ammonia (following filtration)	FC 50	FC 100	FS 20	FS 50	pH	[illegible]
LP1	6	280	8.75	1	124	.17 .75 mg/l NO_3	.11	.37 .45 mg/l NH_3	3	10 10	47	36 150	8.00	6.1
LP2	5	280	8.80	3	142	.24 1.06	.19	.24 .29	1	8 9	14	36 72	7.95	6.3
LP3	5	280	8.25	2.5	143	.30 1.32	.15	.37 .45	1	2 2	8	30 60	8.00	6.9
LP4	5	285	7.70	3	140	.43 1.89	.18	.36 .49	4	11 11	18	20 65	8.00	8.1
1 0.25 = 1.80 cfs	5.5	280	8.05	3	145	.43 1.89	.18	.41 .50	7	5 14	8	28 56	8.05	5.9
2	6	Dead	8.70	3.5	149	.26 1.14	.11	.41 .50	3	2 6	19	29 70	8.00	5.1
3 0.27 = 2.03 cfs	6	battery	8.20	2.5	148	.26 1.14	.12	.36 .49	2	8 8	19	40 80	7.90	5.[illegible]
LP2 + LP3 mean	5	280	8.55	2.75	143	1.19	.17	.37	5		66		8.00	6.[illegible]

12 Nov

	Temp	EC	DO	SS	TDS	Nitrates (following filtration)	Phosph (following filtration)	Ammon (following filtration)	FC 20	FC 50	FS 20	FS 50	pH	turb
LP1	2	265	9.80	10	124	.29	.15	.34	5	6	13	19	7.90	8.[illegible]
						1.28 mg/l NO_3	mg/l	.48 mg/l NH_3	12		39			
LP2	1	280	10.1	15.5	131	.29	.16	.31	4	8	13	16	8.05	8.6
						1.28		.38	16		32			
LP3	1	280	10.0	4	129	.20	.15	.53	3	12	6	12	8.05	9.0
						.88		.65	24		24			
LP4	1.5	280	9.85	13.5	120	.35	.15	.42	4	6	4	23	8.00	8.2
						1.54		.51	12		46			
1	2	280	9.90	12	114	.35	.34	.29	5	7	5	11	8.05	7.1
	0.30 = 3.39 cfs					1.54		.35	14		22			
2	2	280	9.75	7	118	.31	.15	.38	1	3	7	10	8.10	6.3
						1.36		.46	6		20			
3	2	285	9.25	5.5	123	.35	.13	.36	0	12 6	8	16	8.05	6.5
0.36 =	3.19 cfs					1.54		.44	23 at 250 ml		32			
LP2 + LP3 mean	1	280	10.05	10	130	1.08	.16	.52	20				8.05	

* get the exact fig. from Station records or NOAA pub.

Appendix C

Precipitation Date

Date listed is date measured, not necessarily occurence

JUNE	amt	JULY	amt	AUG.	amt	SEPT	amt	OCT	amt	NOV	amt	DEC	amt
5	.21	4	.17	5	.14	5	.07	6	.07	7	.21	2	.10
7	.07	6	.48	6	.17	(12)	.38	21	.14	8	.62	5	.07
8	.07	7	T	10	.03	13	.10	31	.17	21	.03		
14	.14	8	.07	11	.14			4	1" snow	29	.10		
18	.07	14	.10	12	.10								
29	.17	15	.07	14	.03					7-2"			
		20	.31	15	.17					8-6"			
		21	.65	(16)	.41					21-1"			
		22	.24	17	.14					29 2"			
		23	.10	18	.07								
		(24)	1.03	19	.07								
		25	.34	(21)	.38								
		26	.21	29	.21								
		28	.10										

2.97
2.06
.52
5.5

Activities of Range Cattle

☒ = 10 count

Date – 3 Jun 77
Observer – S.T.

Activity	0600	0800	1000	1200	1400	1600	1800
Resting		9	XXX XXX XX4	XX9	XX XXX XXX XX3	4 XX XX	7
Grazing	XXX XXX XX5	XXX XXX X8	XXX X6	XXX XXX XX X5	XXX 1	XXX XX7 XX XX	XXX X3 XX4 XX4 XXX
Watering		5	5	6	0	6	1 ↑ In TRW-
upper ⅓	30	39	37	39	3	21	19
middle ⅓	55	32	73	94	120	101	98
lower ⅓	0	21	25	7	11	25	23
number within 50 yards of stream		79	108	77	127	104	117
Total # obs	85 →	92	135	140	134	147	158

* 10:00 – 11:00 Herd of 95 → 13-15 [illegible] water, crossed stream

% in	0600	0800	1000	1200	1400	1600	1800
upper ⅓	35	42	27	28	2	14	~~15~~ 14
middle	65	35	54	67	90	69	68
lower	0	23	19	5	8	17	18

Activities of Range Cattle
along Trout Creek

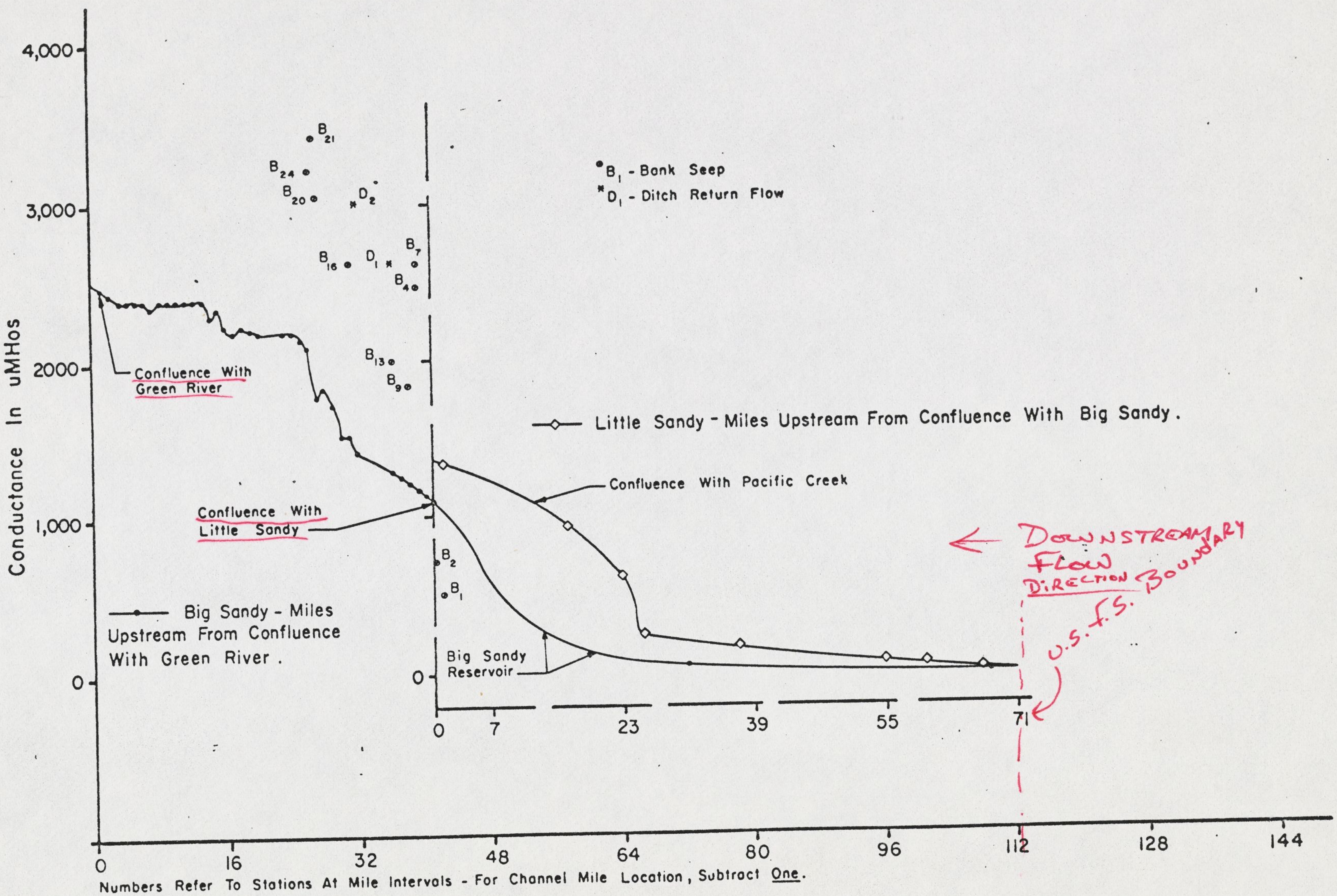
X = 10 count

Date - 7 JUN 77
Observer - S.J

Activity	0600	0800	1000	1200	1400	1600	1730
Resting		X	8 X X X X X X X X X X	2	8 X X	8 X X X X	3 X X
Grazing	X 6 X X X X X	2 X X X X X X X X X X X X	X X X 8	X X X X X X X X X X X X	X X X 4 X X X X X X	X X 6 X X X X X X X	X X X X X X X X X X 8 X
Watering	1	1	2	4	1	0	2
upper 1/3	12	7	10	0	21	31	18
middle	15	69	102	91	97	107	74
lower 1/3	40	57	36	35	11	8	51
number w/in 50 yds of stream	8	101	122	102	26	55	113
Total # obs	67	133	148	126	129	146	143
	↑ remainder in trees meadows to Fut.						
% upper	18	5		0	16	21	13
% middle	22	52		72	75	73	52
% lower	60	43		28	9	6	35

Cattle Activity on Sampling Days - 8 JUN — 14 JUN

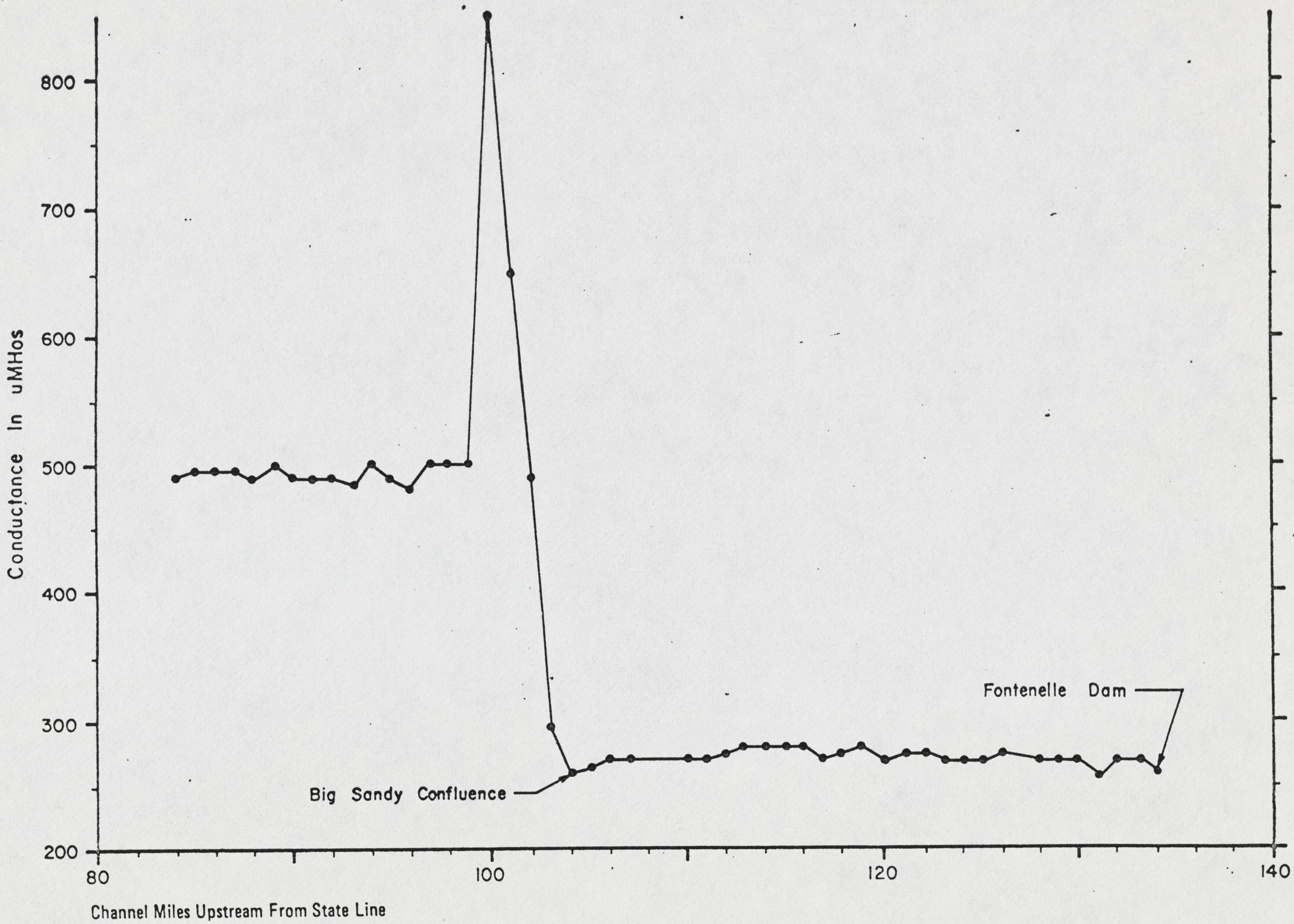
Location		8 JUN		10 JUN	Date	12 JUN		14 JUN	
time		0830	%	0855	%	0900	%	0830	%
upper 1/3		26	25	25	25	34	32	70	71
middle		41	40	0	0	60	56	28	29
lower 1/3		36	35	74	75	13	12	0	0
# waterings		1		0		2		4	
# w/in 50 yards of stream		44		30		67		60	
Total # obs		103		99		107		98	



BLM Stream Inventory - 8/8/75 Big Sandy - 9/3-4/75 Little Sandy.

FIGURE 2-10 Solute Concentration - Sandy Drainage.

[1978]



BLM Stream Inventory 9/16/75 Float Trip

FIGURE 2-11 Solute Concentration-Green River.

Bone Draw - Spot Flow Measurements CFS

June 20, 1977	0.43
July 7, 1977	0.80
July 20, 1977	0.51
Aug 23, 1977	0.63
Aug 30, 1977	1.59
Sept 8, 1977	1.63
Sept 26, 1977	1.63
Oct 11, 1977	1.82
Nov 16, 1977	1.51
Dec 13, 1977	1.33
Jan 11, 1978	1.10
Apr 4, 1978	0.51
June 7, 1978	2.57 Some Irrigation Runoff
June 15, 1978	1.10
August 10, 1978	1.40

These are the flow records that we have on Bone Draw.

If you have any questions please call me.

Duane Klamm - SCS - CASPER

[1980]

1605 Donalynn #26
Rock Springs, Wyo. 82901
January 5, 1980

Mr Dave Dufek
Area Fisheries Biologist
Wyoming Game and Fish Department
351 Astle Ave.
Green River, Wyo. 82935

Dear Dave;

I am writing to you on behalf of the Green River chapter of the Izaak Walton League of America, and in regards to their participation in the BLM's Bone Draw project. As you are aware, the planting of rainbow sac fry in Whitlock Vibert Boxes in the spring of 1978 was largely successful, especially in consideration of the adverse conditions existing at the time. Unfortunately, the chapter never wrote up a project report as several persons recorded various segments of the project and during the next year, much of the information was either misplaced or lost when several of the chapter members became inactive. The chapter has been essentially inactive for the past year, but efforts are currently under way to hopefully re-organize and re-active the chapter and its participation with both the BLM and the Wyoming Game and Fish Department. In lieu of the Chapter's report on its egg hatching study in Bone Draw, I have included an attchment to this letter which summarizes the general conditions and results at the time of the Chapter's project and hope it will suffice, within the terms of our original agreement with the Department and BLM.

Looking ahead to this spring however, I have been recieving a wholly favorable response towards re-organizing the Green River chapter. Most notably, everyone is anxiously anticipating the possibility of conducting another egg planting project on Bone Draw. Public participation in conservation programs or studies on Bone Draw and the lower Big Sandy river seemsto be a focal point for the former (and prospective) members of the Green River chapter. As a medium for public education and the improvement of public relations for resource management programs, Bone Draw and the lower Big Sandy river seem to be recieving a considerable amount of favorable comment from most conservation oriented persons with whom I have discussed this subject. In fact, it is one of the few areas in this state where both state and federal governments are actively participating with the public interests, whatever they may be, in the solution of resource management problems, rather than in the trading off of various resource values.

Without exception, every person with whom I have discussed this subject feels that the League's participation in this program is too important for it to die on the vine, so to speak. Hence the renewed interest in re-activating the Green River chapter. Therfore, on behalf of the chapter and the Wyoming Division, I would like to request your Department's assistance by once again providing the chapter with 5,000 strongly eyed rainbow eggs this spring. In addition, we would like to request your assistance in the project as well, still in hopes of producing a semi-technical account of the project and its findings. Upon recieving your agency's approval, we will then contact the BLM for permission to continue the project within the terms of our original agreement with their agency.

encl.

Sincerely,

Bruce H. Smith

Bruce H. Smith
First Vice-President - IWLA
Wyoming Division

cc. BLM-Rock Springs
Jack Hayes- IWLA

Izaak Walton League of America - Wyoming Division - Green River Chapter

A General Report on the Bone Draw Egg Planting Study - Spring 1978

Background and General Description of Habitat Conditions

Bone Draw is an ephemeral drainage located approximately 15 miles southwest of Eden, Wyoming. Most of the water which the drainage recieves originated as irrigation return flow from the Eden Irrigation Project, or as runoff from infrequent rainstorms. Traversing the cold desert sagebrush plains along the western edge of Wyoming's Red Desert, Bone Draw would not normally be considered as a typical trout stream. The last three quarters of a mile of Bone Draw is unique, however, as numerous springs surface and generate a perrenial flow of about 1 cfs by the time Bone Draw feeds into the lower Big Sandy river. This lower reach of stream was generally a wide, shallow, heavily silted reach of stream which recieved considerable trampling damage from livestock.

During the spring and fall of 1976, Bureau of Land Management Biologists discovered spawning rainbow and brown trout running up the Big Sandy river and attempting to spawn in the Big Sandy near the Bone Draw confluence, or in the lower reaches of Bone Draw itself. This was an interesting phenomenon insofar that neither the Big Sandy river nor Bone Draw would normally be considered acceptable spawning habitat for trout. In an effort to evaluate the potential for intensive management of small tributary streams for trout reprodtion, Bureau biologists began formulating a study program on Bone Draw incorporating protection from and proper management of livestock grazing, along with the addition of instream improvements (log drops and digger logs) in an effort to enhance instream habitat diversity and improve stream bottom substrate for spawning.

In 1977 the BLM began to implement some of the planned inpovements in Bone Draw with the installation of several log drop structures as conservation projects for high school students and summer biological aides. It was at this time that two other significant events occurred. The Green River chapter of the Izaak Walton League was formed and the Whitlock Vibert Box Handbook was published by the Federation of Fly Fishermen. Upon analyzing the ideas and principles presented in the Whitlock Handbook and after evaluating the potential for applying them in a habitat such as Bone Draw, the Green River chapter requested permission from the BLM to participate in their study and requested the assistance of the Wyoming Game and Fish Department to provide some trout eggs for an egg planting study utilizing the Whitlock Vibert Box concepts. Subsequently, in the spring of 1978 approval was recieved from the BLM and the Game and Fish Department provided 5,000 rainbow trout eggs from their Daniel hatchery.

Activities Undertaken (ie. Methods)

Due to the poor quality of the substrate materials in Bone Draw, hardware cloth baskets 12"x12"x6" in size were constructed to hold the gravel in which the Whitlock Vibert Boxes would be buried. (Seepage 38 in the Whitlock handbook.) The two dimensional gravels found in the stream bed were generally shale and sandstone in character and unsuitable for the construction of artificial redds. Alluvial gravel was therefor sifted to obtain the optimum ½-2" size range and brought in for placement in the wire baskets.

The extensive drouth of 1977 resulted in extremely low flow levels during the spring of 1978. Normally producing an accumulated flow of 1 cfs, the springs feeding Bone Draw at the time of the study were generating only 0.1 to 0.3 cfs of accumulated streamflow. Temperatures in the upper reaches of the study area normally were in the low 50's and warmed to the low 60's by the time Bone Draw joined the Big Sandy river. In 1978 the temperatures were reaching into the 70's by the time the water joined the Sandy.

In addition to these factors, there was extensive sediment depositon throughout the entire study readh,as streambank and riparian erosion were prevalent along the entire reach of stream. Generally speaking, it could probably have been said that a person could not have picked a worse year, with a worse set of conditions on a stream any worse than Bone Draw. However, the object of the study was primarily to try a method for the observation of simulated spawning conditions and hopefully,to learn something of the processes and problems of trout reproduction in rangeland streams.

Two weeks prior to recieving the rainbow eggs, the chapter placed the wire backets of gravel in position and practiced planting a few empty Whitlock Vibert boxes. These were then left in place in order to both condition the gravel and to observe the degree of sedimentation which might occur once the boxes were charged with eggs.

During the two week interim cattle had been turned out on the range and began trampling Bone Draw and several of the wire backets of gravel were either collapsed or upended. In addition, irrigation return flows were released from the Eden project further up the drainage and a condition approaching a flood flow occurred. This caused several of the gravel baskets to become scoured and devoid of gravel with some baskets having been washed downstream. Those few baskets which remained intact experiended almost complete siltation by sand and finer sediments generated by the return flows.
Then, last but not least, the trout eggs at the hatchery hatched, one day before they were to be planted in the charged Whitlock Vibert boxes.
The chapter members were recieving an excellent exposure to many of the problems facing trout in their natural reproductive efforts under wildland conditions.

The decision was made to go ahead and plant the WV boxes with the sac fry and to further observe whatever events might occur. With approximately 5000 sac fry on hand, the WV boxes were charged with 300 to 400 fry per box. The boxes were held in an inverted position for charging into the upper chamber; however, the sac fry kept escaping and duct tape had to be used to seal the boxes while tempering, in order to prevent the fry from escaping. One ice chest wiht fry and iced down hatchery water was used for charging the WV boxes and a second ice chest with just hatchery water was used to hold the charged boxes until they were ready for planting. Just prior to planting, the boxes in the second ice chest were covered with a towel and water from Bone Draw was poured over the towel until the water depth doubled (from 1" to 2") and a 50% dilution was attained. After a five minute period, the water was drained back down to a 1" depth (by opening the ice chest drain valve) and the process was repeated two more times. This measure was an attempt at avoiding not only temperature shock, but also was aimed at avoiding possible osmotic shock as well. The water in Bone Draw was quite hard, with conductivities in the neighborhood of 1,500 plus micromhos. It was not known at the time whether trout eggs or sac fry could withstand the transition into water with those chemical characteristics. (It should be noted that O_2, CO_2, pH and alkalinity were not limiting factors at the time of the study as they were within acceptable ranges for trout.)

After placing two charged WV boxes in a gravel basket, the basket was positioned in a suitable location inthe spill pools, below the digger and overpour logs placed in the stream by the BLM.

Results

After approximately three weeks, the gravel baskets were checked for condition and evidence of swim up fry. At this time it was discovered that the higher flows created through the release of irrigation return water had now receded and several of the gravel baskets were sticking out of the water. In addition, those still under water were heavily silted in by SAND and fine organic material, depending of the respective location of the baskets in the stream. Only one gravel basket was found to have had fry which escaped on their own; it was necessary to open the gravel baskets by hand in order to allow the remaining fry to escape from the WV boxes directly into the stream. Overall, it was estimated that a 50% survival had been attained. Approximately five WV boxes had good survival with no dead embryos present or visible, five had fair survival with some dead embryos evident, and about five boxes had poor survival with the majority of the embryos dead and decayed.

Boxes which recieved sedimentation by sand were less impacted than those which were sedimented with organic matter. The sand settled to the bottom of the incubation chamber and formed a solid base upon which the fry could rest, whereas the organic matter and finer sediments surrounded the fry and resulted in almost complete suffocation and mortalities.

A few additional WV boxes and gravel baskets had been placed in two spring seeps, adjactent to the Big Sandy river, as controls. It was found that survival in these locations was similar to that in Bone Draw, however development of the fish was significantly slower due to colder water temperatures.

Periodic trips to Bone Draw through the rest of the summer by members of the chapter indicated that fingerling rainbow trout could be found throughout the study reach and by the end of the summer, the fish were four to five inches in size. With the limited rearing and resident habitat in Bone Draw, it was expected that the fish would drift downstream to the Sandy and eventually to the Green River, with the future possibility of returning to spawn in or near Bone Draw.

In the late summer of 1978, the BLM fenced approximately 85 acres of the lower Bone Draw drainage. This area was then placed into a special management and livestock grazing study status, with the lower perrenial reach and its potential spawning habitat being classified as the control area. With complete rest from livestock and wildlife (antelope) grazing for the past year, this study reach of stream has begun to stabilize, arrest its erosion problems and is developing into a good quality spawning and most significantly, fry/fingerling rearing stream. In the spring of 1979, the Green River chapter was inactive and the BLM and Wyoming Game and Fish Department continued the project through the planting of approximately 2,000 swim up fry. Once again, four to five inch fish could be found in Bone Draw by the end of the summer, but there appeared to be fewer fish evident than the year before. Numerous schools of fingerling rainbow trout were observed in the Big Sandy River, however, during November and December. Most of these schools were found in close association with the several springs feeding the Big Sandy, below Bone Draw.

Conclusions

After two years of trials on Bone Draw, it appears that the original concept of evaluating this stream's potential has some merit. It has been found that trout from the sac fry to fingerling stage can, in fact, survive and even thrive in this stream once improved habitat conditions were attained. The question still remains as to whether the fish produced in these waters will return for their future spawning activites. This will probably not be clearly evident until 1981, 82 and 83, by which time these fish will have matured and be ready for spawning.

Recommendations

Considering the success exhibited by this project and study so far, especially in light of the occurrence of almost every adverse condition imagineable, it is recommended that the Izaak Walton League of America, Green River Chapter, should continue and improve its cooperation with the BLM and Wyoming Game and Fish Department in the performance of resource management studies on Bone Draw and the Big Sandy River. The strong interest and desire, recently exhibited by many former chapter members, in re-organizing the chapter and in continuing this study, points to the value of the Bone Draw project not only as a resource management tool, but as a public education and participation medium as well.

Submitted by,

Bruce H. Smith
January 6, 1980
on behalf of the Green River Chapter
Izaak Walton League of America

Bone Draw Project

Izaak Walton League Egg Study Program - 1980

During the spring of 1980 an early season warm spell initiated a rapid snow-melt and runoff, resulting in extensive flooding throughout the southern half of the Big Sandy drainage. As an example of the severity of this flooding, the Big Sandy River experienced a 100 year runoff event and was over ten feet deep at the confluence with Bone Draw. (Figure 1)

On Bone Draw, the Washington Reservoir, several miles upstream from the project area, was breached during this period. This resulted in severe flooding on Bone Draw as well and several log overpours were either washed out or eroded. (Big Sandy Resource Area staff repaired or replaced the damaged structures and Izaak Walton League members installed three new structures below the project area fence). Inside the project area however, the accumulated bank vegetation and resulting channel stabilization protected the stream channel from erosion. (Figure 2)

Numerous (15-30 fish per pool) trout fingerlings were observed in pools near bank seeps and springs in the Big Sandy River throughout the fall and into the Winter of 1979. In the spring of 1980, sampling was conducted under terms of the Department's collecting permit (Table 1) and three size classes of rainbow were observed to be returning to Bone Draw. Of the three size classes (4 inches, 6-8 inches, over 12 inches) - we were able to capture only those fish in the larger size classes. (Figures 3 & 4) This would tend to indicate that we are experiencing returns from our egg and fry plants of 1977, 1978 and 1979.

In 1980, approximately 5,000 eyed rainbow eggs were once again obtained from the Daniel Hatchery. These eggs were planted in Bone Draw by members of the League, utilizing Whitlock Vibert boxes placed in wire baskets of graded river gravel (Table 2, Figure 5). Hatching had occurred when the eggs were checked two weeks later. Several boxes with swim up fry, once again, had to be liberated by hand three weeks after planting, due to sedimentation within the gravel baskets. Survival to swim up fry was estimated to be 25%, as heavy fungus (Saprolegnia) mortality was incurred. Total survival from eggs to fingerlings (Figure 6) was estimated to be 10%. (This was based on visual observation as sampling for fingerlings was quite difficult using a minnow seine).

In the fall (October 1980) brown trout, rainbows and some brook trout were once again observed by Resource Area staff to be returning to Bone Draw. Field inspection on the 29th of October noted three or four apparent redds in Bone Draw Proper. Due to the two dimensional gravels and extensive amount of fines in the streambottom (Figure 2), it was felt however, that they would not be successful.

Conclusions

1. It appears that the basic fisheries management concept of Bone Draw (intensive management of a small area for maximum return) is producing results, in that several size classes of rainbows are returning to Bone Draw.

2. With the present approach, however (planting eggs), survival rates and subsequent returns are lower than what could potentially be expected.

3. In that Bone draw is a highly productive stream with good nursery habitat

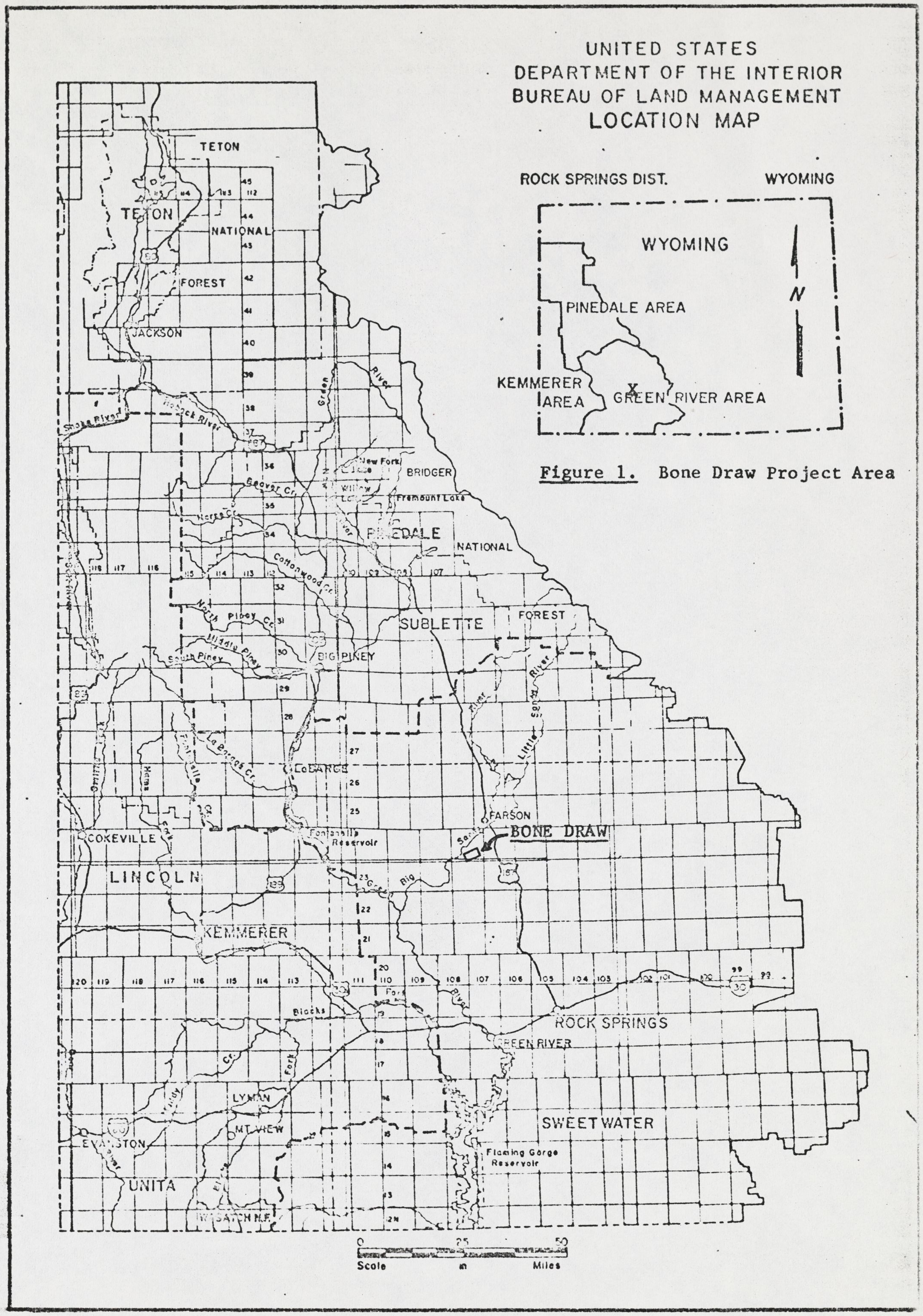


Figure 1. Bone Draw Project Area

Figure 2
Bone Draw after spring flooding in 1980. Note minimum bank erosion due to stable vegetative conditions. Stream bottom has been extensively scoured with flushing of sediment.

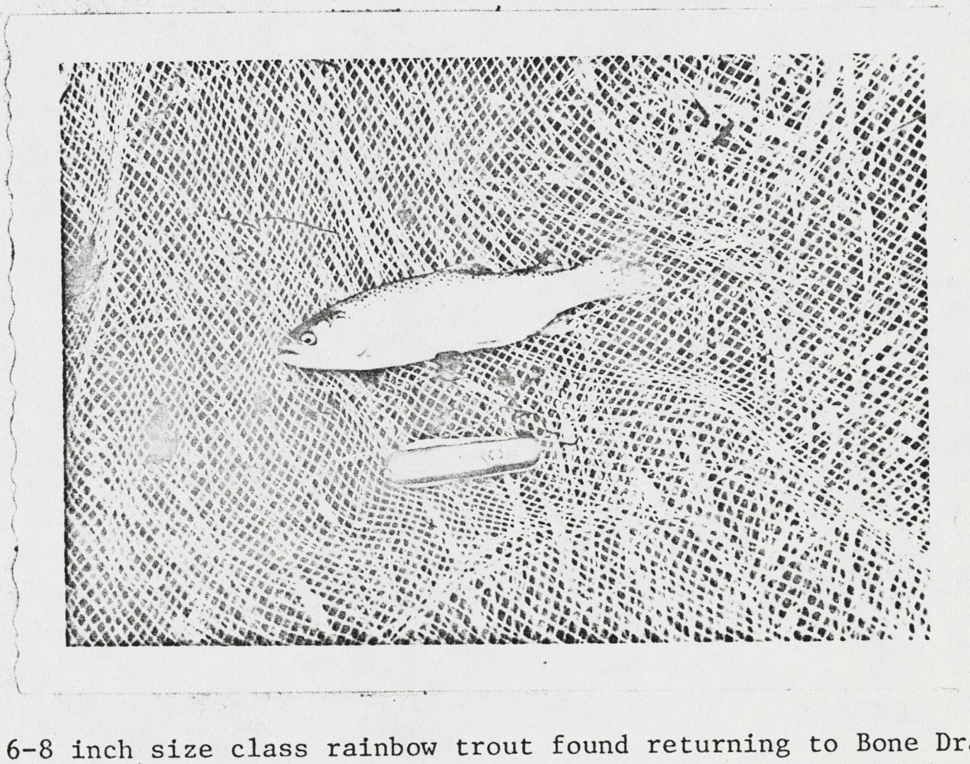


Figure 3 6-8 inch size class rainbow trout found returning to Bone Draw in the spring of 1980.

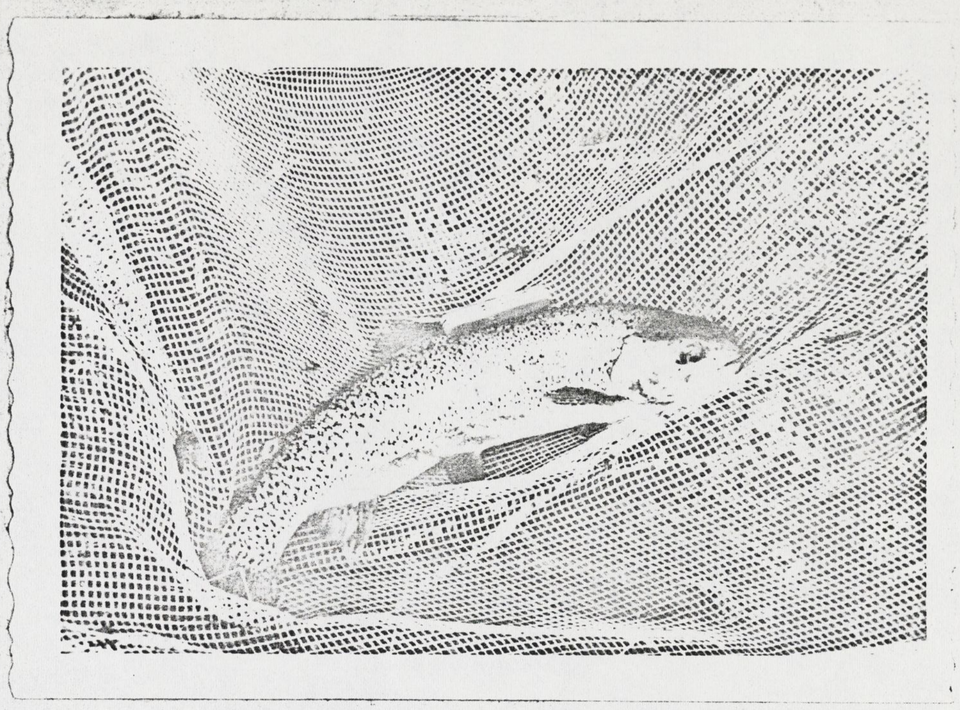
Table 1 BLM Sampling Record for 1980

for Bone Draw

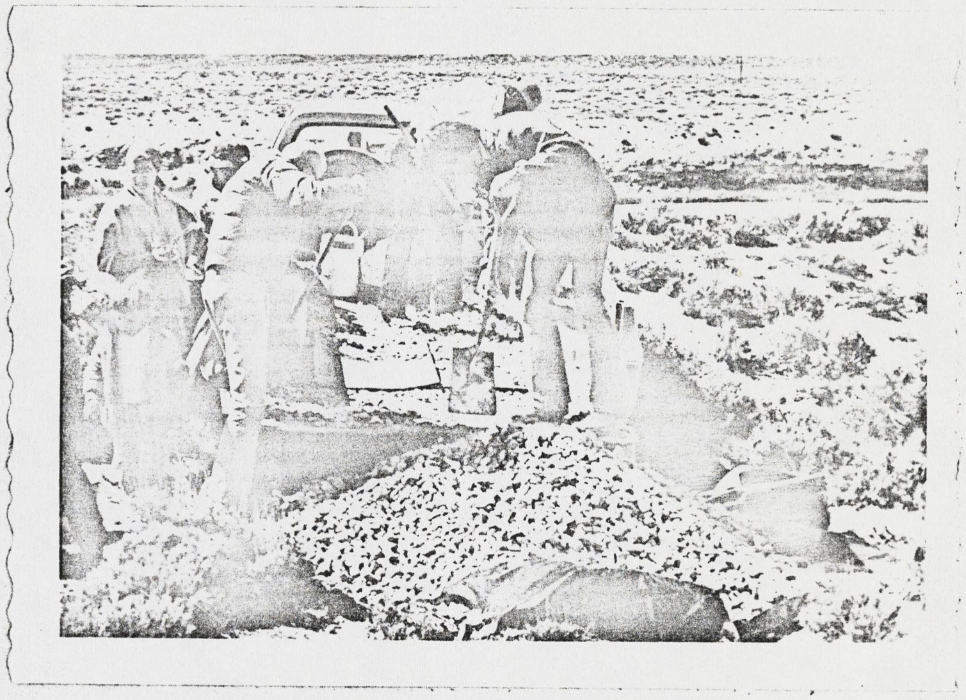
Scientific Permit No. 52

Wyoming Game and Fish Department

Date	Species Observed or Sampled
April 29	Redside Shiners, Fathead Minnows, 15 Rainbow (6-8" size range), 1 female rainbow (14" spawned out).
May 3	Speckled Dace, Redside Shiners, Fathead Minnows, Mountain Suckers, 1 Bluehead Sucker (?), Flannelmouth Suckers, 1 male Cutthroat (21" and ripe).
May 24	Redside Shiners, Speckled Dace, Mountain Suckers, Flannelmouth Suckers, several Bluehead Suckers (?)
May 31	IWLA - Rainbow Egg Plant, 5300 eggs, Bluehead Suckers (?), Mountain Suckers, Speckled Dace, Redside Shiners, 1 Utah Chub.
Oct 29	Poor results - 1-12" Brown covered with water mold. (G & F sample also taken with more extensive results).



<u>Figure 4</u> 14" spawned out female rainbow found in Bone Draw during spring of 1980



<u>Figure 5</u> Members of the Izaak Walton League of America, Green River Basin Chapter, participating in the Bone Draw egg planting study in 1980.

Table 2. Izaak Walton League Egg Plant - May 31

Site	No. Whitlock Boxes	No. Eggs	Water Temp °F
1	2	600	56°
2	2	600	56°
3	2	660	56°
4	2	660	56° (46° spring)
5	2	800	54°
6	4	1700	53°
7	1	300	51°
	15	5350	

Estimated Survival:

25% to swim up fry

10% to fingerlings (by end of summer)

Figure 6 Rainbow fingerling from the IWLA egg planting study, noting growth from early June to August 4, 1980.

developing, and insofar that fingerling growth rates approach those of hatchery raised fish, it appears that the full habitat potential is presently underutilized.

4. The sampling gear employed in 1980 (minnow seine) is not effective for adequate evaluation of age class structure, species composition and trout returns to Bone Draw.

Recommendations

1. I recommend that for our studies in 1981, we request 2-3,000 rainbow fingerlings for the spring plant and 1,000 brown or fall run rainbow for a fall plant. These should be fin clipped with assistance from Izaak Walton League members for future identification. It would be more advantageous to make these plants after the spring and fall runs of larger fish, to minimize losses due to pred tion.

2. I would also recommend that we request a renewal of our scientific collecting permit with the inclusion of approval to use a more effective sampling technique; i.e. electrofishing gear. Initial contacts with Department Biologists at the Green River Area and Cheyenne offices have indicated that they would be willing to consider this request, in light of the progress experienced on Bone Draw to date. In this regard, it would be beneficial to both agencies to develop a monitoring program utilizing Game and Fish methodology (i.e., field forms).

3. With the poor bottom composition of Bone Draw, successful natural reproduction will not be feasible unless river gravel is used to replace instream sand and sandstone below the log drop structures. In addition, the dike and marsh development planned for the FY-81 Annual Work Plan will help mitigate future impacts of sedimentation on these gravels.

4. In light of the results experienced to date on Bone Draw, it would be advisable for the Big Sandy Area staff to consider developing a cooperative Sikes Act Habitat Management Plan with the Game and Fish Department for the lower Big Sandy River. Of particular note would be the potential for similar habitat developments on two springs five miles downstream, which are now located within one of the Sandy E.S. monitoring exclosures.

The four miles of the Big Sandy River which are now in a special management unit plus the three 20 acre monitorining sites, will provide base level habitat improvements for instream fisheries cover. It would therefore appear that the potential for establishing a spring and fall run up the Big Sandy (thereby creating 30-40 miles of new recreational fishing opportunity) is technically feasible. This type of a management program would be quite similar in nature to those already established in other states. Cases in point would be the Lake McConaughy/Platte River program in Nebraska and the Lake Michigan tributary stream programs in Michigan.

Bruce H. Smith
12-80

THE STATE OF WYOMING
ED HERSCHLER
GOVERNOR

STAFF:
BILL GENTLE
STATE EXECUTIVE
DON NELSON
PROGRAM CONSULTANT
BILL LONG
PROGRAM CONSULTANT
LOU WENZEL
AG WATER QUALITY SPECIALIST
MARY LOU O'BLENESS
SECRETARY

Wyoming
STATE CONSERVATION COMMISSION
CONSERVATION DISTRICTS

State Conservation Commission

2219 CAREY AVENUE PHONE (307) 777-7321 CHEYENNE, WYOMING 82002

May 19, 1982

Mr. Clint Hanson, Big Sandy Resource Area Manager
BLM
P.O. Box 1869
Rock Springs, WY 82901

Dear Clint,

This is in reference to our concluding discussion at Bone Draw on the Big Sandy on May 5 regarding the Conservation Commission's future participation.

I would like to schedule June 15, 16, 17 and 18 to work with your representatives and Bruce Smith on the photo coverage and narration draft for the "Bone Draw Story" and the "White Acorn Riparian Management." → (I&E Coop. Slide Program) for use by Conservation Districts in their extension work w/ Ranchers & Public.)

If this is convenient please ask Bruce Smith to phone me direct 777-7321 for arrangements of details, times, etc. If the dates are not convenient please reply with alternate dates. Alternate dates would need to be later in June.

Sincerely,

Lou Wenzel

Lou Wenzel, Ag Water Quality

cc: John Orton, Commissioner Agriculture Department
John Niland, Chairman, Conservation Commission
Jim Hodder, Secretary, Big Sandy Conservation District
Box 46, Farson, WY 82932
Dan Rodgers, Division of Range Mgt., College of Agriculture
WY University, Laramie, WY 82071

dd/LW

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Rock Springs District
Big Sandy Resource Area
P. O. Box 1869
Rock Springs, Wyoming 82901

IN REPLY REFER TO
4112 (480)

6-22-82

Mr. Lou Wenzel
Wyoming State Conservation Commission
2219 Carey Avenue
Cheyenne, Wyoming 82002

JUN 21 1982

Dear Mr. Wenzel:

Following is the information you requested from correspondence of May 19, 1982.

A. Mitigation Items

1. Exclosures

Twenty-one exclosures have been completed according to the discussion in Chapter 4 of the Sandy Grazing ES. Three exclosures are planned for completion by the end of Fiscal Year 1982. The remaining two exclosures will not be built because of survey or engineering problems. A temporary exclosure of electric fence may be placed on the Sweetwater River to rest streambanks where fisheries habitat are of major concern. Direct cost for the exclosures has amounted to $289,000.00.

2. Wild Horse Removal

The Bureau has removed in excess of 600 horses since 1978 at an estimated direct cost of $38,000.00.

3. Gates

A gate opening plan was completed by the Resource Area in 1981. Time has been allocated for personnel to assure gates are left open during the pasture non-use periods to facilitate big game movement.

4. Salting

Our present policy is to avoid placing salt near streams or along historic or known archaeological sites.

5. Ear Tagging

A livestock identification and control program has begun in the ES area. Full implementation of this mitigating measure will not be completed for several years.

THE STATE OF WYOMING
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STATE CONSERVATION COMMISSION
CONSERVATION DISTRICTS

State Conservation Commission

2219 CAREY AVENUE PHONE (307) 777-7321 CHEYENNE, WYOMING 82002

May 19, 1982

Mr. Clint Hanson, Big Sandy Resource Area Manager
BLM, P.O. Box 1869
Rock Springs, WY 82901

Dear Clint:

Your Sandy Grazing Environmental Statement, Chapter 4 described Mitigation Measures of which you reviewed selected riparian studies May 4 and 5 during the scheduled meetings at Farson.

I would like to have your following information for my pending Assessment Report of Stream Water Quality on the Big Sandy River and its environs:

1. Updated list of BLM mitigation items accomplished under Chapter 4. Please include costs.
2. List of your proposed BLM actions remaining in the next 5 year period based on the chapter 4. list.
3. Bone Draw BLM Program, costs of accomplishment and proposals.
Can you furnish this information by June 15?

Sincerely,

Lou Wenzel

Lou Wenzel, Ag Water Quality

cc: John Orton, Commissioner of Agriculture
John Niland, Chairman, Conservation Commission
Jim Hodder, Secretary, Big Sandy Conservation District
Box 46, Farson, WY 82932
Dan Rodgers, Division of Range Mgt. College of Agriculture
WY University, Laramie, WY 82701

dd/LW

6. Other Developments

Twenty-three miles of standard livestock fence were built to control livestock use at a material and contract cost of $37,500.00. Another 7.5 miles of electric fence was installed for material cost of $5,000.00. Eleven cattleguards were constructed for a total figure of $26,800.00. Chicken Springs archaeological site was exclosed to eliminate livestock trampling and 15-Mile Reservoir was fenced to reduce livestock use. Cost of both projects amounted to about $5,700.00.

The preceding figures to accomplish mitigating measures does not include managerial, survey, administration and other indirect costs. If the total of these costs were calculated, I'm sure they would substantially increase the overall figure to implement mitigation.

B. Proposed Future Mitigation

Most of the problem areas identified have received as much attention as appropriate funding will allow. The ear tagging program will continue. We will continue an effective program to control and monitor range trespass. Additional water will be developed to provide better livestock distribution. Some existing fences will be modified to facilitate big game movement.

Visual contrast rating will be analyzed and new facilities painted to blend with the surrounding landscape. Archaeological clearances will be performed on all project locations. No new fences are proposed for the period you discussed.

With current and proposed future budget cuts, we feel maintenance of existing projects will consume most of the appropriations, with few new projects expected annually.

C. Bone Draw

Direct costs of development and maintenance of the Bone Draw Special Management Area amounts to $18,500.00. Administrative and field work month costs are estimated at $27,500.00 to date. Full development will be completed this year, with only maintenance required during subsequent years.

Sincerely yours,

Winston E. Hansen

Area Manager

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Rock Springs District
Big Sandy Resource Area
P. O. Box 1869
Rock Springs, Wyoming 82901

IN REPLY REFER TO
6740

Mr. Steve McCall
U.S. Bureau of Reclamation
764 Horizon Dr.
Grand Junction, CO 81501

Dear Mr. McCall:

Enclosed for your information are copies of a few summary reports on Bone Draw development. The project area was set aside for the following purposes:

1. To provide an area for resource studies without the influence of livestock grazing.
2. To establish a special wetland and aquatic management area for wildlife.
3. To provide a "protected" area in which a variety of wildlife improvements can be tested for usefullness and benefit/cost.
4. To establish a public education area where physical improvements can be demonstrated to conservation groups, schools and the general public.

Project costs are estimated as follows:

$17,760	Material/equipment/contracts
40,300	Administration, monitoring, maintenance
$58,060	Estimated total cost

The Wyoming Game and Fish Department has cooperated in planting of trout eggs, fry and/or fingerlings in the habitat area annually since 1978. With recent development of a hatching facility, we can probably expect the Departments involvement to increase during the next few years.

Long term plans for Bone Draw include the following:

1. Continue annual maintenance of existing facilities.
2. Continue developing stream habitat with materials presently at the site.
3. Expand the hatching facility to a 50,000 egg capacity if current studies are successful.

4. Revise the current "Bone Draw" publication and finalize it for public distribution.
5. Continue studies of habitat improvement methods presently on or suitable to the special Management Area.

Some of the staff reports since 1977 may prove helpful in answering additional questions you may have.

Sincerely,

Area Manager

Enclosure

Quantification Of Fish Habitat That Could Be Impacted By The Proposed Big Sandy River Water Quality Improvement Program - Level III

Prepared for

Wyoming Water Development Commission

by

Allen L. Conder and Thomas C. Annear
Wyoming Game and Fish Department
Fish Division

December, 1982

Quantification Of Fish Habitat That
Could Be Impacted By The Proposed
Big Sandy River Water Quality Improvement
Program - Level III

INTRODUCTION

On March 10, 1982, the Governor of Wyoming signed Enrolled Act No. 35, House of Representatives, which authorized and directed the Water Development Commission to prepare plans for salinity reduction of the waters of the Big Sandy River to allow further development of Wyoming's Colorado River Compact allocation and to provide water for industrial utilization.

Project components listed in the Act included a well field with a maximum capacity of 15,000 acre-feet, a pipeline delivery system to the Rock Springs vicinity for marketing to potential industrial users, two pump lift stations, and a reservoir with storage capacity of about 21,000 acre-feet.

OBJECTIVES

Objectives of this report are:

1. To quantify the impacts of the proposed action and alternatives by calculation of fish habitat gained or lost.

2. To prioritize and quantify a list of mitigating measures that will minimize or alleviate the impacts of the project.

Alternatives evaluated are those presented in the Draft, Joint State and Reclamation Planning Report, Big Sandy River Unit Colorado River Water Quality Improvement Program (1982).

Fishery

The principal aquatic habitats in the unit area include the Big Sandy River, Green River, and the wetlands created by seeps. The most notable of the seeps is Bone Draw. Each of the aquatic habitats provide populations of game fish in an area where the diversity of fishing waters is limited.

Although limited by seasonal low flows, high summer water temperatures, and sedimentation, portions of the Big Sandy River study area support resident rainbow and brown trout populations. Results of sampling efforts appear in Appendix A. Evidence also indicates the Big Sandy provides nursery and marginal spawning habitat for small spawning runs of rainbow trout in the spring and brown trout in the fall from the Green River. Reproduction attempts have been observed, but very few if any viable eggs have been recovered.

In addition to game fish, the Big Sandy also supports mottled sculpin, redside shiner, Utah chub, fathead minnow, longnose dace, speckled dace, white sucker, flannelmouth sucker, and bluehead sucker. The bluehead sucker is considered rare and the flannelmouth sucker is considered uncommon in Wyoming (Wyoming Game and Fish Department, 1977). Populations of both species are in a sensitive situation.

The sport fishery value of the Big Sandy is not fully appreciated due to the proximity to the high quality fishery in the Green River. Fishing pressure was estimated at 152 fisherman days on the 63 mile reach from Big Sandy Reservoir to the confluence with the Green River in 1977 (Miller). An estimated 51 percent or 77.5 fisherman days were spent in the stream reach which would be affected by the Big Sandy project. With the increase in population in southwestern Wyoming and the associated increase in demand for recreation, this estimate of fishing pressure is probably low, although updated information is not available. A formal fish stocking policy does not exist for the lower Big Sandy. Recent stocking has been associated with the BLM's habitat improvement project on Bone Draw.

Bone Draw provides valuable nursery and possible spawning habitat. Although spawning success is questionable due to high TDS, spawning activity has been witnessed. Rainbow trout,(Lake McConaughy and Eagle Lake fingerling),kokanee salmon eggs,and brown trout eggs have been stocked in Bone Draw in cooperation with the BLM's habitat improvement program. The stocking and habitat improvement program has resulted in an increase of 137 pounds of trout per acre in Bone Draw (175.6 lb/acre in 1980 to 312.6 lb/acre in 1982). Bone Draw is not only an important fishery to the area but also serves as a valuable demonstration of successful fish management in an arid location.

The Green River is a Class 1 stream (fishery of national importance) supporting populations of seven game fish species and 13 nongame species. Species known to be present are:

Game Fish

Rainbow trout
Brown trout
Kokanee
Mackinaw (Lake trout)
Mountain whitefish
Snake River cutthroat trout
Channel catfish

Nongame Fish

Mottled sculpin
White sucker
Flannelmouth sucker
Mountain sucker
Bluehead sucker
Utah chub
Roundtail
Redside shiner
Speckled dace
Longnose dace
Red shiner
Fathead minnow
Carp

Current information indicates both a resident and migrating population of trout exists. A population of kokanee is also being established which will migrate up the Green River to spawn.

METHODS

Game Fish

Impacts on trout populations were quantified for each alternative by calculating trout habitat unit (HU) values. Binns (1979) defined a trout HU as the amount of habitat quality required to produce an increase in trout standing crop by one pound per acre.

Trout HU are calculated by:

1. Estimating the standing crop (SC) in pounds per acre in a stream by Habitat Quality Index (HQI) scores (Binns 1982) or sampling efforts.

2. Converting SC to HU by multiplying the SC figure by the coefficient for streams (1.08). Binns (1976, 1979) derived and showed the justification and limitations for this coefficient.

The existing trout HU calculated were used to quantify the impacts that will occur by the proposed alternatives in the Big Sandy Project. Due to the time constraints placed on the project and limited available data, some judgmental values, based on the expertise of Department biologists, were assigned to the possible impacts. Calculation of HU are located in Appendix B.

Fishery and instream flow studies were conducted at two sites during the 1982 field season. Data collected at the upper site (T24N, R107W, S32) were applied to a stream reach extending 9.2 river miles downstream and 2.4 river miles upstream of Bone Draw. Data collected near Gasson Bridge (T24N, R109W, S26) were applied to the stream reach from the Big Sandy's confluence with the Green River to 9.2 river miles upstream of Gasson Bridge. Discharge records from the USGS gauge station (09216000) near Bone Draw were used for the upper reach. The use of the gauge records near Bone Draw will introduce some error into the habitat calculations due to the accretion from springs. Until additional information is available on well locations and operation (net water depletion and location of depletions in Bone Draw and the Big Sandy River) the USGS gauge records are perceived as the best available information to address the impacts. Records from USGS gauge station (09216050) at Gasson Bridge were used to address impacts on the lower reach.

Recent studies on the Green River (Wyoming Game and Fish Department 1979, Banks et al. 1974) have recommended an instream flow of 800 cfs for the period of April through October and 500 cfs for the period of November through March. A flow of 800 cfs was used to quantify the possible impacts the project may have on the Green River.

The amount of spawning habitat was quantified using methods developed by the U.S. Fish and Wildlife Service's Cooperative Instream Flow Group (Bovee and Milhous 1978, Milhous et al. 1981).

RESULTS

Game Fish

Alternative 1 - Chevron

This alternative would develop 7,000 acre feet of saline water of about 4,000 mg/L from the Big Sandy River annually for Chevron Chemical Company to meet part of its total 13,700 acre foot requirement. The water would be developed from a well field which would be installed in the Big Bend area and then pumped through a pipeline which would extend southeast to the proposed fertilizer plant near Rock Springs. To meet its remaining water requirement of 6,700 acre feet annually, Chevron would construct a pipeline from the Green River to the proposed plant.

This alternative would reduce flows in the Big Sandy by 9.67 cfs. The reduction in flow results in a reduction of critical period flow (August 15 to September 15) of 16.5% in the Bone Draw area and 11.8% at Gasson Bridge (based on USGS gauge records, station numbers 09216000 and 09216050, respectively). This reduction in flow in the Big Sandy will result in the loss of 189 HU. The effect of the wells on the flow in Bone Draw is unknown to date. It is assumed that the flow will be greatly reduced. If Bone Draw is totally dewatered it will result in the loss of an additional 176 HU. The net loss in HU from the Chevron alternative would be 365 or 18.8% of the total available trout habitat (1939 HU) in the Big Sandy River and Bone Draw.

The reduction in flow will reduce brown trout spawning habitat in the fall by 25.8% as defined by the IFG's habitat model in the Big Sandy River at the upper study site. The reduction in flow would provide a 3.8% increase in rainbow trout spawning habitat in the spring. Based on available data, it is impossible to quantify the effect that the change in spawning habitat would have on recruitment of game fish.

The reduction in flow of 18.9 cfs (9.67 cfs from Big Sandy and 9.25 cfs from the Green River) will result in a loss of 652 HU in the Green River at a flow of 800 cfs. The Chevron alternative will result in a loss of 1017 HU. The reduction in salinity to the Green River from diversions on the Big Sandy should enhance the Green River fishery. Additional data would be required to quantify the possible enhancement of the fishery.

Alternative 2 Chevron and Texasgulf

Alternative 2 would develop 12,000 acre feet of saline water of about 4,000 mg/L from the Big Sandy River annually including 7,000 acre feet for Chevron and 5,000 acre feet for Texasgulf. In addition, Chevron would obtain 6,700 acre feet from the Green River. The plan and features are essentially the same as in Alternative 1 except that a single pipeline would carry the water supply for both companies to a point south of the well field, from which one pipe would extend southeast to the proposed Chevron plant, and a second pipe would extend southwest to the Texasgulf plant.

This alternative would reduce flows in the Big Sandy by 16.57 cfs. The reduction in flow results in a reduction of critical period flow of 28.3% in the Bone Draw area and 20.2% at Gasson Bridge. This reduction in flow will result in a net loss of 550 HU or 28.4% of the available trout habitat (1939 HU) in the Big Sandy and Bone Draw.

The reduction in flow will result in a 44.2% reduction in brown trout spawning habitat in the fall. Rainbow spawning habitat in the spring would increase by 2.7% with the reduction in flow.

The reduction in flow in the Big Sandy and diversion of 9.25 cfs from the Green River would reduce the flow in the Green River by 3.2%. This reduction in flow will result in a loss of 1207 HU. The reduction in salinity in the Green River due to the diversion of the saline water from the Big Sandy will enhance the fishery, but data are not available to quantify the enhancement.

Alternative 3 Chevron, Texasgulf, other Trona

Alternative 3 would develop 21,900 acre feet of water annually from the Big Sandy River, including 7,000 acre feet for Chevron, 5,000 acre feet for Texasgulf, and 9,900 acre-feet for four other trona processing companies for expansion of their existing plants. Of the 9,900 acre feet, 2,800 acre feet would be supplied to Tenneco Oil, 1,900 acre feet to Allied Chemicals, 1,100 acre feet for Church and Dwight, and 4,100 acre feet to FMC.

As in Alternative 2, Chevron and Texasgulf would obtain 12,000 acre feet of saline water of about 4,000 mg/L water from the well field and pipeline, and Chevron would obtain an additional 6,700 acre feet from the Green River. Water for the other trona companies would be developed by constructing an 11,200 acre foot Plains Reservoir on the Big Sandy River near Gasson Bridge.

At present, the exact location and size of the proposed reservoir has not been determined. The fishery impact evaluation was based on Plains Reservoir

Unit D with a maximum storage capacity of 69,215 acre feet. If the reservoir is located on stream or has a diversion structure which would block fish migration in approximately the same location, the habitat evaluation would be applicable.

Alternative three would reduce critical period flow by 16.57 cfs or 28.3% in the Big Sandy in the Bone Draw area. This reduction in flow will result in the loss of 293 HU above the impoundment. The high salinity, high turbidity, high water temperature, and reservoir fluctuation in Plains Reservoir precludes development of a sport fishery. No fishery benefits will be realized from the reservoir and the impoundment will cause the loss of 553 HU. Current plans are to release 5 cfs for stock watering below the dam. This release will result in the loss of 779 HU from the dam to the confluence with the Green River. This alternative will result in a loss of 1,625 HU or 83.8% of the trout habitat in the area of impact in the Big Sandy River.

The dam will block upstream spawning migration from the Green River. Any spawning in Bone Draw and the Big Sandy will be limited to the resident populations. The reduction in flow above the impoundment will reduce brown trout spawning habitat by 41.2% while increasing rainbow trout spawning habitat by 2.7% in the Bone Draw area. With available data it is not possible to quantify the resulting loss in recruitment to the trout population in the Big Sandy and Green River.

If critical period releases are 5 cfs from the reservoir, based on channel morphology and tributaries to the Big Sandy below the proposed dam, the Big Sandy will be totally dewatered at the confluence except during spring runoff. Flows in the Green River will be reduced by 91.1 cfs (81.8 cfs critical period flow at Gasson Bridge and 9.25 cfs diverted from the Green River). This reduction in flow will result in the loss of 5,461 HU in the Green River.

Alternative three will result in the loss of 7,086 HU. Dewatering the

Big Sandy will enhance the Green River fishery by possible reduction in sediment loads and salinity. With available data quantification of the enhancement is not possible but it would buffer in some measure the reduction in HU.

Native Nongame Species

Review of sensitive, rare, and endangered species which have native ranges inclusive of Big Sandy:

The Bureau of Reclamation Report (Final Alternative Report for Salinity Control, 1982) listed the bonytail chub, the humpback chub, and the Colorado squawfish as endangered species which have the potential to be within the study area. Baxter (1970), however, states that all three of these species are probably extinct in Wyoming.

A biological assessment must be made during the draft EIS to determine the effect of the proposal on endangered species. The lead federal agency must comply with the consultation requirement of Section 7 of the Endangered Species Act. One endangered species, Kendall Warm Springs dace (*Rhinichthys osculus thermalis*), is present in the Green River Drainage in Wyoming. The total habitat of the Kendall Warm Springs dace is an isolated spring area and short stream reach 31 miles north-northwest of Pinedale in Sublette County, Wyoming. The proposed development sites would not impact the habitat of this species.

The U. S. Fish and Wildlife Service, Endangered Species Office, Billings, Montana, has provided a list of endangered fish species that may occur in the area of the proposed project (personal communication 12-23-82).

Listed Endangered Species

Colorado squawfish	*Ptychocheilus lucius*
Humpback chub	*Gila cypha*
Bonytail chub	*Gila elegans*

No legally determined critical habitat is present within the area of construction.

The flannelmouth sucker is listed as uncommon and sensitive by the Wyoming Game and Fish Department (1977). It was sampled in Bone Draw and Big Sandy River by Wyoming Game and Fish personnel in 1977 (Miller, 1978) and in 1982 (Appendix A). The BLM (Big Sandy Resource Area BLM Rock Springs District, Bone Draw-Big Sandy River, Fisheries Sampling Report 1981) captured what they suspected as being bluehead suckers in 1981. The bluehead sucker is listed as rare by the Wyoming Game and Fish Department (1977). This species was not found during sampling by the Wyoming Game and Fish Department in 1977 but was in 1982. Both the flannelmouth and the bluehead sucker are declining in numbers in Wyoming due to loss of preferred habitat.

Both the flannelmouth and bluehead sucker spawn in the spring. They prefer fast water habitat with bottoms of rock or boulders. All of the alternatives would negatively impact migration either by lowered flows or physical blockage by the Plains Reservoir Dam. More information is needed on the status of these species in the Big Sandy River before the significance of impacts can be determined. Since the flannelmouth and bluehead sucker prefer swift current with a rock and boulder bottom, the habitat of the Big Sandy River is probably already marginal for these species. Any further loss of flows could very likely eliminate these two species from the lower Big Sandy River.

More information is needed before impacts on these species can be determined. However, present data and information on the biology of these species indicates that their existence is already tenuous in the study area and any of the proposed alternatives for development would probably have adverse effects.

SUMMARY

Table 1 lists the impacts of the three alternatives. Each alternative will have negative impacts to the fishery resource.

Table 1. Summary of impacts from the proposed alternatives on the Big Sandy Project.

	Alternatives		
	1 Chevron	2 Chevron and Texasgulf	3 Chevron, Texasgulf Other Trona
Big Sandy River			
Game Fish (trout) HU	-189	-374	-1449
Rainbow Spawning Habitat	+3.8%	+2.7%	+2.7%
Brown Spawning Habitat	-25.8%	-44.2%	-44.2%
Native Nongame Species	0	0	0
Bone Draw HU	-176	-176	-176
Green River			
Game Fish HU	-652	-1207	-5461
Possible Enhancement	X	X	X
Grand Total	-1017HU -22% spawning habitat	-1757HU -41.5% spawning habitat	-7086HU -41.5% spawning habitat

0 - Denotes negative impact but not quantifiable.
X - Denotes enhancement but not quantifiable.

Alternative three is by far the most detrimental in terms of quantifiable HU, but also offers the greatest enhancement opportunities to the Green River fishery. Implementation of alternative three with fisheries provisions may enhance the Green River fishery and outweigh the loss of the already marginal fishery in the area of development in the Big Sandy River. The reduction in salinity and reduction in silt load could enhance the Green River if flow releases from Fontenelle Reservoir are sufficient to compensate for flow reductions below the Big Sandy confluence. Additional information is needed to quantify the effects of implementation of alternative three in the Green River fishery.

Implementation of either alternative one or two would result in negative impacts to the area fisheries, with alternative two being the most detrimental. These alternatives also present very limited fisheries benefits. Minimal enhancement to the Green River fishery may result from the reduction in salinity but data are unavailable to quantify the possible enhancement.

Recommendations

The opportunity exists for mitigation of negative impacts from the various alternatives.

Alternative 1 - Chevron

1. It is recommended that stored water in Fontenelle Reservoir be dedicated for release to augment flows in the Green River during periods when the flow in the Green River falls below 800 cfs in the period of April through October or 500 cfs for the period of November through March. Flows should be augmented at a rate equal to depletion below the recommended instream flow. Augmentation of flows in the Green River will eliminate impacts below the confluence with the Big Sandy and provide flow enhancement from Fontenelle Reservoir downstream to the confluence to compensate for impacts on the Big Sandy.

2. Reduced flows in Bone Draw should be mitigated by fish habitat improvements in the area. Funds should be allocated to the Wyoming Game and Fish Department for habitat improvements and evaluation of such improvements to mitigate for HU lost in Bone Draw. The decision of location and type of habitat improvement measures should be made following detailed evaluation of alternatives by Department biologists to maximize the effectiveness of the program.

Alternative 2 - Chevron and Texasgulf

1. The same mitigation procedure outlined for Alternative 1 should be used to mitigate this alternative.

Alternative 3 - Chevron, Texasgulf and other Trona

1. We recommended that a hydrologic study be initiated to determine the useful life of the reservoir, the effects that altered flow regimes would have on the morphological characteristics of the stream channel below the reservoir, and sediment loading in the Green River. We question what the life expectancy of the reservoir might be and the reduction in sediment in the Green River. If a hydrologic study could document a substantial reduction in the sediment load to the Green River for a meaningful duration of time by impoundment and reducing flows in the Big Sandy, the loss in habitat in the Big Sandy may be offset by the enhancement to the Green River fishery. Instream flow recommendations below the proposed reservoir will not be made until additional information is available on the alterations to stream channel characteristics which will result from altered flow regimes. Data have been collected for a maintenance flow under present conditions. The additional information is requested to enable evaluation based on fish habitat, channel maintenance, and sediment loading.

2. The proposed dam would block any upstream migration for spawning. Based on the tenuous existence of native nongame species and questionable

viability of the trout spawning, a fish ladder is not recommended. Mitigation by augmenting flows in the Green River with stored water from Fontenelle Reservoir would offset impacts to the Big Sandy and Green River systems.

3. Reduced flows in Bone Draw should be mitigated by fish habitat improvements in the area. Funds should be allocated to the Wyoming Game and Fish Department for habitat improvements and evaluation of such improvements to mitigate for HU lost in Bone Draw. The decision of location and type of habitat improvement measures should be made following detailed evaluation of alternatives by Department biologists to maximize the effectiveness of the program.

Selected References

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Project Name: Big Sandy at Bone Draw   Development Site Location: T24N,R107W,S32,SE¼

Stream Name: Big Sandy River

Stream Class: 4 - low production waters; fishery of local importance

Productivity: 2 - Fishable area is small and cannot withstand much fishing pressure.

Esthetics: 1 - Fair esthetic qualities; water is often turbid, streamside cover is lacking.

Access: 5 - Satisfactory for modern cars, stream is floatable

Fishery

Species present: rainbow trout, brown trout, white sucker, Utah chub, longnose dace, speckled dace, redside shiner, flannelmouth sucker, mottled sculpin, mountain sucker, bluehead sucker.

Estimated fishing pressure: 2.4 fisherman days/year/mile.

Stocking policy/history: Not stocked; rainbow trout fingerlings are stocked in Bone Draw proper and are an important source of recruitment to the Big Sandy River throughout this area.

Management concept: basic yield.

Managed for species: rainbow trout and naturally occurring fish populations.

Fish population data: Date 10-21-82   Method Zippin

SPECIES

	Rainbow	Brown	White Sucker
Total Captured	1	2	4
No. per mile	10	38	-
95% CI	-	-	-
Lbs/Acre	1.5	6.8	-
95% CI	-	-	-
Ave.Length (in.)	12.3	21.3	3.23
Range (in.)	-	20.4 - 22.1	2.4 - 5.2
95% CI	-	-	-
Ave. Weight (oz.)	11.0	55.0	-
Range (lb.)	-	48 - 62	-
95% CI	-	-	-

POPULATION ESTIMATE RESULTS

Date: 8-19-82 Method: Zippin

SPECIES

	Rainbow	Brown	Utah Chub	White Sucker	Speckled Dace	Redside Shiner	Fathead Minnow	Mtn. Suck
Total Captured	6	2	7	10	5	1	1	1
No. Per Mile	307	19	96	-	-	-	-	-
95% CI	±96	±10	±58	-	-	-	-	-
Lbs/Acre	8.2	1.0	0.2	-	-	-	-	-
95% CI	±2.6	±0.5	±0.1	-	-	-	-	-
Ave Length (in.)	6.9	8.1	3.3	7.2	3.4	3.0	2.5	4.1
Range	4.6-9.5	7.8-8.5	3.0-3.7	1.9-16.0	3.1-3.6	-	-	-
95% CI	±2.1	-	±0.20	±3.21	±0.23	-	-	-
Ave. Weight (oz.)	2.18	3.7	0.17	4.8	0.17	0.14	0.07	0.3
Range	0.6-5.1	3.5-4.0	0.07-0.28	0.07-23.3	0.07-0.21	-	-	-
95% CI	±166	-	±0.06	±5.14	±0.08	-	-	-

Date: 6-29-82 Method: Cyanide

SPECIES

	Rainbow	Brown	Speckled Longnose Dace	Redside Shiner	Utah Chub	White Sucker	Flannelmouth Sucker	Mott Scul
Total Captured	13	3	92	10	9	6	4	1
No. Per Mile	-	-	-	-	-	-	-	-
95% CI	-	-	-	-	-	-	-	-
Lbs/Acre	-	-	-	-	-	-	-	-
95% CI	-	-	-	-	-	-	-	-
Ave Length (in.)	9.2	14.8	3.1	3.2	10.2	9.1	6.6	3.7
Range	5.4-15.1	12.6-16.5	2.7-4.6	2.5-4.5	9.8-10.9	3.5-14.6	4.6-10.3	-
95% CI	±1.74	±5.0	±0.16	±0.49	±0.30	±5.05	-	-
Ave. Weight (oz.)	6.0	18.2	0.16	0.20	6.6	7.6	2.5	0.3
Range	1.0-18.0	10.5-24	-	-	5.5-8.0	0.3-17.5	0.5-6.5	-
95% CI	±3.40	±17.2	-	-	±0.62	±7.92	-	-

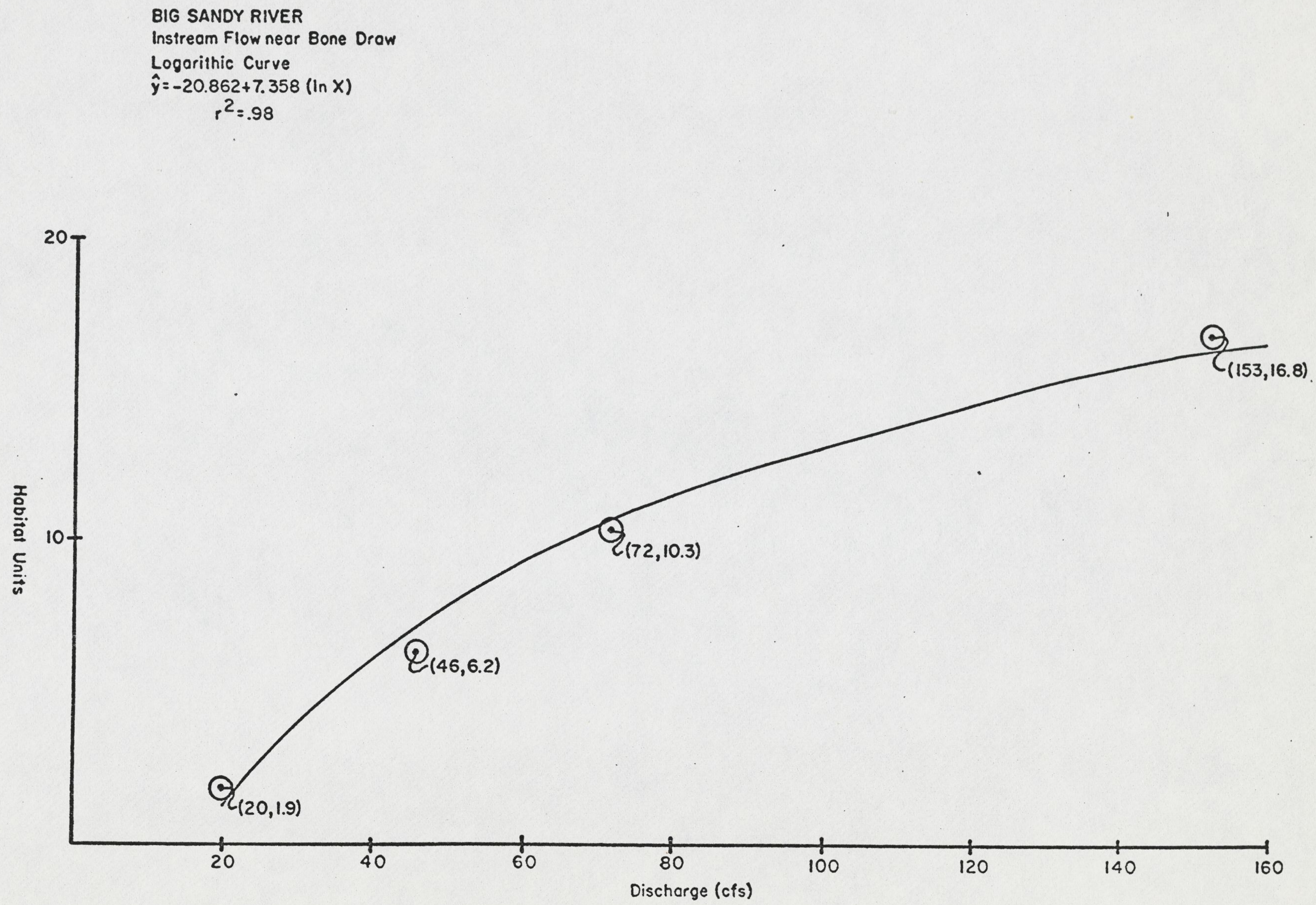
HABITAT QUALITY INDEX (HQI)
SUMMARY OF RATINGS AT MEASURED FLOWS

	DISCHARGE (CFS)			
Attribute	153	72	46	20
X-1 Critical period stream flow	4	4	4	3
X-2 Annual stream flow variation	4	4	3	2
X-3 Maximum summer temperature	3	2	2	1
X-4 Nitrate Nitrogen	4	4	4	4
X-7 Cover	2	1	0	0
X-8 Bank stability	1	1	1	1
X-9 Substrate	0	0	0	0
X-10 Water velocity	0	3	4	NA
X-11 Stream Width	3	3	3	NA
HQI Score (Lbs/Acre)	15.6	9.5	5.7	1.64
Trout Habitat Units	16.8	10.3	6.2	1.95

Measured Trout Standing Crop: 8.3 lbs/acre

Date of Population Estimate: 10-21-82

HQI Sampling Dates:	Date	Discharge (CFS)
1	7-28-82	153
2	8-22-82	72
3	10-20-82	46
4	Simulated	20


BIG SANDY RIVER
Instream Flow near Bone Draw
Logarithic Curve
ŷ=-20.862+7.358 (ln X)
r2=.98
Habitat Units
20
10
(20,1.9)
(46,6.2)
(72,10.3)
(153,16.8)
20
40
60
80
100
120
140
160
Discharge (cfs)

Project Name Big Sandy   Development Site Location Below Gasson Bridge
T24N, R109W, S26SE¼

Stream Name Big Sandy River

Stream Class 4 - Generally incapable of sustaining substantial fishing pressure.

Productivity 1 - Supports low populations of game fish.

Esthetics 1 - Fair esthetic qualities, a lack of streamside cover is apparent.

Access 5 - Stream access in terms of posting and availability to fisherman use is very good.

Fishery

Species present Varies with time of year but includes brown trout, rainbow trout, white sucker, flannelmouth sucker, redside shiner, Utah chub, speckled dace, mottled sculpin, fathead minnow, bluehead sucker, longnose dace.

Estimated fishing pressure 2.4 fisherman days/year/mile.

Stocking policy/history Fingerling rainbow trout are stocked in Bone Draw, which are occasionally found in the study area. No other stocking is conducted.

Management concept Basic yield

Managed for species Native fish populations

Fish population data: Date 10-21-82 Method Zippin

	SPECIES				
	Rainbow	Brown	White Sucker	Flannelmouth Sucker	Redside Shiner
Total Captured	4	6	23	2	6
No. per mile	62	75	-	-	-
95% CI	±37	±19	-	-	-
Lbs/Acre	0.64	0.33	-	-	-
95% CI	±0.38	±0.08	-	-	-
Ave Length (in.)	6.1	4.8	3.27	8.55	3.43
Range (in.)	4.6-8.0	4.1-5.4	1.6-7.7	7.7-9.4	2.5-4.0
95% CI	±2.29	±0.53	±0.61	U	±0.53
Ave. Weight (oz.)	1.46	0.77	0.32	2.9	0.28
Range (lb.)	0.6-2.75	0.4-1.2	0.1-2.75	-	0.15-0.5
95% CI	U	±0.36	±0.25	U	±0.13

U = undefined

Appendix A

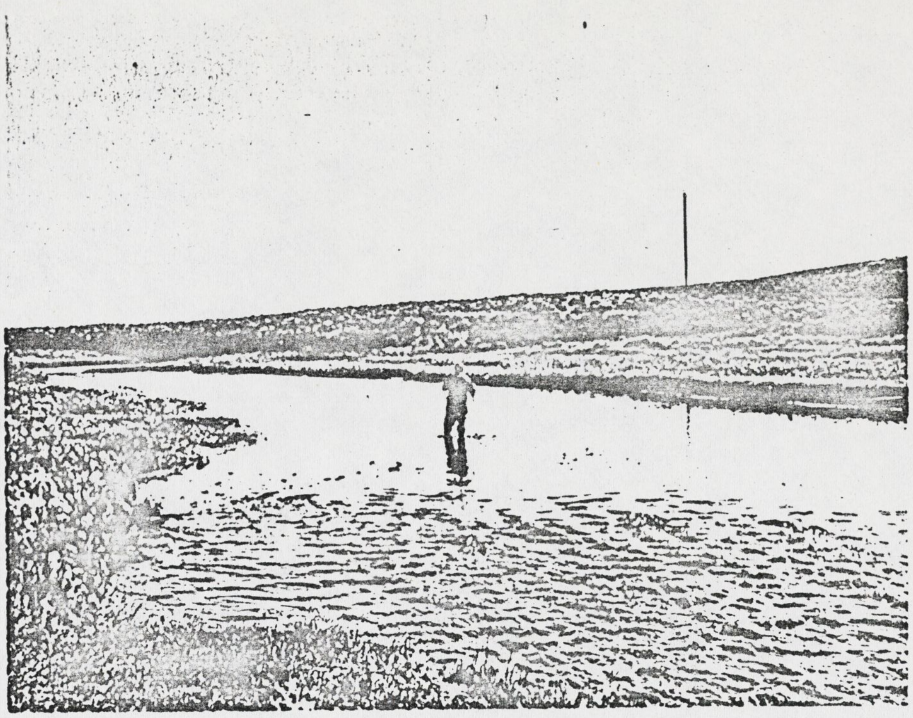
POPULATION ESTIMATE RESULTS

Date: 8-19-82 Method: Relative abundance

	Rainbow	Brown	Utah Chub	Fathead Minnow	White Sucker	Speckled Dace	Mottled Sculpin
Total Captured	1	1	5	6	13	1	1
No. Per Mile	-	-	-	-	-	-	-
95% CI	-	-	-	-	-	-	-
Lbs/acre	-	-	-	-	-	-	-
95% CI	-	-	-	-	-	-	-
Ave Length (in.)	9.0	9.0	3.4	2.1	3.9	3.7	2.0
Range (in.)	-	-	3.0-4.0	1.6-2.8	1.9-7.6	-	-
95% CI	-	-	±0.54	±0.56	±0.98	-	-
Ave Weight (oz.)	4.6	-	0.22	0.07	0.59	-	.07
Range	-	-	-	-	0.04-3.35	-	-
95% CI	-	-	-	-	±0.58	-	-

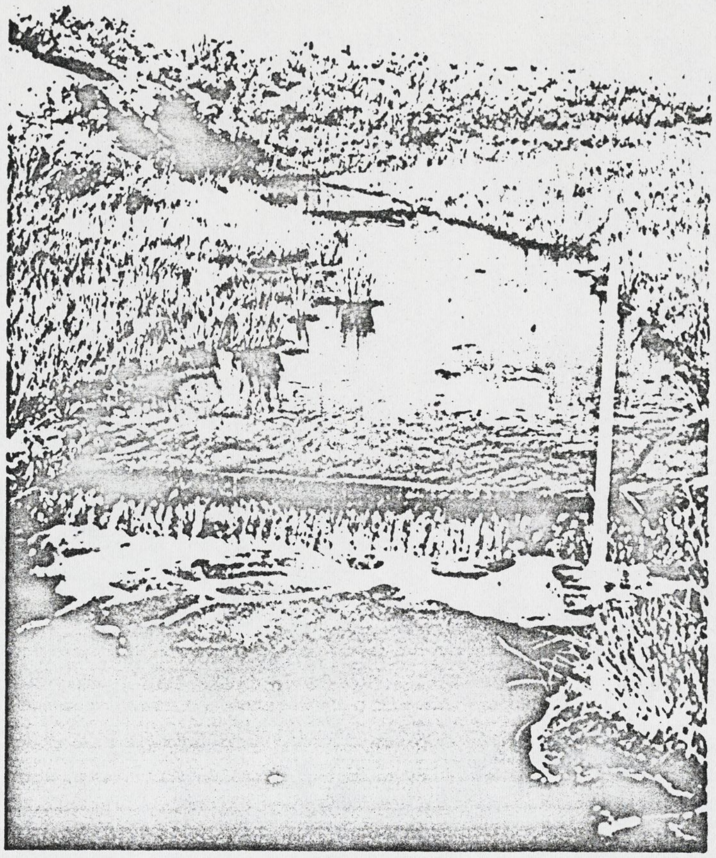
Date: 6-29-82 Method: Relative abundance

	Redside Shiner	Utah Chub	Mottled Sculpin	Flannel-mouth Sucker	Bluehead Sucker	White Sucker	Long-nose Dace	Fathead Minnow
Total Captured	13	9	7	6	5	3	2	2
No. Per Mile	-	-	-	-	-	-	-	-
95%	-	-	-	-	-	-	-	-
Lbs/acre	-	-	-	-	-	-	-	-
95% CI	-	-	-	-	-	-	-	-
Ave Length (in.)	3.16	10.41	4.29	3.65	4.36	3.3	3.15	2.5
Range (in.)	2.8-3.5	9.2-11.7	3.8-4.8	2.8-4.9	4.2-4.8	3.0-3.8	3.1-3.2	-
95% CI	-	-	-	-	-	-	-	-
Ave Weight (oz.)	0.25	7.14	1.17	0.5	0.5	0.33	0.25	0.1
Range	-	5.0-10.5	0.3-1.7	-	-	-	-	-
95% CI	-	-	-	-	-	-	-	-



Upstream view of study site on the Big Sandy near Bone Draw on August 22, 1982.

Upstream view of study site on Big Sandy approximately two miles downstream of Gasson Bridge on June 29, 1982.



Upstream view of study site on Bone Draw on
August 17, 1982.

HABITAT QUALITY INDEX (HQI)
SUMMARY OF RATINGS AT MEASURED FLOWS

Attribute	DISCHARGE (CFS) 75
X-1 Critical period stream flow	4
X-2 Annual stream flow variation	3
X-3 Maximum summer temperature	2
X-4 Nitrate nitrogen	1
X-7 Cover	0
X-8 Bank stability	3
X-9 Substrate	0
X-10 Water velocity	-
X-11 Stream Width	1
HQI Score (Lbs/Acre)	5.7
Trout Habitat Units	6.2

Measured trout standing crop: 0.84 ±.22 lbs/acre

Date of Population Estimate: 10-21-82

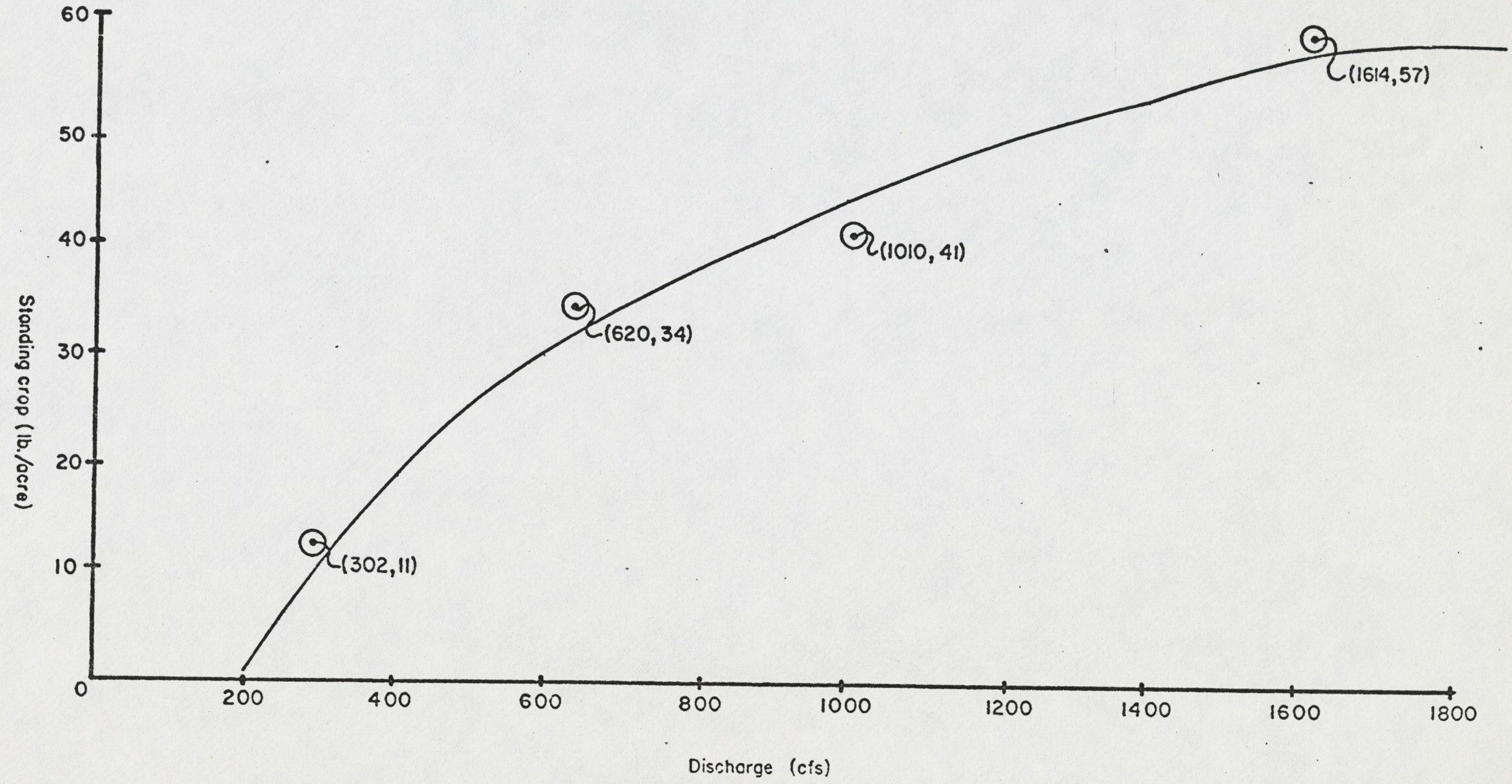
HQI Sampling dates:	Date	Discharge (CFS)
1	10-20-82	75

GREEN RIVER
Instream Flow 1.25 miles upstream from Big Sandy River confluence

Logarithic Curve

$\hat{y} = -139.029 + 26.437 (\ln X)$

$r^2 = .98$



Appendix B

Habitat Calculation Alternative 1 - Chevron

Upper Reach

9.1	HU/acre at 58.6 cfs (critical period)
-7.8	HU/acre at 48.9 cfs
1.3	HU/acre lost

1.3 HU/acre x 44.7 acres impacted = 58 HU lost
1.3 HU/acre represents 14.3% reduction
9.67 cfs reduction represents 16.5% reduction in critical period flow.

Lower Reach

$$\frac{14.3\% \text{ reduction HU Upper Reach}}{16.5\% \text{ reduction flow}} = \frac{X\% \text{ reduction HU Lower Reach}}{11.8\% \text{ reduction in flow at Lower Reach}}$$

X% = 10.2% reduction in Lower Reach

6.2 HU/acre at Lower Reach x 10.2% reduction = 0.6 HU/acre

0.6 HU/acre lost x 218.7 acres affected = 131 HU lost

Bone Draw

312.6 lb/acre x 1.08 HU converting coefficient x .52 acres = 176 HU in Bone Draw

Spawning Habitat Calculation - Upper Reach

Brown Trout

Discharge	Square feet per 1,000 feet of stream
40	2,332.12
38.1 normal flow	2,220.03
30	1,742.18
28.4 reduction	1,647.5
20	1,150.47

2,220.03 - 1,647.5 = 572.53 ft^2 reduction = 25.8% reduction

Rainbow Trout

Discharge	Square feet per 1,000 feet of stream
80	3,159.21
74.2 normal flow	3,271.52
70	3,352.86
64.5 reduction	3,396.83
60	3,432.81

3,396.83 - 3,271.52 = 125.31 ft^2 increase = 3.8% increase

Green River

37.7 lb/acre at 800 cfs instream flow recommendation
-37.4 lb/acre with 9.67 cfs reduction
0.3 lb/acre reduction x 1.08 HU converting coefficient x 1413.2 acres affected (confluence to Town of Green River) = 458 HU reduction

37.7 lb/acre at 800 cfs
37.1 lb/acre with 9.67 cfs + 9.25 cfs reduction
0.6 lb/acre x 1.08 HU converting coefficient x 299.4 acres affected (Town of Green River to Flaming Gorge Reservoir) = 194 HU lost

HU lost due to Alternative 1

58 upper reach + 131 lower reach + 176 HU Bone Draw + 652 Green River = 1,017 HU lost

Habitat Calculation Alternative 2 - Chevron and Texasgulf

Upper Reach

9.1 HU/acre
-6.6 HU/acre at 41.91 cfs.
2.5 HU lost per acre = 27.5% reduction
2.5 HU/acre x 44.7 acres = 112 HU lost

Lower Reach

$$\frac{27.5\%\text{ reduction HU}}{28.3\%\text{ reduction in flow}} = \frac{X\%\text{ reduction HU}}{20.2\%\text{ reduction in flow}}$$

X% = 19.6% reduction in HU at Lower Reach

6.2 HU/acre x 19.6% reduction = 1.2 HU/acre lost

1.2 HU/acre lost x 218.7 = 262 HU lost

Bone Draw

176 HU lost

Spawning Habitat Calculation - Upper Reach

Brown Trout Discharge	Square feet per 1,000 feet of stream
40	2,332.12
38.1	2,220.03
30	1,742.18
21.5	1,239.20
20	1,150.47

2,220.03 - 1,239.2 = 980.83 ft^2 reduction = 44.2% reduction

Rainbow Trout Discharge	Square feet per 1,000 ft. of stream
80	3,159.21
74.2	3,271.52
70	3,352.86
60	3,432.81
57.6	3,361.29
50	3,131.02

3,361.29 - 3271.52 = 89.77 ft^2 increase = 2.7% increase

Green River

37.7 lb/acre
37.1 lb/acre with 16.57 cfs reduction
0.6 lb/acre reduction x 1.08 x 1413.2 acres = 916 HU reduction

37.7 lb/acre
36.8 lb/acre with 25.82 cfs reduction
0.9 lb/acre reduction x 1.08 x 299.4 acres = 291 HU reduction

HU lost due to Alternative 2

112 upper reach + 262 lower reach + 176 Bone Draw + 1207 Green River = 1757

Habitat Calculation Alternative 3 Chevron Texasgulf and other Trona

Upper Reach

Same HU as Alternative 2
112 HU Big Sandy + 176 HU Bone Draw = 288 HU lost

Lower Reach

4.18 acres above impoundment will have reduced flow
reduced flow results in 1.2 HU lost per acre
4.18 acres x 1.2 HU reduction = 5 HU lost

reservoir will flood 89.2 acres of stream
89.2 acres x 6.2 HU = 553 HU lost

HU loss from 5 cfs release from reservoir

125.7 acres x 6.2 HU = 779 HU lost

1,625 HU lost in Big Sandy and Bone Draw

Spawning Habitat Calculation

Same impact as Alternative 2
44.2% reduction in brown trout spawning habitat
3.8% increase in rainbow trout spawning habitat

Green River

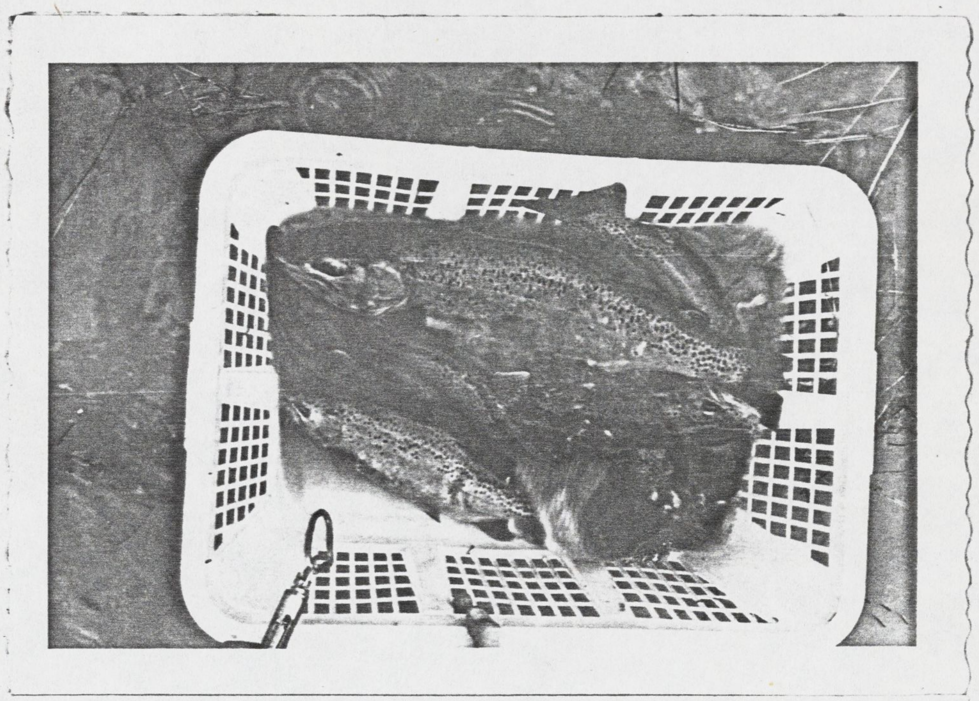
37.7 lb/acre
<u>34.8</u> lb/acre with 81.8 cfs reduction
2.9 lb/acre x 1.08 x 1413.2 acres = 4,426 HU lost from confluence to Town of Green River

37.7 lb/acre
<u>34.5</u> lb/acre with 81.8 cfs + 925 cfs reduction
3.2 lb/acre x 1.08 x 299.4 acres = 1,035 HU lost from Town of Green River to Flaming Gorge Reservoir

1,625 HU Big Sandy and Bone Draw + 5,461 = 7,086 HU reduction

BONE DRAW

THEN (1978)



AND

NOW..

(1983)

ORIGINAL - B.H.S. copy

Big Sandy Resource Area

Bureau of Land Management

Rock Springs District

Bone Draw - Big Sandy River

Fisheries Sampling Report

1981

In 1981, the Wyoming Game and Fish Department issued the BLM a scientific collection permit (No. 35-1981) which permitted the use of electrofishing equipment in monitoring Bone Draw and the Big Sandy River. (Map No. 1) Subsequently, a 1,000 foot transect was established on the Big Sandy River and a 600 foot transect was established on Bone Draw. (Map No. 2) Continued Wyoming Game and Fish Department program coordination provided fish stocks as noted in Table 1.

Table 1. Fish Stocking Record - Bone Draw - 1981

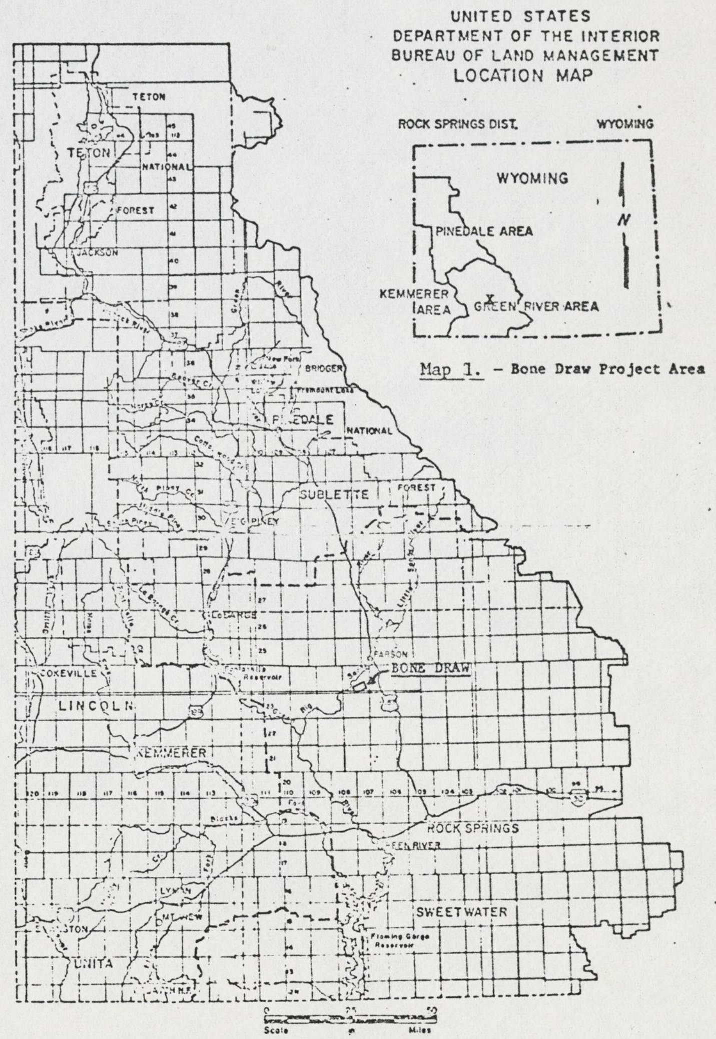
Date	Plant Type	Number	Size	Comments
May 21	Rainbow Trout (Lake McConaughy) (Fingerlings)	2,000	200/lb.	Left Pelvic Fin Clip
September 1	Rainbow Trout (Eagle Lake) (Fingerlings)	2,000	68/lb.	Adipose Fin Clip
November 5	Kokanee Salmon (Eggs)	5,000±		Whitlock Vibert Box Incubation

Electrofishing sample results are depicted in Figures 1, 2, and 3 are discussed below.

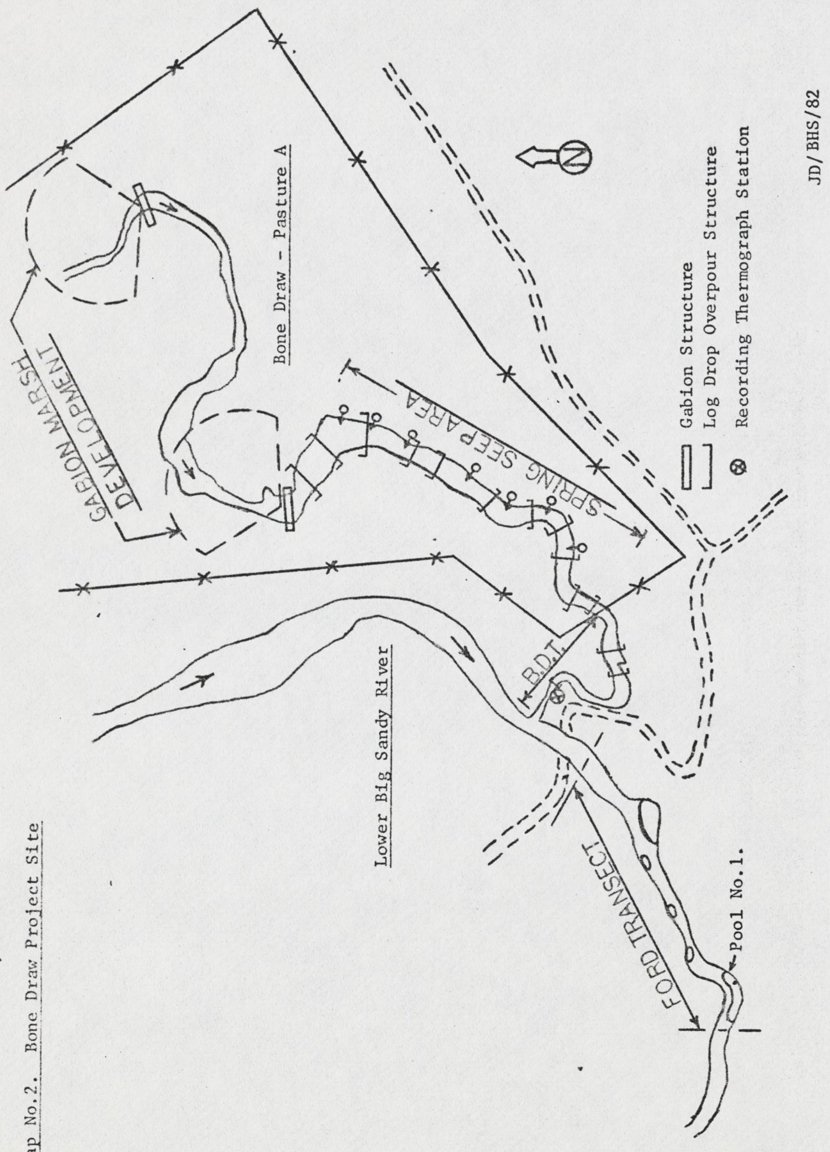
A. Big Sandy Ford (Figure 1)

Background

This transect ran from the vehicle ford of the Big Sandy River, to 1,000 feet downstreams (ending at the tail of the deep pool) adjacent to the high cutbank. Often, it was difficult to obtain more than one assistant. Due to this situation and high conductivity levels (1,000 + uMhos), sampling in the Big Sandy was biased against larger rainbow and brown trout, i.e. Larger fish were difficult to



Map 1. - Bone Draw Project Area



Map No.2. Bone Draw Project Site

capture and usually several escaped, decreasing the sample size by 3-5 fish on the average. To prevent excessive handling and minimize sampling mortality, only total length measurements were taken. Mark/capture estimates were initially attempted by means of a round paper punch in the ventral edge of the caudal fin. Only two marked fish were recaptured as of August 8, so the effort was abandoned. Throughout the season, sampling was conducted on a one pass basis.

Conclusions

In sampling this reach of the Sandy, there appeared to be a considerable amount of seasonal movement (ingress and egress) by not only various species of fish, but sizes as well. All fish were associated with the deeper pools (or pools with bank cover) and several rainbow trout were observed while spawning at the head of pool No. 1 (Map 2) on April 17, 1982.

Rainbow Trout

From the data, it can be seen that while the numbers of rainbow gradually increased into late summer, the average size decreased. With the onset of the fall season, numbers of rainbow declined, but average size once again increased. Very few (two or three) McConaughy or Eagle Lake fish were sampled in the Sandy Ford transect.

Brown Trout

In contrast, brown trout numbers remained relatively constant throughout the summer, however, there was a distinct shift in average size between spring, summer, and fall. While the size data on brown trout is fairly representative, average size and sample size are slgihtly depressed, due to escape of larger fish as noted earlier.

Suckers

Seasonal activity and movements of suckers were the most pronounced of all fish observed. Distinct periods of ingress and egress were noted, with flannel-mouth suckers in the vast majority on May 12th, and mountain suckers in the majority (with very few flannelmouths) on August 27th. A few small suspected bluehead suckers, as well as a few small unknown individuals, were also captured. Surprisingly, in earlier years of the Bone Draw study project, speckled dace, fathead minnows and redside shiners appeared to be relatively abundant. In the 1981 sampling efforts, these fish were conspicuous by their absence.

B. Bone Draw (Figures 2, 3, and 4)

Background

This transect ran from the Bone Draw/Big Sandy confluence, to 600 feet upstream and the exclosure fence crossing of Bone Draw. (Map No. 2) Due to the smaller stream size, sampling was considerably more effective, with a one pass sample being utilized, as well as only length measurements, to minimize sampling mortality. Due to three distinct populations of rainbow trout, plus a population of brown trout, it was necessary to break out the data in four separate analyses. (Figure 2)

Conclusions

There appeared to be a definite ingress and egress of unmarked rainbow (probably past year's egg and fingerling plants) and brown trout. In contrast, the 1981 plants of McConoughy and Eagle Lake rainbow exhibited a strong holding tendency in Bone Draw during their first summer, as evidenced by the minimal capture of these fish in the Big Sandy River. All of this, despite summer water temperatures in excess of 25° C! (Figure 4.) The seasonal responses and impressive growth rates of these fish serve to further illustrate the important significance of smaller, highly productive, tributary streams as rearing and nursery areas. In fact, the natural growth rate of the McConoughy fingerlings in Bone Draw has been almost double the average growth rate in state fish hatcheries! Given the present cost of planting hatchery reared catchable size fish in order to maintain state recreational objectives, and given the value provided by production of fish in Bone Draw, I am confident that fisheries returns alone will have paid for this project's initial capital improvement costs by 1983; a period of only four years.

Unmarked Rainbow Trout

Unmarked rainbow trout sampled in Bone Draw, exhibited a direct correlation to rainbow in the Sandy, in relation to seasonal variations and average size. However, while seasonal movements were closely related, the average size of unmarked rainbow in Bone Draw was approximately 10-15 cm. less, than rainbow in the Sandy. Interestingly however, seasonal variations in numbers of fish were inversely related! i.e. Bone Draw had the greatest number of unmarked rainbow in the spring and fall (probably return of prior egg or fry plants in 1978, 1979, and 1980), while the Sandy experienced the greatest number of rainbows during the summer months. The apparently extensive degree of movement by these fish is also illustrated by the fact that while there is some overlap in size ranges, the smallest average size collected in the Sandy exceeds the largest average size collected in Bone Draw.

McConaughy Rainbow

The most noteable observation of these fish was their impressive growth rate

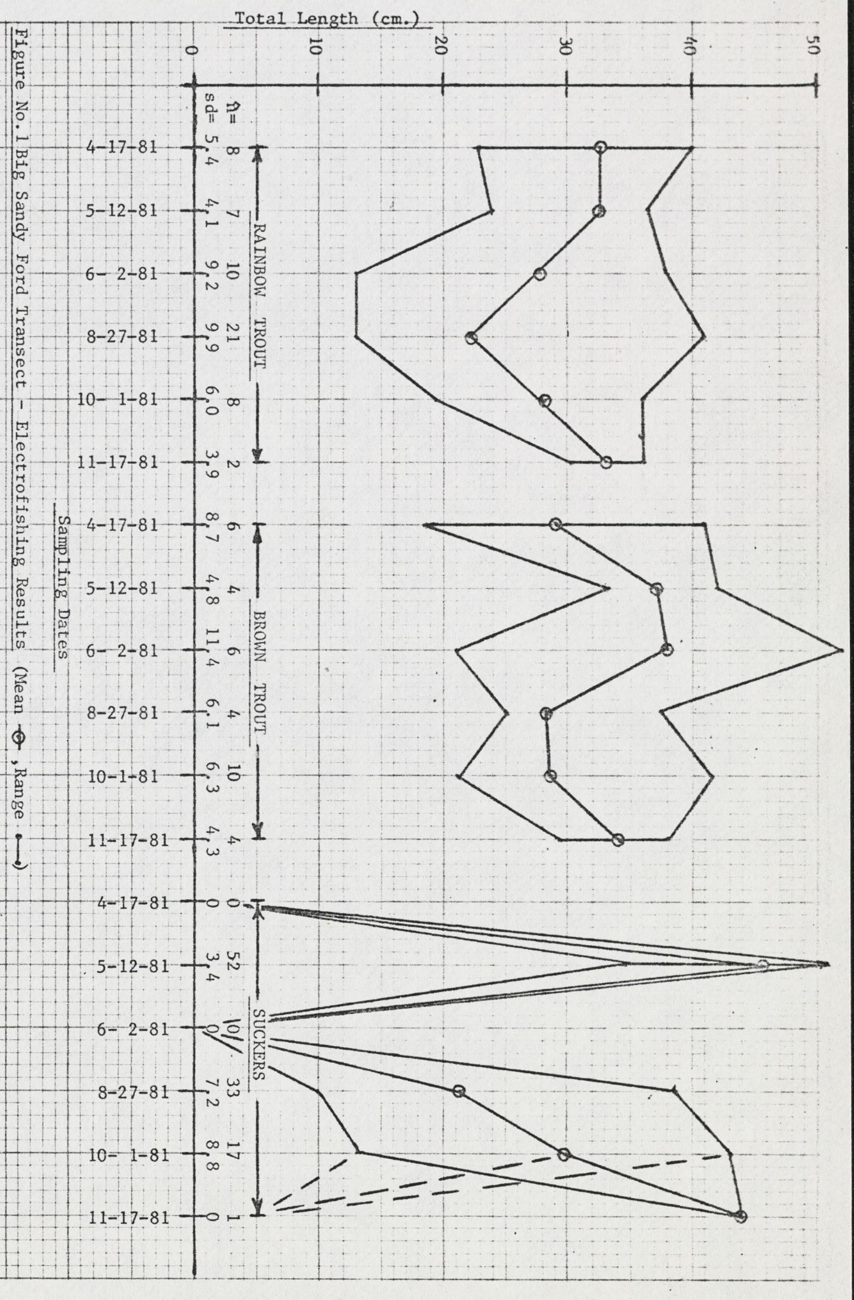


Figure No. 1 Big Sandy Ford Transect - Electrofishing Results (Mean, Range)

BHS/82

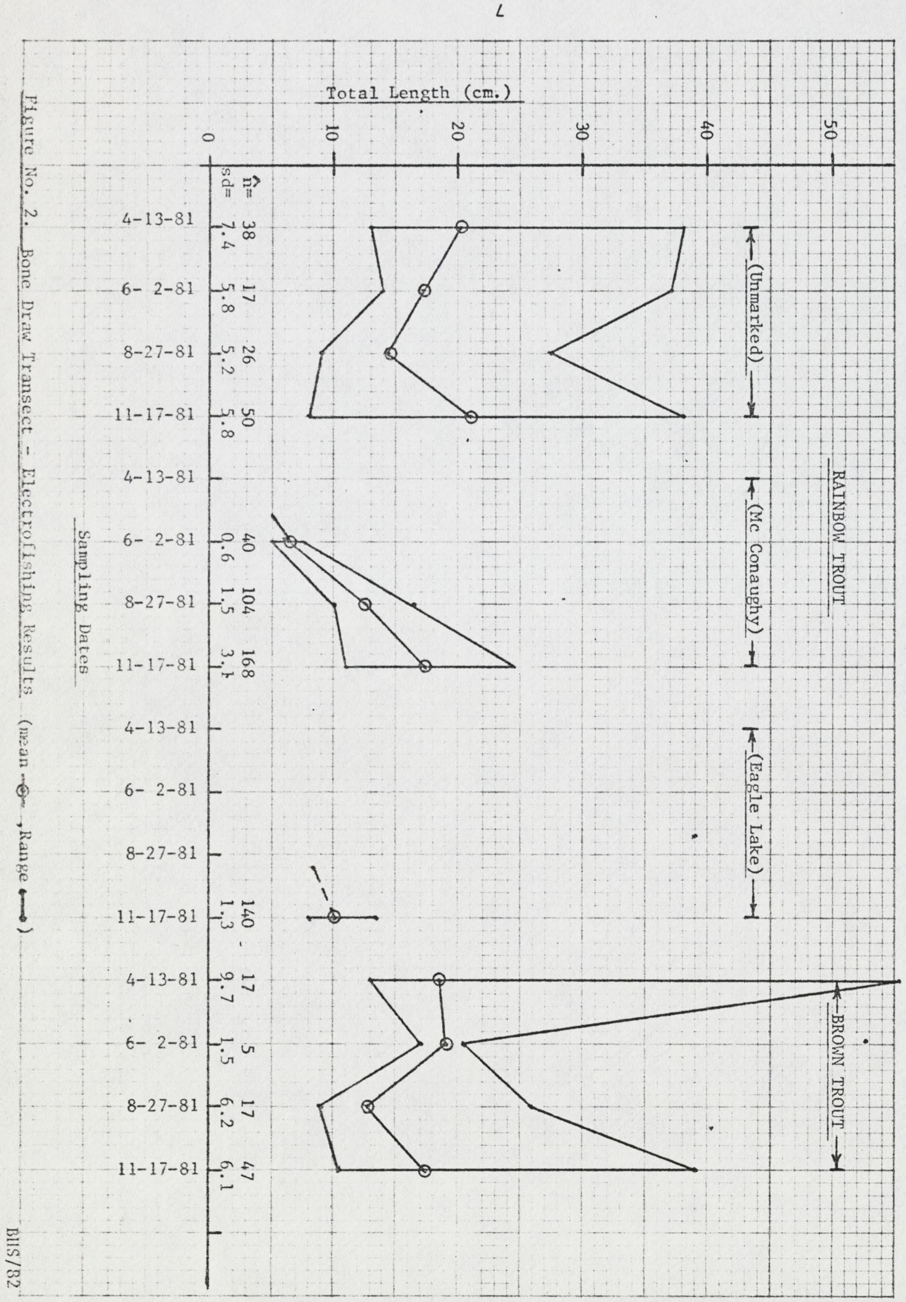


Figure No. 2. Bone Draw Transect - Electrofishing Results (mean -⊖-, Range ●—●)

BHS/82

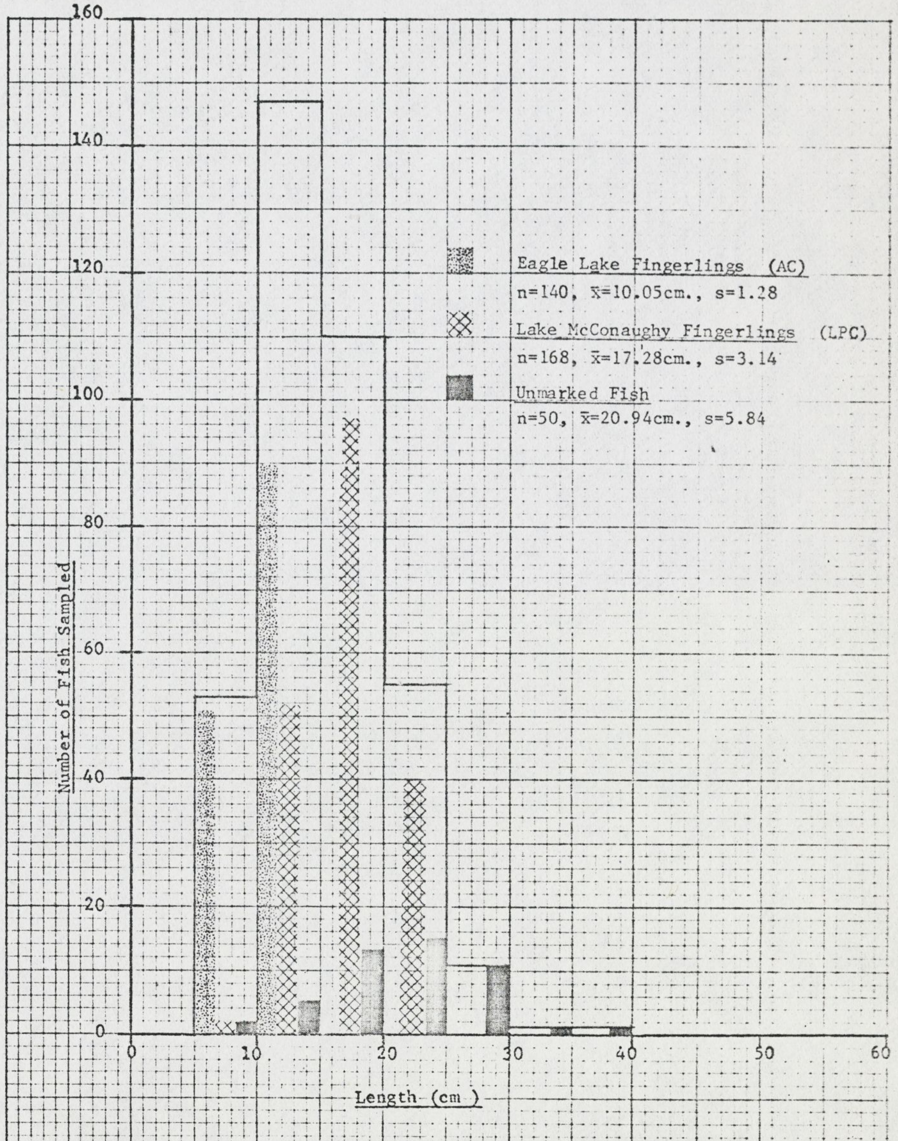


Figure No. 3 Bone Draw Electrofishing Samples -(All Rainbow sampled)
(November 17, 1981)

BHS/82

and high degree of affinity for habitat conditions in Bone Draw. As noted earlier, this natural growth rate was approximately double that generally found in State hatcheries. Warmer water temperatures (Figure 4.) and the high productivity of Bone Draw were probably primary factors, enabling these fish to grow from an average size of two inches (200/lb.) to as much as ten inches, in approximately six month's time. The increasing number of McConaughy rainbow within the transect reach is most likely a function of late season downstream displacement from planting sites 1/4 - 1/2 mile upstream, within the habitat improvement and spring seep areas.

Eagle Lake Rainbow

Eagle Lake fingerlings were planted quite late in the season and exhibited very little growth by the time of our last sampling date. Figure 3, illustrates the relationship of Eagle Lake stocks to both the total rainbow population and the McConaughy and unmarked fish, by the end of the 1981 sampling season.

Brown Trout

Brown trout within Bone Draw showed a similar seasonal trend in average size, to those fish in the Sandy. While average size ranged 10-20 cm. less, there appeared to be a considerably more significant association with habitat or niche differentiation, as related to seasonal ingress or egress in Bone Draw. This is evident by both the greater variation in numbers of brown trout, as well as the greater range and variation in size, at various time of the year. If one were to combine the numbers (one pass sample) of wild brown trout (47) on November 17, 1981, with those of natural return, unmarked, rainbow (50) (not to mention the 308 planted fingerlings) within the 600 foot reach of Bone Draw, this seemingly "insignificant" little stream would, in fact, be considerably more significant than an idealized trout stream such as, say, Huff Creek within the control exclosure, after six years of habitat improvement!

The high degree of community/habitat structure in this small stream is no doubt due to its innate productivity, supported and expanded upon through the habitat improvement accomplishments of the Big Sandy Resource Area and public asistance, in cooperation with Wyoming Game and Fish Department fingerling stocking support.

Kokanee Salmon Eggs

On November 5, 1981, approximately 5,000 Kokanee salmon eggs were provided by and planted with WGF Area 4 Fish Division Personnel, in Whitlock Vibert boxes. These boxes were wired together and placed in groups of two or four, on the stream bottom, with a large rock placed on top. By January 19, 1982 numerous eggs could be seen to be weakly eyed, but sedimentation by fine organic matter was extensive. Charged with approximately 500 eggs per box, several boxes had experienced a high (50-75%) mortality by this time.

On March 15, 1982, the eggs were checked once again, with WGF Area 4 personnel assisting. At this time, most surviving eggs (approximately 10%) were strongly eyed. Despite further extensive sedimentation, several boxes were found to contain one or two dozen sac fry, which were released into Bone Draw by hand.

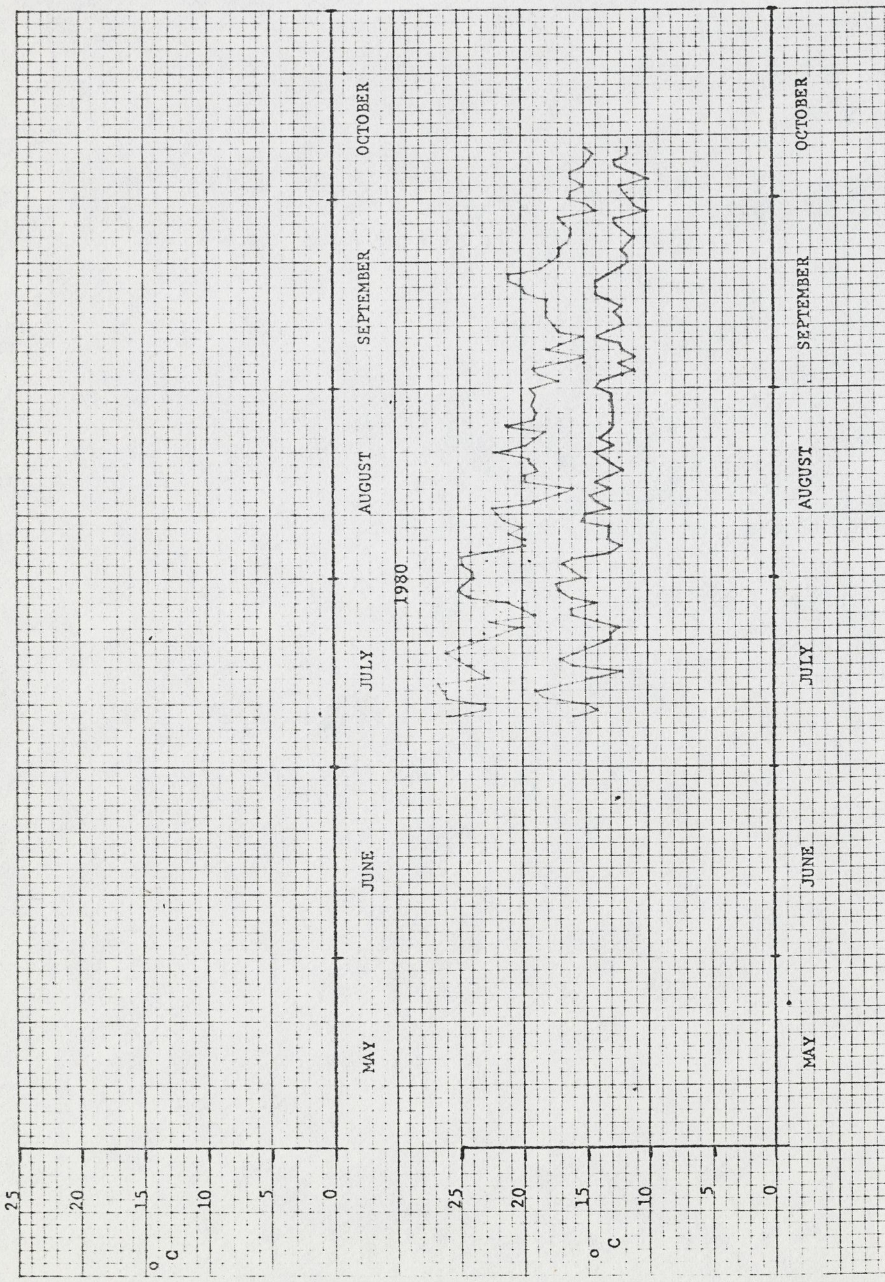


Figure No. 4. THERMOGRAPH RECORD - Bone Draw - 1982

All parties agreed that while Kokanee showed promise in Bone Draw, a more successful approach should be investigated. (i.e. Small hatching troughs fed directly from spring seeps or, sac fry, swim up fry, or fingerling plants.)

Summary

Since its inception in 1976 as an idea for a riparian improvement study and public demonstration project, I believe the Bone Draw project has been an unquestionable success.

The ongoing implementation and management of this project by Big Sandy Resource Area personnel and their extensive efforts to incorporate cooperative information and education projects with the Izank Walton League, Sweetwater County Wildlife Association, Boy Scouts of America, local school system science classes, as well as continued cooperation with and assistance from Wyoming Game and Fish Department personnel are primary reasons for this projects accomplishments to date. (Not only for fisheries habitat and management, but for riparian restoration, wildlife habitat improvement, rangeland improvement and recreation development as well.)

To date, it is my opinion that the original aquatic objectives and goals of this project have been achieved. In this light, I propose the following aquatic recommendations for consideration in the future management of this project.

Recommendations

1. Insofar that the initial aquatic habitat and fisheries study objectives of this project have been met, I recommend that fisheries study and monitoring efforts by Bureau personnel be terminated.

2. Insofar that fisheries aspects of the Bone Draw project have passed from a study to a management stage, the fisheries population management objectives of this project are now within the area of responsibility of the Wyoming Game and Fish Department. I, therefore, recommend that:

   a. The Big Sandy Resource Area continue to request a spring and fall plant of fish from the Wyoming Game and Fish Department in order to perpetuate this project's beneficial returns to the American public.

   b. The Big Sandy Resource Area initiate a written agreement in FY83' with the Wyoming Game and Fish Department, to define and clarify habitat and wildlife management objectives and responsibiilties for the next five years, on the Lower Sandy project (including Bone Draw). In addition to updating management goals and strategies for the lower Big Sandy River, this action will initiate a cooperative Sike's Act programatic approach, ensuring a more stable program base in coming years.

Bruce H. Smith
April 1982

Bruce H. Smith
District Fisheries Biologist

Bone Draw Improvements
Fall 1982 Update

The Bone Draw Gabion wiers are working very effectively in retaining water, reducing downstream silt and providing streambank recharge. The structures appear to have improved stream flows and habitat conditions. A large musk-rat lodge has been built above each wier and the rodents are actively work-ing on the riparian vegetation.

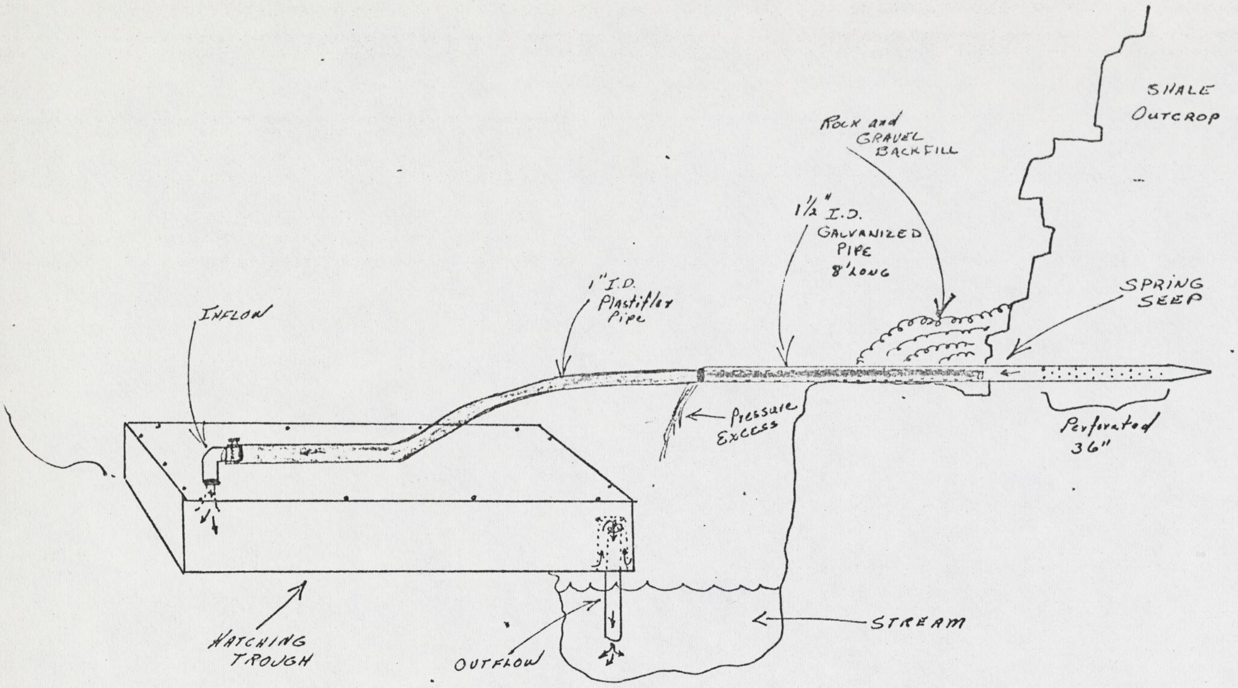
One of the two log drops severely damaged by livestock was repaired with all but one log drop now functioning properly. Several-thousand small trout now occupy cover in the small stream.

In keeping with improved habitat, the resource area constructed a hatching box from surplus materials. An 8 ft. piece of 1½" galvanized pipe was cut to a chisel point and welded. The pipe was then perforated with 5/8" holes placed each 2" apart in staggered lines to a distance 36" back from the point. (See illustration 1). This pipe was driven into an active spring along Bone Draw. A reduction collar to choke the water from 1½" to 1" diameter was attempted but high water pressure flowing out of the pipe made this task difficult. A 10' piece of black plastic pipe was inserted into the galvanized pipe and excess water allowed to flow into the creek. The plastic flex pipe was coupled to a 90° elbow and mounted to the lid of the hatching box.

The hatching box was made from a discarded metal bookcase. Seams were seal-ed with silicone sealant and scrap plexiglass (¼" Thickness) used to divide the box into a continuous raceway. (See illustration 2). A plexiglass splash pan was mounted with silicone to 3½" below the water intake 90° el-bow. Plexiglass dividers were placed 6½" apart and plexiglass baffels mount-ed randomly down the raceway. The baffels direct waterflows under and over them, giving a mixing action to the current. A 4" P.V.C. section 9" long was mounted at the outflow corner and holes cut into the bottom of the P.V.C. An 18" section of 2" p.v.c. was used for outflow and inserted through the bottom of the box into the 4" p.v.c. a distance of 8". The outflow empties directly into the creek about 4" below the stream surface. Bubbling action from the outflow and warmer spring water should keep an ice free area at the box outflow.

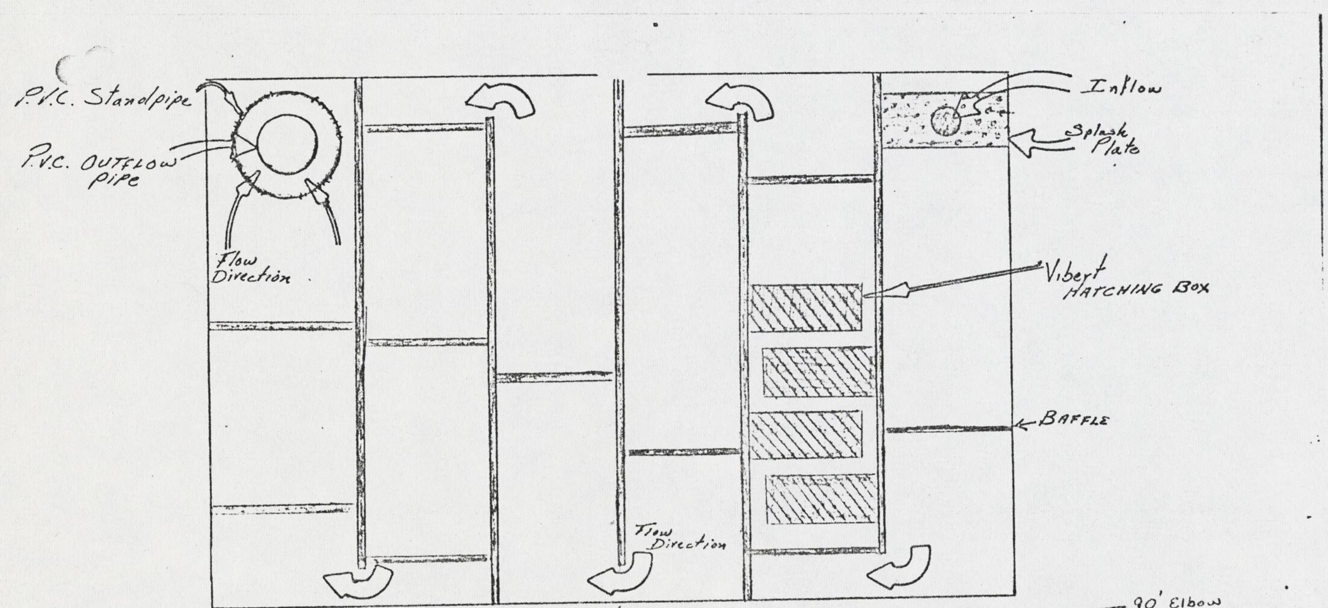
A follow up check 12 days after installation found the facility working as it should. Thirteen Vibert hatching boxes were weighted with stones and placed in the raceways of the hatching facility. The facility should easily handle 30 or more vibert boxes and 15,000 trout eggs. With the facility completed it only awaits use by the Wyoming Game and Fish Department.

J. Dunder

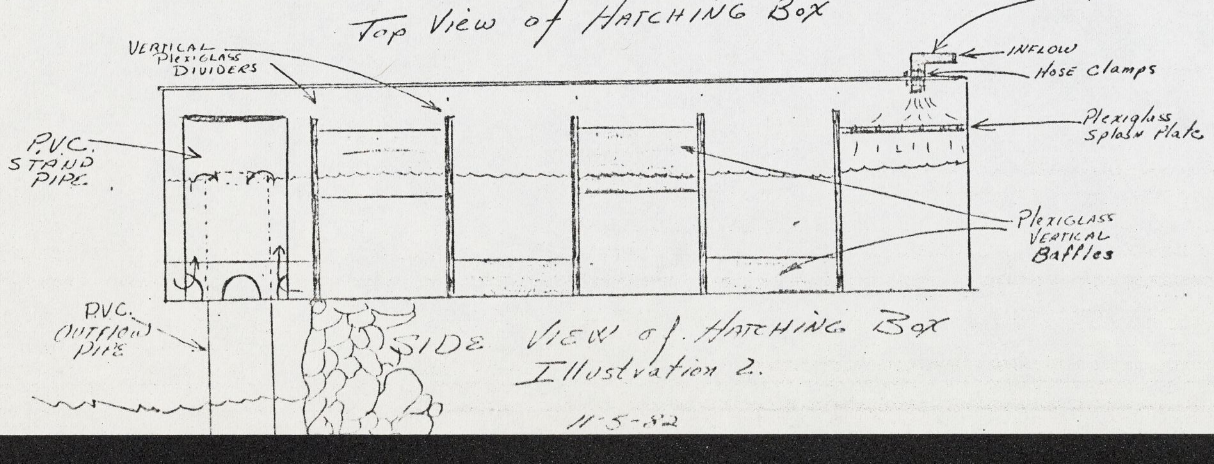


TROUT Egg HATCHING facility ON BONE DRAW

11-5-1982
by J. DUNDER
Illustration 1.



Top View of HATCHING BOX



SIDE VIEW of HATCHING BOX
Illustration 2.

11-5-82

Bureau of Land Management
P.O. Box 1869
Rock Springs, Wyoming 82901

Trout Egg Hatching Response To Small Off-Stream Hatching Box

James Dunder

Abstract: A 3½' X 4' trout egg hatching box was designed and installed at a developed spring on Bone Draw in southwestern Wyoming. A successful hatch of more than 90 percent of the brown trout (Salmo trutta) eggs resulted, through use of Whitlock Vibert hatching boxes used in the small facility.

Since 1977 the Bureau of Land Management (BLM) has used a variety of methods, structures and materials to enhance sport fish rearing habitat on a tributary stream to the Big Sandy River. Aquatic habitat on Bone Draw has favorably responded to the improvements through greater stream cover, reduced siltation, higher average stream flows, greater quantity and varity of aquatic invertibrates and yearlong habitation by trout.

Methods

A Kokanee salmon (Oncorhynchus nerka) egg plant was made in the fall of 1981, using Whitlock Vibert boxes placed in the stream with overhead shading. Instream planting of the boxed eggs resulted in poor hatching success because of several uncontrolled environmental factors.

In November of 1982, a small off-stream hatching facility was improved using an old metal bookcase, scrap plexiglass and plywood and lengths of P.V.C. and flexpipe. A two-inch diameter perforated steel pipe was driven into a seep to supply a silt-free water source. The entire facility was designed so environmental conditions could be managed with greater control.

Spring water piped into the box maintained a temperature of 46° F (± 2° F). A small quantity of sand was moved out of the spring pipe for the first two or three weeks. No further sand was noted after the initial flushing.

On 1 December, 1982, the Fisheries Division, Boulder Hatchery, Wyoming Game and Fish Department notified the BLM that 5,200 brown trout eggs were available at the Flume Creek Hatching facility and ready for planting. The heavily "eyed" eggs were trucked to Bone Draw and distributed between 14 Vibert boxes. Two stones were placed in the lower compartment of each box to prevent floating. Since only four teaspoons full of eggs were placed in each box, we felt that fungus spread would be minimal.

Results

An exam of the facility on December 10 found only a few eggs hatched, but the structure was functioning as designed. No evidence of fungus growth was noted. Re-examination on December 30 found most of the eggs hatched and several thousand sac-fry, free swimming outside the Vibert boxes and in the raceway. As the fry became active and moved about near the outflow, the current swept them up and through the ouflow pipe into the creek. Unfortunately, several large trout have congregated in the stream reach near the hatching box. Predation on the young trout may prove significant if the adult and subadult trout are not relocated.

Discussion

The project was successful enough that the BLM plans similar hatching facilities in other suitable locations. The addition of sorted pea-gravel to the floor of the hatching box would benefit the fry in providing refuge and reduce crowding. The present facility can easily handle 15,000 or more eggs without crowding them in the Whitlock Vibert boxes. Resident predaceous fish should be relocated to the lower log drop and a ½" mesh wire barrier placed across Bone Draw until swim-up fry are large enough to fend for themselves. A "T" coupling should be placed in the spring pipe for dividing water flows into the existing facility and possibly an additional similar structure. Following additional tests of similar small facilities, maintenance and operation should be assumed by the Wyoming Game & Fish Department through cooperative agreement.

THE STATE OF WYOMING

ED HERSCHLER
GOVERNOR

RECEIVED
BLM ROCK SPRINGS
DISTRICT
NOV 17 '82

Game and Fish Department

CHEYENNE, WYOMING 82002

W. DONALD DEXTER
DIRECTOR

November 15, 1982

OPER
ADM SP
SO
P & E SW
RES PINE

TO: Mike Reese

FROM: Allen Conder, Tom Annear

COPIES: Mike Stone, Don Miller, Glen Dunning, Dave Dufek, John Mueller, Bruce Smith, Cliff Franklin

SUBJECT: Progress Report on WWDC Projects

Town of Encampment 5082-09

We received a letter from Evan Green WWDC with the request to terminate any further work on the Encampment study. Field data collection and analyses had been completed prior to the request for termination. We plan to prepare a report to the WWDC on the work that was conducted prior to the letter.

Population estimates were obtained on the North Fork Encampment River, Willow Creek and Beaver Creek.

	Trout/mile	Pounds/acre	Species
NF Encampment River	1056	38.8	Brook, Brown, Rainbow
Willow Creek	1491	73.2	Brook, Brown, Rainbow
Beaver Creek	749	33.3	Rainbow

City of Rawlins 5082-09

Field data collection and analysis have been completed on Sage Creek. The level one report on the project is being prepared. This report will contain level II type information on Sage Creek which was funded by the BLM.

Kemmerer 4082-09

Population estimates were obtained from the two study reaches on the Ham's Fork River. Brown trout redds were observed at the upper site below Kemmerer City Reservoir.

Site	Trout/mile	Game fish/mile
Below Kemmerer City Reservoir	878	1095
Below Diamondville	No game fish were captured*	

*Past sampling efforts have found brown trout in the river below Diamondville.

The report on the project is being prepared. The report will contain level II type of information on the Ham's Fork River which was funded in part by the BLM.

Big Sandy 4082-09

Field data collection has been completed for this season. If possible, another sampling attempt will be made next spring to determine if rainbow trout migrate into the river to spawn in the spring. A report is being prepared based on the data collected to date.

A population estimate was made on Bone Draw yielding an estimate of 2046 trout/mile and 312.6 pounds per acre. Brown trout spawning activity was noted in the Big Sandy River in the Bone Draw area.

Buffalo 3082-09

The level I report is being prepared on the five reservoir sites. A meeting was held to discuss various methodologies with the Forest Service and Fish and Wildlife Service. The Forest Service is preparing a report including flow regimes for channel maintenance which will be used in conjunction with the instream flows for fisheries.

Powder River 3082-09

A draft level I report has been prepared which is being reviewed by our personnel. This report contains fact sheets on the various streams which maybe impacted by the project and our concerns for the project. This type of information is all that can be provided until more information is available on the project.

600ft.

Bone Draw Electrofishing Sample

Personnel: Apple, Dunder, Dufek, Smith

600 ft. BS → fence

one pass

Date: 4/19/83

Bone Draw water temp. 10°C

Big Sandy water temp. 5°C

"O" clip given fish ≥6" only

"X" clip (15cm) present

Species	Length (cm)	Weight (gms)	Pectoral fin clip L	Pectoral fin clip R	Pelvic fin clip L	Pelvic fin clip R	Caudal fin clip Top	Caudal fin clip Bottom	Adipose fin clip	Sex
Rainbow	36.5	590	O		X					♂
R	48.5	1.4 Kg	O							♂
R	32.5	385	O		X					–
R	31.0	320	O							–
R	32.5	390	O		X					–
R	43.0	900	O							♂
R	23.4	45	O		X					–
R	24.8	175	O						X	♂
R	21.3	110	O		X					–
R	18.3	70	O		X					–
R	19.5	85	O		X					–
R	18.8	75	O							–
R	21.0	110	O		X					–
R	15.0	40	–		X				X	–
R	18.0	85	O		X					–
R	22.0	120	O		X					–
R	14.0	40	~~O~~		X					–
R	15.5	50	O		X					–
R	15.2	40	O		X					–
R	14.0	30	–						X	–
R	14.8	35	–						X	–
R	18.2	70	O		X					–
R	15.0	40	–		X					
R	11.4	15	–						X	
R	15.0	40	–						X	
R	13.6	25	–						X	
R	14.0	30	–						X	
Fathead (6)	–	–			–	–			–	
Sculpin	12.5	35	–						–	
R	18.5	80	O						X	
R	12.5	20	–						X	
R	9.5	10	–							
R	~~[illegible]~~ 13.0	30	–						X	
R	12.0	20	–						X	
R	13.7	30	–						X	
R	9.5	10	–						X	
R	12.4	20	–						X	
R	12.4	20	–						X	
White Sucker	13.1	25	–						–	
Speckled Dace	9.7	10							–	
Fathead minnow	–	–							–	

Big Sandy up to level of last Bone Draw log drop spiked - full bank flow & turbid. Large Rbws (15-18") at silt cloud fringe in confluence of Sandy & Bone Draw. (Using turbidity for cover)

BONE DRAW ELECTROFISHING SAMPLE

PERSONNEL:

DATE: 4-19-83

BONE DRAW WATER TEMP. —

BIG SANDY WATER TEMP. —

0 = Fin clip

Conductivity: Bone D. 3500 umhos; Big S. 1,000

SPECIES	LENGTH	WEIGHT	PECTORAL FIN CLIP L	PECTORAL FIN CLIP R	PELVIC FIN CLIP L	PELVIC FIN CLIP R	CAUDAL FIN CLIP TOP	CAUDAL FIN CLIP BOTTOM	ADIPOSE FIN CLIP	SEX
R	8.4	5							X	—
R	15.0	35							X	—
R	13.0	36							X	—
R	15.5	40	0		X					—
R	20.4	11.0	0		X					—
R	19.3	90	0		X					—
R	20.8	110	0							—
R	22.7	95	0						X	—
R	19.5	90	0		X					—
R	17.0	60	0		X					—
R	16.7	60	0		X					—
R	14.0	25	—		X					—
R	14.3	30	—						X	—
R	13.0	25	—						X	—
R	9.0	10	—						X	—
R	13.8	40	—						X	—
R	11.8	20	—						X	—
R	14.0	30	—						X	—
R	12.3	20	—						X	—
R	11.7	10	—						X	—
R	11.0	10	—						X	—
R	13.5	25	—						X	—
R	9.1	10	—						X	—
R	15.0	40	—						X	—
R	16.2	50	0		X					—
R	12.5	20	—						X	—
R	11.8	10	—						X	—
R	10.5	10	—						X	—
R	14.0	30	—						X	—
R	8.0	10	—		—		—	—	—	—
R	10	10	—		—		—		X	—
R	8.6	5	—		—		—		X	—
R	11.9	20	—		—		—		X	—
R	11.3	15	—		—		—		X	—
R	10.4	10	—		—		—		X	—
Brown	11.8	20	—		—		—		—	
R	21.5	110	0		X					—
R	18.2	60	0		X					
R	39.7	590	0		—		—		—	♂
R	42.2	760	0		—		—	—	—	♀
R	17.0	60	0		X					
R	31.6	360	0		X					
R	16.5	65	0		X					
R	26.7	260	0		—		—	—	—	♂
R	35.5	430	0		—		—	—	—	—
R	17.7	70	0		X					♂
R	27.5	230			X					

BONE DRAW ELECTROFISHING SAMPLE

DATE: 4-19-83

PERSONNEL:

BONE DRAW WATER TEMP. —

BIG SANDY WATER TEMP. —

SPECIES	LENGTH	WEIGHT	PECTORAL FIN CLIP L	PECTORAL FIN CLIP R	PELVIC FIN CLIP L	PELVIC FIN CLIP R	CAUDAL FIN CLIP TOP	CAUDAL FIN CLIP BOTTOM	ADIPOSE FIN CLIP	SEX
R	21.5	110	0		X					
R	15.5	50	0						X	
R	18.5	70	0		X					
R	14.5	30	—						X	
R	17.5	60	0							
R	16.6	35	0		X					
R	13.2	20	—		X				—	

BONE DRAW ELECTROFISHING SAMPLE (1 of 3)

DATE: 4-22-82

PERSONNEL: DUNDER, LOWE 4/22/83
SMITH

BONE DRAW WATER TEMP. 8°C
BIG SANDY WATER TEMP. 7.5°C

600 FT.

0 Fin clip given
X Fin clip present

Species	Length (CM)	Weight (GM)	Pectoral fin clip L	Pectoral fin clip R	Pelvic fin clip L	Pelvic fin clip R	Caudal fin clip Top	Caudal fin clip Bottom	Adipose fin clip	SEX
R	45.5	880					0			♂
R	35.5	510			X		0			♂
R	32.5	420			X		0			♂
R	20.0	80			X		0			—
R	42.0	685			X		0			♀
R	45.5	1100					0			♀
R	32.0	420			X		0			♂
R	52.5	1700					0			♂
R	43.5	800					0			♂
R	34.5	500			X		0			♀
R	38.0	590					0			♂
R	18.5	[illegible]	X		X		0			—
R	15.5	50					0		X	—
R	11.5	20							X	
R	10.5	15							X	
R	12.0	20			X					
R	39.5	650				X	0			
White sucker	32.5	43[illegible]								
R	41.[illegible]	600					0			
W/Sucker	31.[illegible]	300								
R	16	50					0			
R	33.5	43[illegible]	[illegible] #654				0			
R	23.0	105	X		X					
R	42.0	670					0			♂
R	14.0	30								
R	12.0	20								
R	14.0	30								
R	11.0	15								
R	25.5	170			X		0			
R	21.5	120			X		0			
R	10.5	20					0		X	
R	15.0	50			X					
R	33.0	590					0			♂
R	41.5	650					0			♀
R	21.0	100	X							
R	15.5	30			X		0			
R	16.0	40			X					
R	20.0	80					0			
R	44.0	750					0			
R	42.5	[illegible]								
R	14.0	30								
R	28.5	280	X		X		0			♂
R	23.5	120			X		0			
R	22.0	100			X					
R	17.5	50	X		X		0			

BONE DRAW ELECTROFISHING SAMPLE (2 of 3) DATE: 4-22-83

PERSONNEL:

BONE DRAW WATER TEMP. —

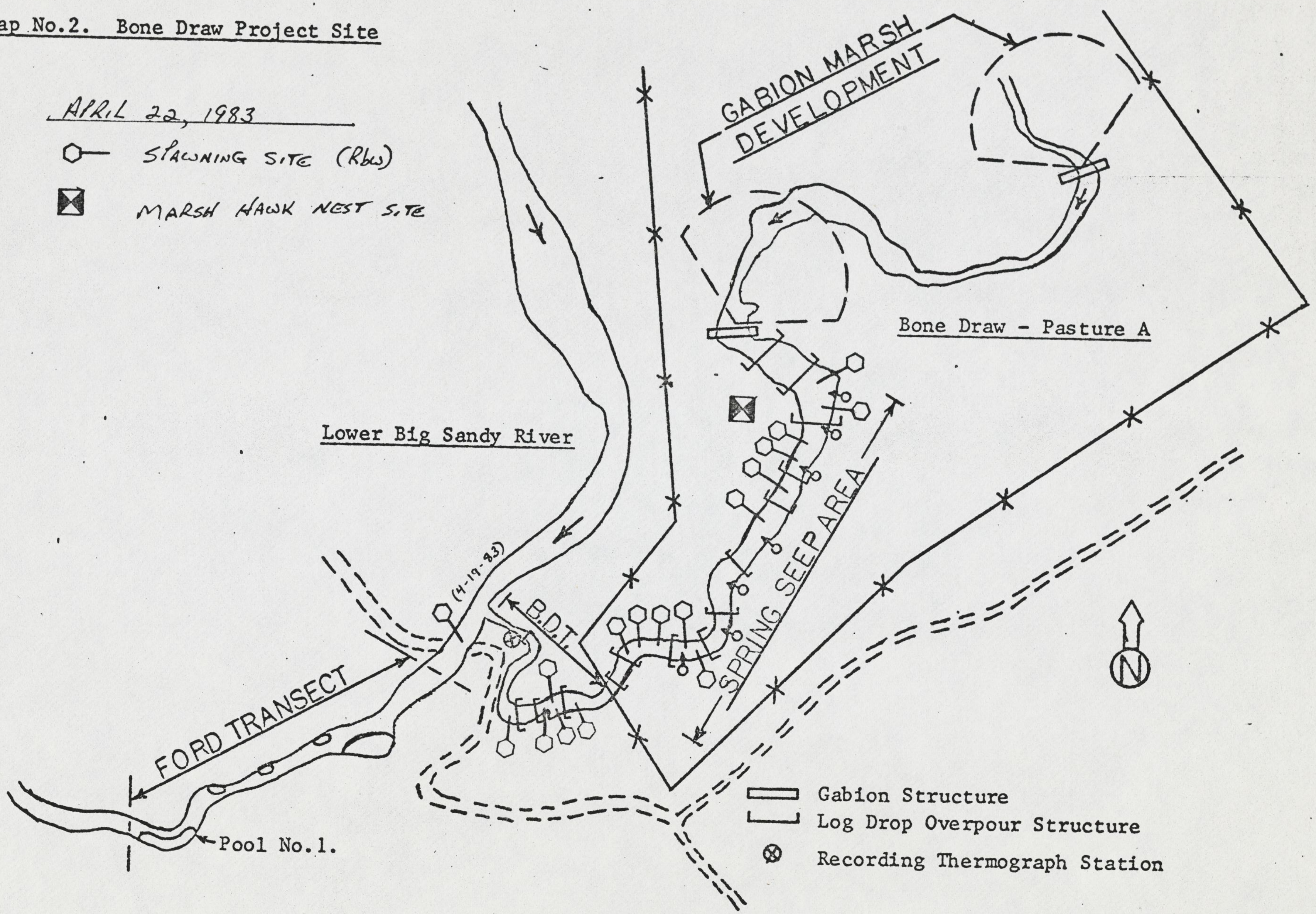
BIG SANDY WATER TEMP. —

SPECIES	LENGTH	WEIGHT	PECTORAL FIN CLIP L	PECTORAL FIN CLIP R	PELVIC FIN CLIP L	PELVIC FIN CLIP R	CAUDAL FIN CLIP TOP	CAUDAL FIN CLIP BOTTOM	ADIPOSE FIN CLIP	SEX
R	20.0	95	X		X		O			—
R	14.5	40			X		—			—
R	19.5	70			X		O			
R	12.5	20					—		X	
R	24.0	160			X		O			
R	20.0	90					O		X	
R	14.0	30					—			
R	17.5	55			X		O			
R	19.5	80			X		O			
R	16.5	60					O		X	
R	13.5	30					—		X	
R	19.0	[illegible]			X		O			
R	15.5	[illegible]					O		X	
R	13.5	35					—		X	
R	17.5	[illegible]			X		O			
R	15.0	60			X		O			
R	13.0	[illegible]			X		—			
R	[illegible]	[illegible]			X		O			
R	19.5	[illegible]			X		O			
R	14.5	30					—		X	
R	18.0	[illegible]					—		X	
R	16.0	40			X		—			
R	11.5	20					—			
R	11.5	20					—		X	
R	14.0	[illegible]					—		X	
R	10.5	[illegible]							X	
R	17.0	50			X		O			
R	11.5	[illegible]					—		X	
R	15.0	40			X		O			
R	14.5	40			X		—			
R	13.0	30							X	
R	13.0	20							X	
R	09.0									
R	29.0									

Big Sandy Res. spilling.
River in flood - 20" over last
Drop-log on Bone Draw.
Tough to access first 150 ft. due
to high water & deep holes.

Generally speaking, there were a pair of spawning size RBW in each run/pool reach of Bone Draw up to termination of the spring redds. Spawning activity & the indications of disturbance (ie redds) are noted on page 3.

Map No.2. Bone Draw Project Site



3 of 3.

JD/BHS/82

600 ft.

BONE DRAW ELECTROFISHING SAMPLE

PERSONNEL: Eyre, Smith, DUNDER

DATE: MAY 3-83

BONE DRAW WATER TEMP. 8.~°C

BIG SANDY WATER TEMP. 4.~°C

Big Sandy Normal & muddy (3.7-4.2 CFS flow)? NOT GAGED

Bone Draw milky Translucent - Turbid.

X-CLIP PRESENT

O-CLIP GIVEN

SPECIES R=Rbw	LENGTH CM	WEIGHT GMS.	PECTORAL FIN CLIP L	PECTORAL FIN CLIP R	PELVIC FIN CLIP L	PELVIC FIN CLIP R	CAUDAL FIN CLIP TOP	CAUDAL FIN CLIP BOTTOM	ADIPOSE FIN CLIP	SEX
R	20.0	10.5						O		
R	18.5	6.5						O	X	
R	16.5	5.0			X			O		
R	12.5	2.5						-	X	
FATHEAD MINNOWS	MANY									
R	39	680						O		♂
MISSED - 4 Rbw										
R	12.5	20						-	X	
Redside Shiners										
R	9.0	10						-	-	
R	48.0	980						O		♀
R	33.0	385			X		X			♂
R	12.5	20						-	X	
R	11.0	10						-	X	
MISSED 3 R										
Speckled dace										
Fathead minnows										
R	36.0	580	X		X			O		♂
R	11.5	20						-	X	
R	11.5	20						-	X	
R	31.5	420						O		♂
R	20.5	100			X			O		
R	12.5	20						-	X	
R	10.9	15						-	X	
R	13.5	25.0						-	X	
R	13.5	20.0	(3 pelvic fins)							
R	14.0	30						-	X	
R	11.5	20						-	X	
R	8.5	10			X			-	.	
R	17.0	60			X			O		
R	15.5	40					X	O	X	
R	17.0	60	X		X			O		
R	13.5	25						-	X	
R	17.0	50					X	O	X	
R	12.5	25			X			-		
R	12.5	25							X	
R	9.5	10								
R	15.0	35			X			-		
R	14.0	30							X	
R	16.0	50			X		X	O		
					~~X~~		~~X~~	~~O~~		
R	13.5	20							X	
R	14.5	45			X					
R	38.5	560			X			O		♂
R	14.0	3.0							X	
R	15.0	35			X					
R	9.7	10							X	

BONE DRAW ELECTROFISHING SAMPLE

PERSONNEL: DUNDER - Eyre - Smith

DATE: May 3-83

BONE DRAW WATER TEMP. —

BIG SANDY WATER TEMP. —

SPECIES	LENGTH	WEIGHT	PECTORAL FIN CLIP L	PECTORAL FIN CLIP R	PELVIC FIN CLIP L	PELVIC FIN CLIP R	CAUDAL FIN CLIP TOP	CAUDAL FIN CLIP BOTTOM	ADIPOSE FIN CLIP	SEX
R	15.5	45			X			0		
R	17.0	50			X		X	0		
R	13.7	30						-	X	
R	34.0	340						0		♂
R	34.0	430						0		♂
R	36.0	535						0		♀
R	23.0	120			X			0		
R	39.0	530	X					0		♂
R	20.0	80			X			0		
R	37.0	550			X			0		♀
R	34.0	385						0		♂
Eggs R	43.0	750								♀
R	19.5	80			X			0		
R	45.5	920					X			♀
R	41.5	780					X			♂
R	27.0	200		X	X			0		[illegible]
R	41.0	650						0		♂
R	27.0	235			X			0		
R	17.0	50			X			0		
R	18.0	55			X			0		
R	16.5	45							X	
R	51.5	1650					X	0		♂
R	[illegible].5	50			X					
R	19.0	75			X		X	0		
R	17.5	60			X			0		
R	13.0	70			X			0		
R	11.5	15						-	X	

Big Sandy R. flow dropped down to point where a few mid stream bars are visible. ie. 1ft → 2.5ft. deep. Still highly turbid. Bone Draw w/ irrigation return flow & slightly turbid, but fast & spilling over full width of log drops, (2" → 3" head). Taylor Max/Min thermo. set in lower B. Draw & Big Sandy R. Several (≥ 6) grayling & 3 or 4 Rbw observed spawning all the way up to 1st. gabion.

BE

600 ft.

BONE DRAW ELECTROFISHING SAMPLE Page 1/2 DATE: 5/10/83

PERSONNEL: Apple - Smith - DUNDER - Branchwein

BONE DRAW WATER TEMP. 10°C
BIG SANDY WATER TEMP. 11°C

0 CLIP GIVEN
X CLIP PRESENT

clear day 54°F
Bone Draw water almost clear

– Right Pectoral fin clip = 0

SPECIES	LENGTH (CM)	WEIGHT (GM)	PECTORAL FIN CLIP L	PECTORAL FIN CLIP R	PELVIC FIN CLIP L	PELVIC FIN CLIP R	CAUDAL FIN CLIP TOP	CAUDAL FIN CLIP BOTTOM	ADIPOSE FIN CLIP	SEX
R	38.5	610		0	–	–	–	–	–	♂
R	26.5	230		0	X					
R	30.0	250	X	0						♂
R	17.5	70		0	X					
R	19.0	70		0	–	–	–	–	–	
R	11.25	20		–					X	
R	10.5	20		–					X	
R	9.0	10		–					X	
R	10.5	20							X	
R	10.0	10							X	
Fathead	minnows	many								
Redside	shiners	some								
R	12.0	25								
R	14.5	40			X					
Sculpin	14.0	40								
R	13.0	20							X	
R	11.5	40							X	
R	10.0	10								
R	15.0	40		0	X		X			
R	10.0	10							X	
R	13.5	30							X	
R	13.0	25							X	
R	13.0	30							X	
R	12.0	20			X		X	X	X	
R	17.0	70		0	X			X	X	
R	17.0	80		0	X			X	X	
R	17.0	75		0			X	X	X	
R	13.0	30			X					
R	17.5	70		0	X			X		
R	8.5	10			X					
R	17.0	70		0	X			X		
R	10.5	20							X	
R	11.0	30							X	
R	18.0	80		0	X			X		
R	13.0	30							X	
R	14.0	50							X	
R	10.0	15							X	
R	13.5	50							X	
R	13.0	20							X	
R	12.0	20							X	
R	11.5	20							X	
R	13.5	30							X	
R	9.5	10							X	
R	11.0	20							X	
R	9.5	10							X	
R	16.0	65		0						
R	19.0	90		0	X					

BONE DRAW ELECTROFISHING SAMPLE Pg 2 of 2 — DATE: 5/10/83

PERSONNEL: Dunder, Smith, Apple, [illegible]

BONE DRAW WATER TEMP. —

BIG SANDY WATER TEMP. —

SPECIES	LENGTH	WEIGHT	PECTORAL FIN CLIP L	PECTORAL FIN CLIP R	PELVIC FIN CLIP L	PELVIC FIN CLIP R	CAUDAL FIN CLIP TOP	CAUDAL FIN CLIP BOTTOM	ADIPOSE FIN CLIP
R	9.0	10							
R	11.0	20							X
R	11.5	25							X
R	15.5	50		0					
R	16.0	55		0	X		X	X	
R	13.0	22							
R	12.5	20							X
R	15.5	50		0	X				
R	17.0	70		0	X		X	X	
R	18.0	70		0	X				
R	12.0	30							X
R	13.5	30							X
R	10.0	10			X		X		X
R	17.5	70		0	X		X		
R	7.5	05							X
R	10.0	10							
R	11.5	10							X
R	15.0	40			X				
damaged gill → R	18.5	50		0	X				
R	12.0	30							X
R	13.0	30							X
R	12.0	20							X
R	13.0	30							X
spec dace	8.0								[illegible]
R	7.0	10							
R	7.5	5							
R	20.0	110		0	X			X	
R	38.5	520		0				X	

Big Sandy normal flow, but still turbid. Bone Draw flows down & stream clearing up. Larger fish moved out & small fish back in. Many people (6) showed up & began fishing. One reported "cleaning house" over the weekend & catching one "cutthroat" of 6 lb. size. (LEE KIMBALL - PIONEER BLDRS. - GREEN RIVER)

LBS