S
597.559
N7hrag
1987

1987
HYALITE RESERVOIR
- ARCTIC GRAYLING STUDY -

Prepared by OEA Research
and
Dave Fernet,
Environmental Management Associates
September 1987

STATE DOCUMENTS COLLECTION

JUN 2 4 2002

MONTANA STATE LIBRARY
1515 E. 6th AVE.
HELENA, MONTANA 59620

OEA Research
Ecological Services

P.O. Box 1209 • 635 North Jackson • Helena, Montana 59624 • (406) 443-5560

MONTANA STATE LIBRARY
3 0864 0014 4291 5

1987

HYALITE RESERVOIR
- ARCTIC GRAYLING STUDY -

Prepared by OEA Research
and
Dave Fernet,
Environmental Management Associates
September 1987

Prepared for HKM Associates
and
Montana Department of Natural Resources and Conservation

Digitized by the Internet Archive
in 2013

http://archive.org/details/1987hyalitereser1987fern

TABLE OF CONTENTS

ARCTIC GRAYLING STUDY
---- 1987 ----

INTRODUCTION

In October of 1986 a study group (U.S. Forest Service, U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, Montana Departments of Fish Wildlife and Parks and Natural Resources and Conservation, Middle Creek Water Users Association, and HKM Associates) reviewed the 1986 Hyalite Reservoir Arctic Grayling Study report. The group accepted the findings of the report and recommended additional studies be undertaken in 1987 to investigate the feasibility of providing mitigation by creating new spawning areas for Arctic grayling.

The investigators (Dave Fernet, Environmental Management Associates; Chris Hunter, OEA Research) developed a study plan in consultation with HKM Associates, Montana Department of Natural Resources and Conservation (DNRC), and the study group. The objectives of the study were:

- Create spawning habitat that would be used by Arctic grayling.
- Demonstrate that grayling will move through subreach 2 to spawning areas in subreach 3.
- Provide information on fry emergence from created and naturally occurring spawning areas.
- Collect additional spawning habitat (depth and velocity) data to further refine the 1986 habitat suitability curves.
- Refine identification of suitable spawning areas in subreach 3.

The study was presented in the Draft Middle Creek Dam Rehabilitation Environmental Assessment (HKM 1986) and accepted by the study group.

METHODS

Several tasks were undertaken in order to meet the objectives of the 1987 study. These tasks are outlined in the Draft Middle Creek Dam Rehabilitation Environmental Assessment (HKM 1986) and are described in detail here. In those instances where methods used in 1987 were the same as those employed in 1986, the reader is referred to the 1986 report.

SPAWNING HABITAT STRUCTURE

During an October 23, 1986 field review of the proposed study plan, the investigators and study group members agreed that spawning habitat structures would be constructed at three locations in subreach 1.

It was decided to confine the construction of spawning habitat enhancement structures to subreach 1 because this area would definitely be visited by fish. If structures were constructed in subreach 3, fish might not reach them based upon observations during 1986 and by previous investigators.

The three locations were chosen because few or no fish were observed spawning at these sites during 1986, apparently because the water was too fast or too shallow. Since depth and velocity appear to be the limiting factors, it was important to demonstrate that they can be changed to fit the preferences of the spawning fish.

HKM designed the structures utilizing the habitat utilization data gathered during the 1986 field effort. The designs were reviewed by the investigators and incorporated into the Notice of Construction of Hydraulic Project Affecting Fishing Waters (Appendix A) prepared by OEA Research and submitted to Montana Department of Fish, Wildlife and Parks (MDFWP). This was the only permit required to construct these projects.

Construction was scheduled to take place in the fall of 1986 with adjustments made to the structures in the spring of 1987 prior to the spawning run. However, due to inclement weather, the construction was delayed until the spring of 1987.

Winter snowfall was very light and spring 1987 came early. When DNRC completed construction of the structure located downstream of survey stake 7 on Friday, May 8, the 1 p.m. water temperature was 7°C. Because the arrival of the spawning Arctic grayling appeared imminent and cutthroat trout were in the stream and spawning, construction of the remaining two structures was cancelled. The structure is shown in Photo 1.

PRE-SPAWNING MIGRATION MONITORING

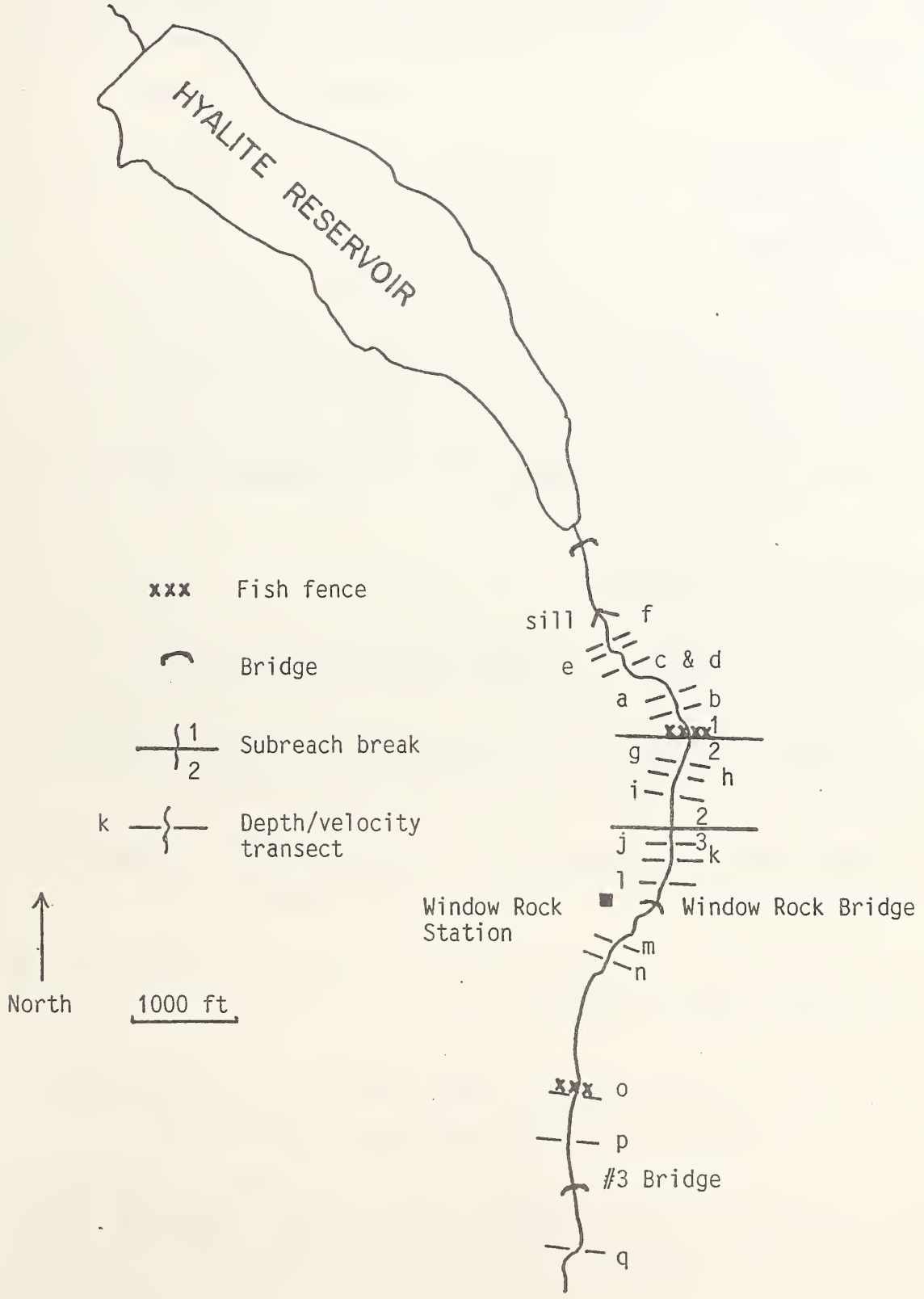
In 1986 the pre-spawning migration monitoring began on May 1 when afternoon water temperatures approached 7°C. The 2 p.m. water temperature at the Middle Creek bridge on May 6, 1987 was 8°C. In 1986 Arctic grayling were spawning in Middle Creek at this water temperature.

On May 12 the investigators took up residence at the USFS Window Rock cabin expecting the spawning migration to be under way. Approximately 12 grayling were observed in the stream on this date. Numerous cutthroat were also observed.

The morning of May 13 the fish fences, described below, were constructed (Figure 1). At 3:20 p.m. the stream temperature was 9°C. However, fewer Arctic grayling were observed than the previous day. May 14 and 15 habitat transect data were collected at 1986's stations a, b, c, e, f and at 5 transects covering the area influenced by the spawning habitat enhancement structure (refer to 1986 Methods section) (Figure 1). Water temperatures both days reached 8°C without any sign of Arctic grayling moving into the stream.

Photo 1. Spawning habitat enhancement structure.

Figure 1. West Fork Hyalite Creek with subreach breaks, habitat transects, and fish fence locations.



On the evening of May 15 the air temperature dropped and it began to rain. By the morning of May 16 the stream had risen 0.1 feet and continued to rise. The highest water temperature recorded during the day was 5°C. By 9:00 p.m. that evening the stream had risen over 0.3 feet.

The investigators left the area on May 17 when it became obvious that the Arctic grayling would not be moving into the stream until the weather changed.

Stream temperature was monitored every other day from May 17 until May 29 when the 5:30 p.m. water temperature was 5.5°C and approximately 15 grayling were observed moving into the stream.

The spawning observation began on May 31 compared to June 12 in 1986.

SPAWNING INVESTIGATION

The spawning investigation consisted of several separate tasks:

- Collecting habitat transect data for subreach 1 and the area influenced by the spawning habitat enhancement structure.

- Radio-tagging and tracking of 12 Arctic grayling to determine their ability to move through subreach 2 into subreach 3.

- Determining and mapping the locations used for spawning during the 1987 spawning migration.

- Collecting additional water depth and velocity information for further refinement of spawning habitat suitability curves.

The collection of habitat transect data has been described above. These data are compared to similar data collected during 1986 in the results section of this report.

Due to low flow conditions, which significantly decreased the amount of available habitat, no attempt was made to refine 1986 estimates of suitable Arctic grayling spawning habitat in subreach 3.

Radio-Tagging and Tracking

Radio-tagging and tracking of fish was undertaken to determine if Arctic grayling would move through subreach 2 into subreach 3. It was anticipated that it would be possible to determine where grayling entering subreach 3 spawned.

Twelve radio transmitters were prepared by Custom Telemetry and Consulting (CTC) of Athens, Georgia. The radios were implanted in the stomachs of 12 mature Arctic grayling that were captured by electrofishing techniques as they entered the stream to spawn on June 1 and 2, 1987.

Implantation of the radio transmitters was accomplished by coating them with petroleum jelly and inserting them into the stomach via the mouth with a piece of plastic tubing (Photo 2). After the radios were implanted the fish were moved to a holding pen at the lower end of subreach 2. The fish were left in the holding pen overnight to make certain they were healthy and that no radios had been regurgitated. They were released the following morning. The holding pen was located approximately 30 feet upstream of the downstream of two fences that were constructed across the stream.

The fences were fabricated by HKM Associates using a design suggested by Dave Fernet using 2x4 lumber as the frame. Three-quarter inch holes were drilled in the cross-members at 1.5 inch intervals. Three-quarter inch dowels were threaded through the holes and pushed into the stream substrate. This design was used to keep fish from passing through the fences (Photo 3). The fence downstream of the holding pen was placed there to keep fish from moving downstream into subreach 1. An upstream fence was placed in the vicinity of 1986 habitat transect "o" (Figure 1). The intent of the fences was to keep fish

Photo 2. Implantation of radio tag.

Photo 3. Fish fence.

from going farther upstream than this point. If this upstream fence had not been installed the area to be covered by radio-tracking efforts would have been much larger and required a greater expenditure of time.

Radio-tracking was accomplished using a 12 channel analog receiver manufactured by CTC in conjunction with a standard CB whip antenna. The receiver and antennae picked up signals within a 75-foot radius. Radio-tracking efforts began on the evening of June 2, 1987 and were conducted morning and evening through June 4, and the morning of June 5 and June 8.

Observation of Spawning

Spawning observations were made on the afternoons of June 3, 4, and 5. As with the 1986 observations, this effort was confined to subreach 1. Spawning observations were not attempted in subreach 3 because Arctic grayling did not enter this subreach until the last day of the study. Incidental observations were made at this time. In an effort to eliminate any bias in observations caused by concentrating observation time on areas where spawning was occurring regularly a systematic approach to sampling was followed. Subreach 1 was divided into thirteen 100-foot sections. These sections were marked by DNRC survey stakes (Figure 2). The sampling period (1:00 p.m. to 5:00 p.m.) was divided into eight half-hour intervals. The numbers of the sampling sections, beginning with survey marker 6 and continuing through 20, were randomly drawn and assigned to consecutive half-hour sampling intervals. The sections 6-sill and sill-8 were each drawn twice. The order was reversed each day to eliminate bias introduced by sampling the same section at the same time each day. The resulting sampling schedule is shown in Table 1.

Figure 2. Spawning observation sections and fry trap locations.

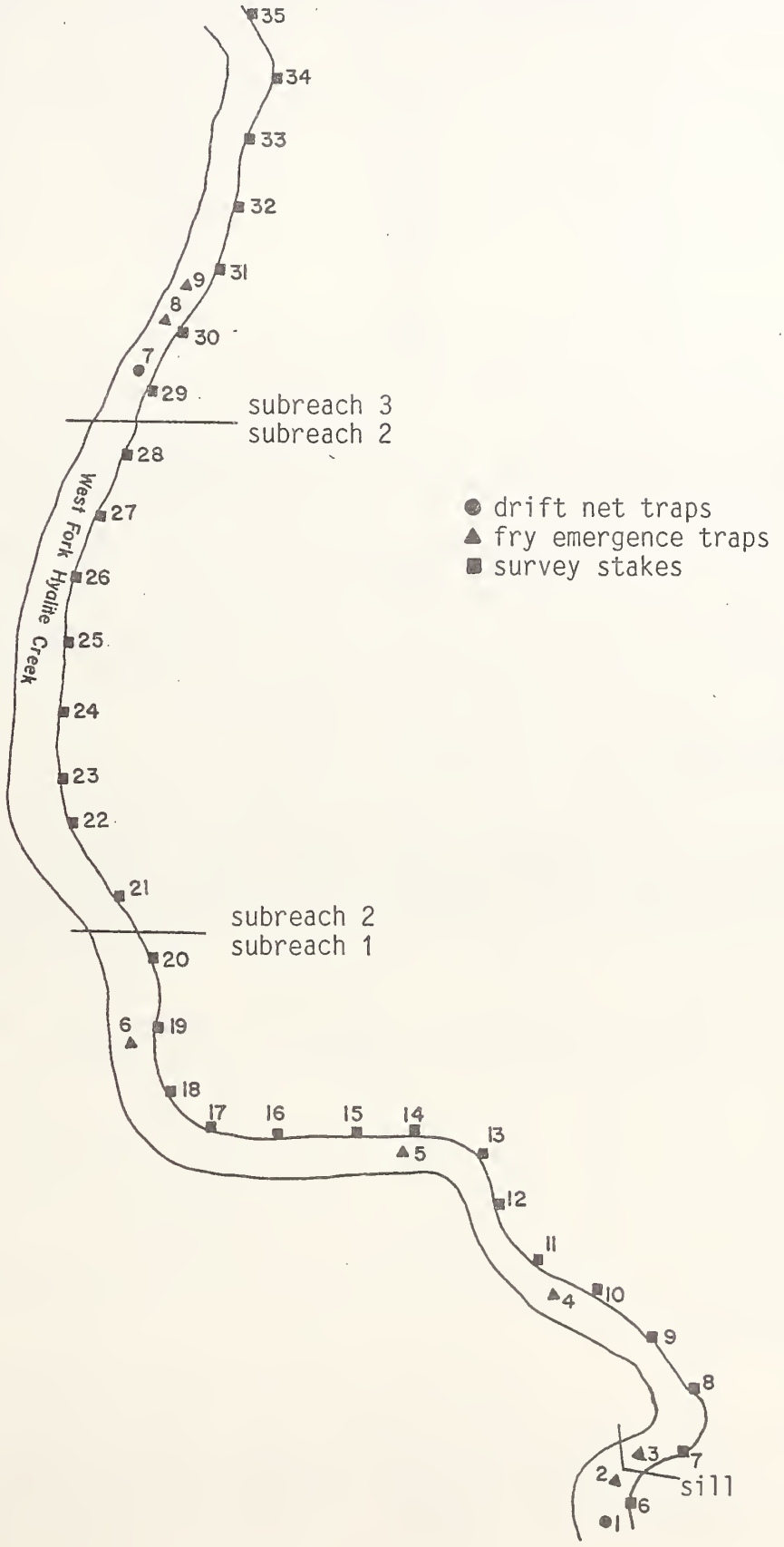


Table 1. Sampling schedule by study reach for spawning observations.

Time	--------June 3-------- Hunter	Fernet	June 4 Fernet	June 5 Hunter
1:00 p.m.	8-9	11-12	6-sill	sill-8
1:30	16-17	15-16	19-20	18-19
2:00	9-10	13-14	12-13	17-18
2:30	10-11	sill-8	6-sill	14-15
3:00	14-15	6-sill	sill-8	10-11
3:30	17-18	12-13	13-14	9-10
4:00	18-19	19-20	15-16	16-17
4:30	sill-8	6-sill	11-12	8-9

All locations of observed spawning acts were marked on a hand-drawn map in a field notebook. At the end of the half-hour sampling period these locations were marked with red flags as was done during 1986. At the end of the day depth, mean column velocity, and nose velocity measurements were taken at each of the flags. The velocity measurements were taken with a Type AA current meter provided by MDFWP.

FRY TRAPPING

Fry trapping was undertaken from July 7-17, 1987 to determine if spawning was successful. This effort was particularly important in the area of the spawning habitat enhancement structure to determine if the grayling spawned successfully in this area. It was also important to learn if grayling had spawned successfully in subreach 3. Recruitment during 1987 was compared to that observed by Wells (1976).

Two types of fry traps were used. A drift net type trap (2 ft x 2 ft) was placed near survey marker 6. An identical net was placed at the lower end of subreach 3. These nets subsampled all fry production upstream of them. These nets were equipped with holding bottles as described below.

Emergence traps with holding bottles were placed at seven locations (Figure 2). The emergence traps sit on the stream bottom and are designed to sample all fry emerging from the area enclosed by the net

(Photo 4). The fry, upon emerging, swim up and are washed into the holding bottle where they survive until the investigator empties the bottle. The design for the emergence trap and holding bottle was a modification of that reported by Fraley et al. (1986). The emergence traps were constructed of 2 ft x 2 ft steel frames. The netting material for both emergence and drift nets was fiberglass window screen (6 meshes/cm).

The drift nets and emergence traps were checked in the morning and evening each day. The holding bottles were emptied into an enamel pan and the captured fry were counted and released. Fry trapped on the screen of the drift nets were picked off with forceps and counted.

RESULTS

HABITAT TRANSECTS

Habitat transect data were collected at locations corresponding to 1986's transects a, b, c, e, and f to compare in a general way the availability of spawning habitat in subreach 1 in 1986 and 1987. Figures 3 and 4 present the data collected for these transects in 1987 in exactly the same way that Figures 11 and 12 (1986 report) present the 1986 data for these transects.

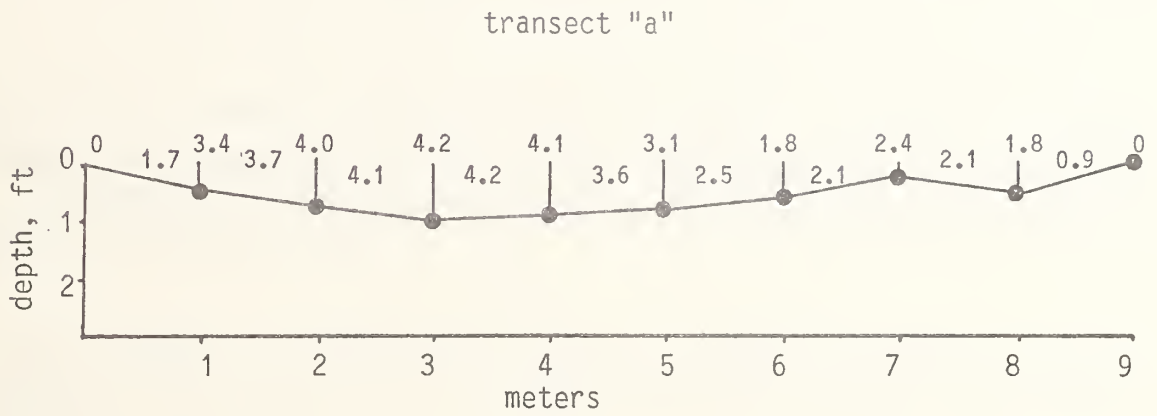
The best comparisons of available spawning habitat can be made for transects a and c because these transects were taken in exactly the same location both years. Transects b, e, and f were taken in the same vicinity as last year but probably not in exactly the same location.

In 1986, 11% of the area along transect a was considered marginally suitable for Arctic grayling spawning. No excellent or good habitat was found. In 1987 none of the habitat along transect a could be classified as suitable Arctic grayling spawning habitat.

There was a similar decrease in the quality and quantity of suitable spawning habitat at transect c. In 1986, 43% of this transect covered

Photo 4. Fry emergence trap located upstream of spawning enhancement structure.

Figure 3. Water depth/velocity measurements for transects a and b.



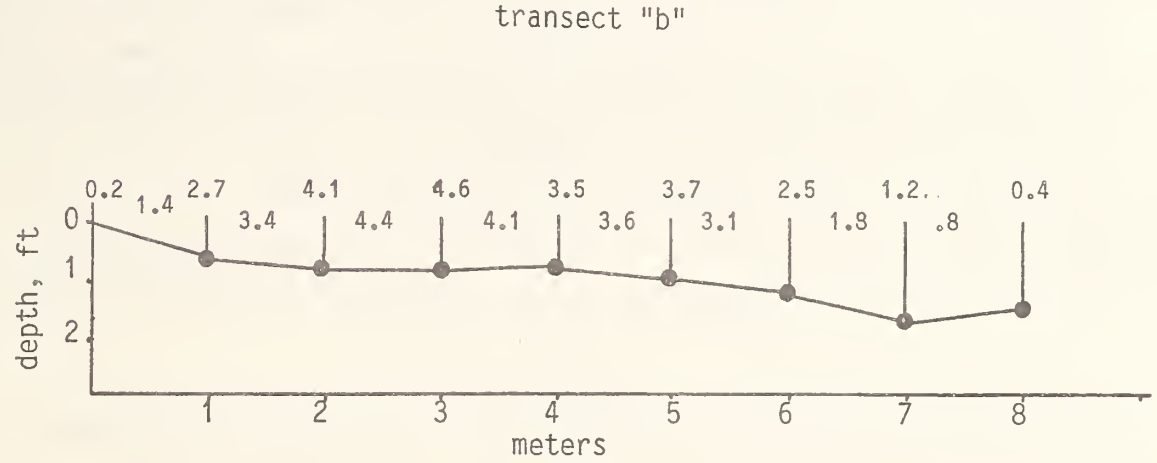
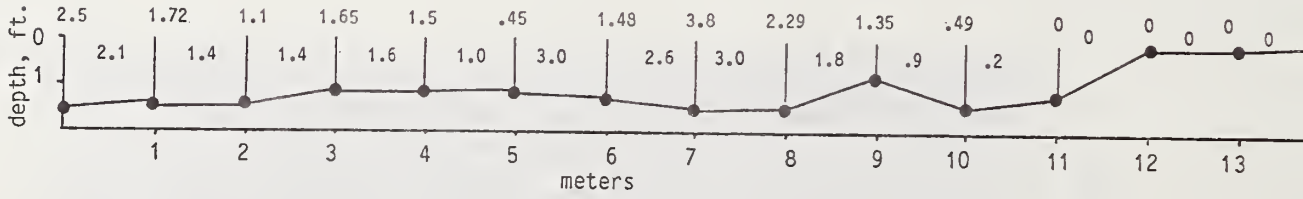
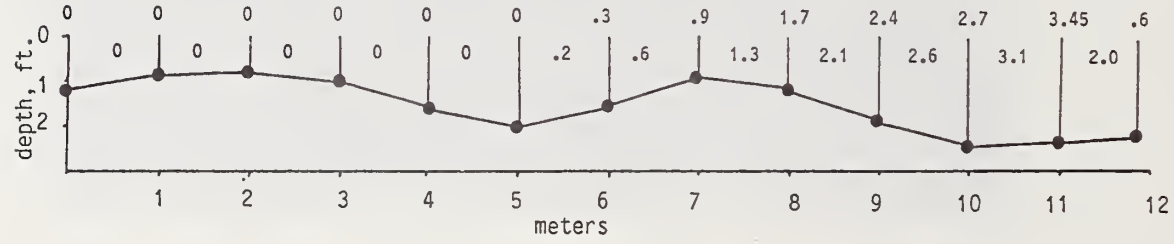


Figure 4. Water depth/velocity measurements for transects c, d, e, and f.

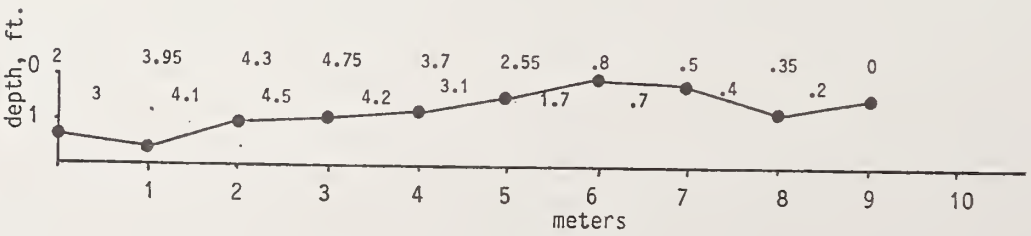
transect "c" & "d"



transect "e"



transect "f"



excellent habitat and 7% was good. In 1987 there was only 29% excellent habitat and 21% good habitat.

Peak runoff conditions were extremely low in 1987. The peak flow of the Yellowstone River at Corwin Springs in 1987 (approximately 7,000 cfs) was approximately one-half the historical low peak flow (14,000 cfs, 80 years of record) (Phil Farnes, pers. comm.). It is reasonable to assume that conditions in the Hyalite drainage were similarly low since these two drainages are very close geographically. They are situated on the east and west sides of the Gallatin Range which contributes run-off to both drainages.

The reduction in quality and quantity of Arctic grayling spawning habitat in 1987 is due to the extremely low flow conditions experienced in 1987 (Figures 5 and 6).

Habitat transect data were also collected in the area influenced by the spawning habitat enhancement structure. These data were collected to determine how closely the created habitat matched the spawning habitat suitability criteria developed in 1986.

The intent of the sill, as designed, was to create habitat having depths ranging from 1-2 feet and mean column velocities of 1.7 to 2.3 ft/sec (52-70 cm/sec). Mean column velocity was used because nose velocities are difficult to predict and design for, although they do not reflect habitat suitability as accurately as nose velocity.

In attempting to design for these criteria a number of variables had to be considered including the extent to which the sill was filled with gravel and the range of flows that were expected based upon historical flow records. As mentioned above the flows in 1987 were well below historic peak flows.

Figure 7 displays the depths and mean column velocities that were measured along the habitat transects in the area of the spawning enhancement structure. Areas meeting the design criteria are shown by

Figure 5. Comparison of depths and mean column velocities at transect a, 1986 and 1987.

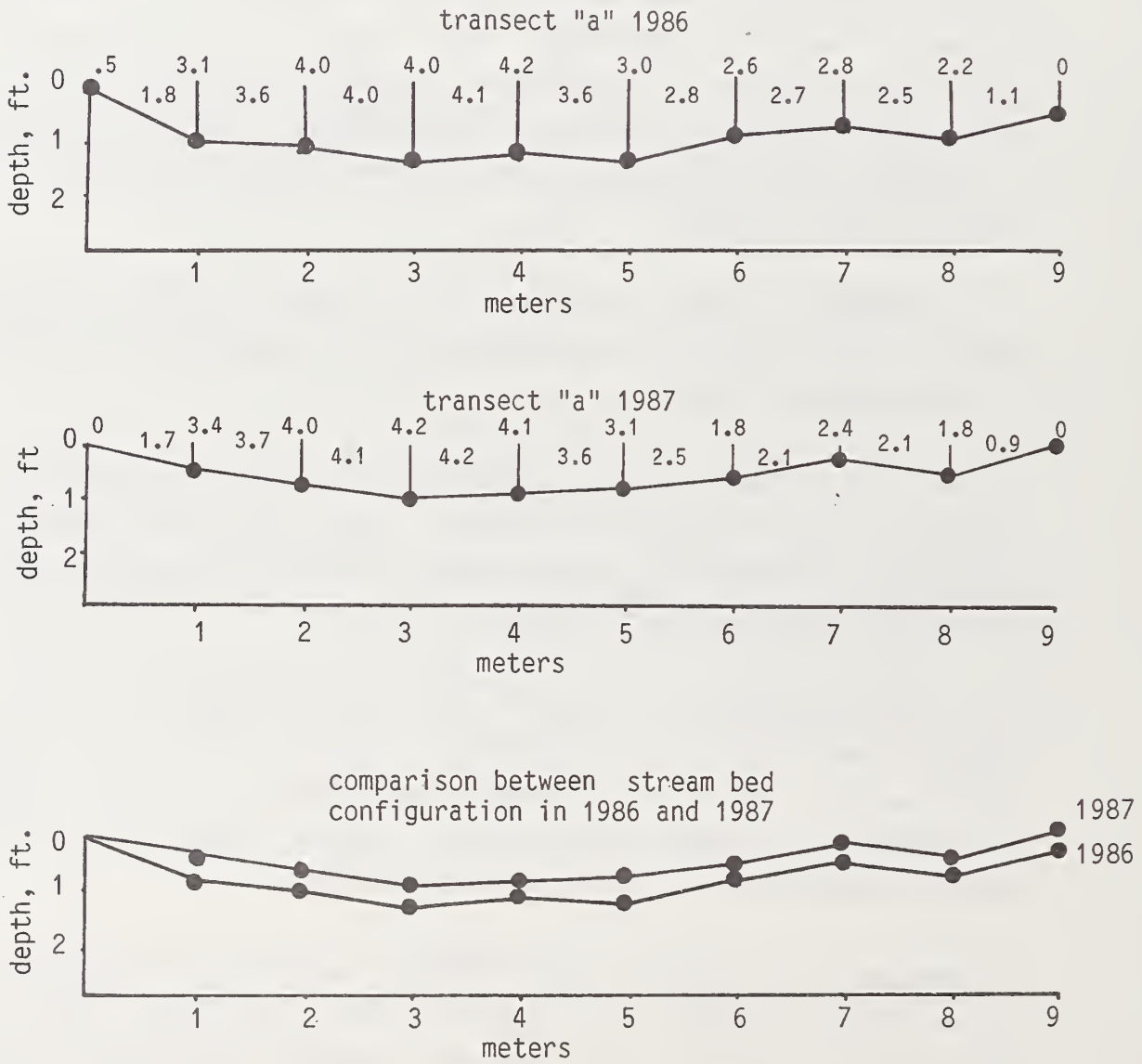


Figure 6. Comparison of depths and mean column velocities at transect c, 1986 and 1987.

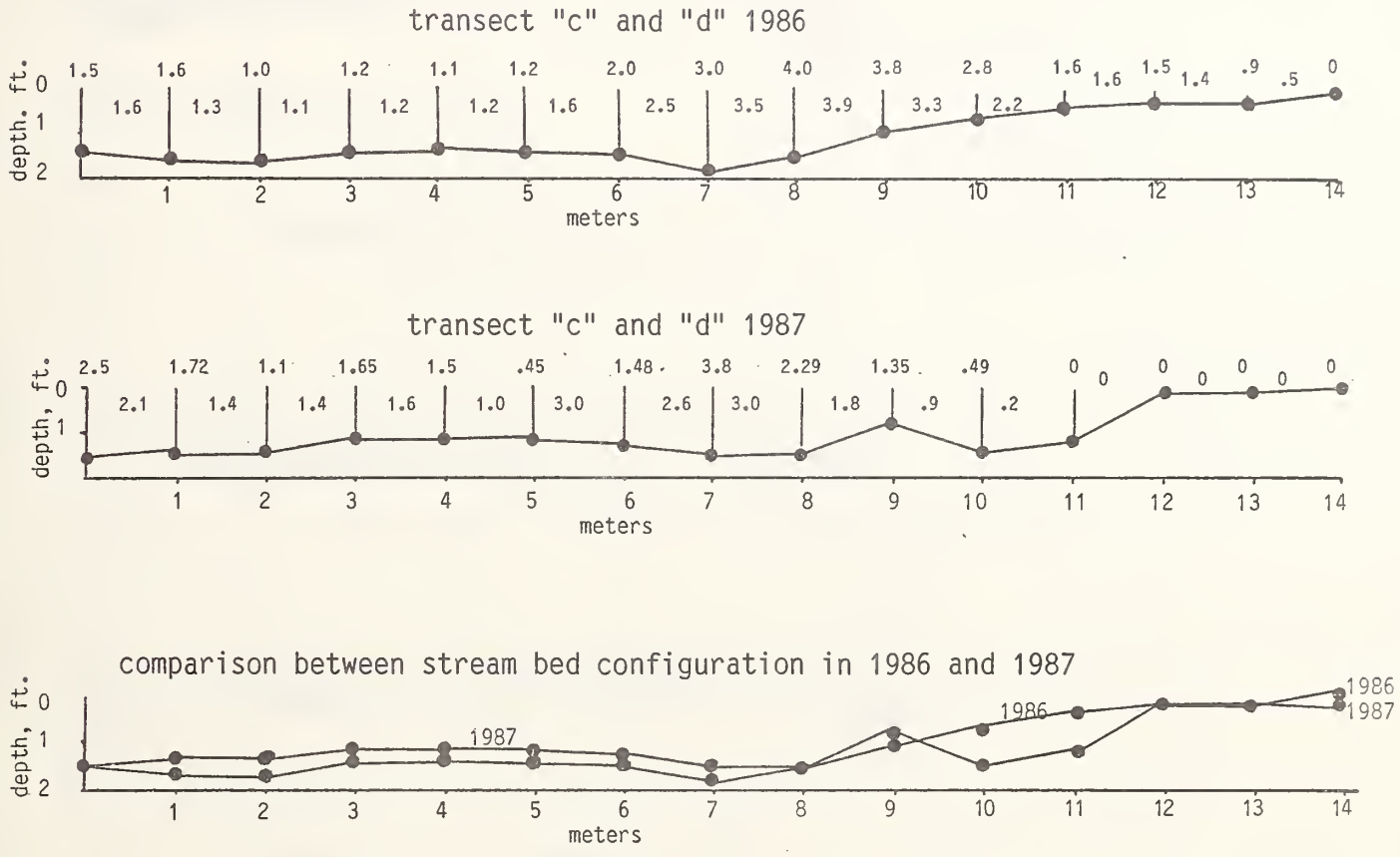
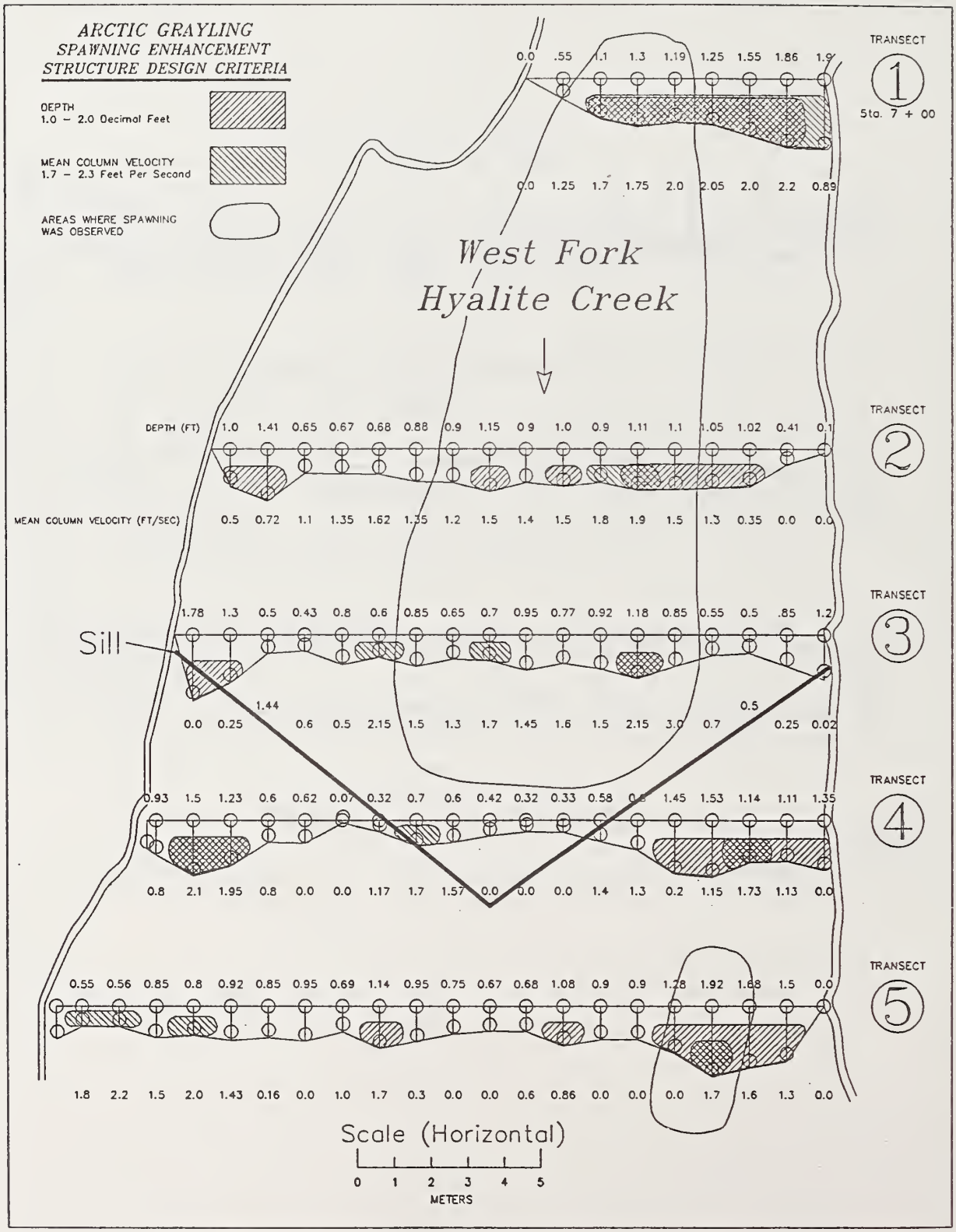


Figure 7. Grayling spawning habitat suitability measures.



cross-hatching on the figure. It is apparent from the figure that while the structure provided a large amount of habitat meeting the design criteria for depth, very few areas meet the criteria for mean column velocity. Spawning observed in this area during 1987 occurred in those areas enclosed by the solid line on the figure.

Radio-Tagging and Tracking

Table 2 provides data on the tag number, fork length, weight, age and sex of the radio-tagged Arctic grayling. Table 3 and Figure 8 are provided to aid the reader in understanding fish movements.

Radio-tracking efforts began on the evening of June 2 when the second group of fish (tags 87-92) was placed in the holding pen. The first group of fish (tags 92-99) had been released from the holding pen that morning. All 12 fish were in the vicinity of the holding pen and fence at this time.

The morning of June 3 radio-tracking was undertaken immediately after releasing the second group of grayling from the holding pen. This effort revealed that all of the fish, with the exceptions of 95 and 94 were in the vicinity of the holding pen and fence. An upstream search for 95 and 94 ending at the upstream end of subreach 2 was unsuccessful.

The evening of June 3 (6:00 p.m.) another radio-tracking episode was conducted. Again all fish except 95 and 94 were found in the vicinity of the holding pen and fence. A downstream search for these fish located 95 in reach 10-11 and 94 in reach 7-8. These two fish had managed to move downstream past the fence.

The morning of June 4, 1987 all fish except 95, 94 and 89 were radio-tracked in the area of the fence. Fish 95 had moved upstream to survey stake 14. No signal was received from 94. Tagged female 89 had moved upstream approximately 330 feet to the base of a whitewater section near survey marker 24 in subreach 2. An untagged grayling

Table 2. Length, weight, age, sex and tag number of radio-tagged Arctic grayling.

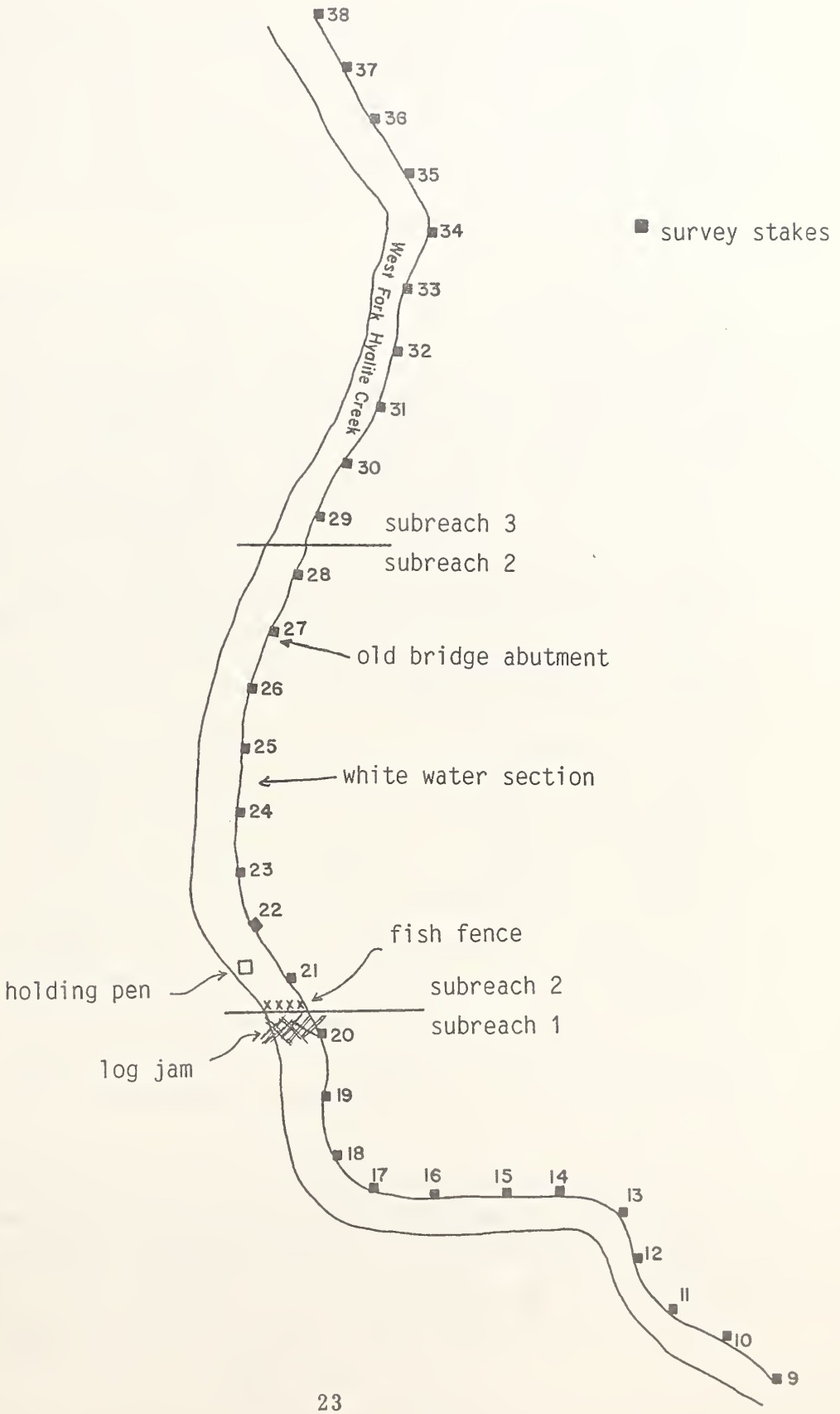
Tag Number	Fork Length (cm)	Weight (gm)	Age* (years)	Sex
99	34.4	480	---	male
98	43.8	802	5 or 6	male
97	36.8	500	4	male
96	37.2	520	4	male
95	34.0	370	4	male
94	36.0	460	4	male
92	41.2	705	6	female
91	36.0	520	4	female
90	34.4	470	4	female
89	41.0	722	5	female
88	33.6	478	4	female
87	39.2	610	5	male

* Age (years) determined by Jerry Wells, MDFWP, from scales taken from the fish.

Table 3. Location of radio-tagged fish during sampling effort. Fish not located indicated by a dash. Locations indicated by survey stake number.

Fish Tag #	June 3 a.m.	June 3 p.m.	June 4 a.m.	June 4 p.m.	June 5 a.m.	June 8 a.m.
99	21	21	21	-	27	24
98	21	21	21	21	21	-
97	21	21	21	-	-	-
96	21	21	21	24	24	24
95	-	10	14	20	20	37
94	-	8	-	-	-	-
92	21	21	21	24	24	30
90	21	21	21	24	-	30
89	21	21	24	21	24	-
88	21	21	21	21	19	30
87	21	21	21	24	-	-

Figure 8. Radio-tracking locations.



was observed 660 feet above the fence. This fish must have been in the creek before the fence was established or had passed the fence.

By the evening of the June 4 fish 95 had moved upstream to the vicinity of the logjam (survey stake 20). Signals from tags 98, 89, and 88 were received in the area of the fence. Tags 96, 87, 92, 91 and 90 were located at the base of the whitewater near survey stake 24. No signals were received from fish 99, 97, and 94. An untagged grayling was observed downstream of survey stake 24.

On the morning of June 5 only one fish, 98, was located at the fence. Fish 89 was located in the same vicinity where she had been located (survey stake 24) on the previous morning. Fish 96, 92, and 91 were also in this area as they had been the previous evening. An untagged fish was again seen in this area. Fish 99 was located approximately another 330 feet upstream near the old bridge abutment. No fish were located upstream of this point. On moving downstream, fish 95 was again located in the area of survey stake 20. Fish number 88 was located near survey stake 19 with several spawning grayling. Fish not located on this morning were 97, 94, 90, 87.

On the morning of June 8, 1987 no grayling were located in the vicinity of the fence. Fish 99 and 96 were at the base of the whitewater approximately 330 feet upstream of the fence. Three untagged fish were observed near the old bridge abutment. Fish 88, 90 and 92 were located in a pool approximately 160 feet upstream of the downstream end of subreach 3 (survey stake 30) with three untagged fish. Two more untagged fish were observed in a pool 30 feet farther upstream. Fish 95 was located at survey stake 37 approximately 330 feet above the downstream end of subreach 3. A total of 4 tagged and 5 untagged fish were observed at this time in subreach 3.

Later in the morning grayling were observed spawning at the tail of the pool at survey stake 30 and at another pool about 60 feet farther upstream. These fish were not radio-tagged. Fish not located this date were 98, 97, 94, 91, 89, 87.

In summary, of the 12 radio-tagged fish four eventually traversed subreach 2 and entered subreach 3 (Table 3). Of these four fish, three were female and one was a male. Two of these fish passed through the fence at least twice (once upstream, once downstream).

Two fish, 97 and 94 were lost fairly early in the tracking and never heard from again. Fish 98 never appeared to move much at all. The remaining fish appear to have gone part way up subreach 2 but were never tracked above survey stake 27.

OBSERVATION OF SPAWNING

Fourteen 100 foot segments of Middle Creek were observed for two to four 30 minute periods during the course of the spawning migration. Spawning was observed to occur in eight of these segments. Table 4 presents the average number of spawning observations per 30 minute period for each of these segments.

Table 4. Average number of observed spawns per 30 minutes for several 100 foot sections of Middle Creek.

Stream Segment	Average Number of Observed Spawns/ 30 minutes
6-sill	0.6
sill-8	11.7
10-11	10.8
11-12	1.2
13-14	6.0
14-15	11.4
17-18	0.6
18-19	4.2

Segments 10-11, 13-14 and 14-15 correspond to the areas where spawning was concentrated during 1986 (Figure 7, 1986 report). Segments 6-sill, and sill-8 are those segments influenced by the spawning habitat enhancement structure. Only 4 spawning acts were observed in this area last year; 46 spawning acts were observed in this area in 1987. The 1986 observation effort was equal to or greater than the 1987 effort in this locale. This indicates that the structure was very successful in providing habitat the Arctic grayling found suitable for spawning.

No fish were observed spawning above section 14-15 during 1986. During 1987 spawning was observed in both sections 17-18 and 18-19.

Figures 9, 10 and 11 represent the habitat utilization curves that were generated combining the 1986 and 1987 data. These curves are based on a total of 176 observations. These curves are category two (utilization) curves that will be used to design mitigation structures. The plotted points are the result of the frequency analysis. The dashed line is the authors' interpolation of the plotted points.

FRY EMERGENCE

Fry emergence traps and drift nets were located throughout subreach 1 and at the downstream end of subreach 3 (Figure 2). These nets were visited morning and evening from July 7-17, 1987. The results of the fry trapping are presented in Table 5.

Table 5. Numbers of grayling fry collected from fry emergence traps and drift nets (indicated by *). (No data are presented for trap 9 as no fry were captured in this trap).

Date	Trap 1* am/pm	Trap 2 am/pm	Trap 3 am/pm	Trap 4 am/pm	Trap 5 am/pm	Trap 6 am/pm	Trap 7* am/pm	Trap 8 am/pm
July 7	57/59	0/0	19/12	--/56	--/2	--/1	0/0	--/0
July 8	160/71	0/0	29/15	31/53	2/1	15/0	0/7	0/0
July 9	52/101	0/0	21/18	32/83	0/0	0/0	3/2	0/0
July 10	73/52	0/0	96/9	17/2	0/1	0/0	2/3	0/0
July 11	9/60	0/4	35/23	40/3	0/0	0/0	0/3	0/1
July 12	37/98	0/2	40/159	26/4	0/0	1/0	0/14	0/0
July 13	45/34	1/9	49/87	0/1	0/0	2/0	4/12	0/2
July 14	30/34	6/22	20/30	0/2	0/0	0/0	1/10	2/0
July 15	36/21	7/17	12/4	1/0	0/0	0/2	4/5	0/0
July 16	6/6	5/24	11/0	0/0	0/0	0/0	2/0	0/0
July 17	11/2	6/5	4/0	0/0	0/0	0/0	4/2	0/4
TOTALS	516/538	25/83	336/357	147/204	2/4	18/3	20/58	2/7

Fry were successfully trapped in all nets with the exception of net 9. This emergence trap was located at the tail of a pool in subreach 3 where one spawn was observed.

Figure 9. Habitat utilization curve and histogram, depth in feet 1986 and 1987 data.

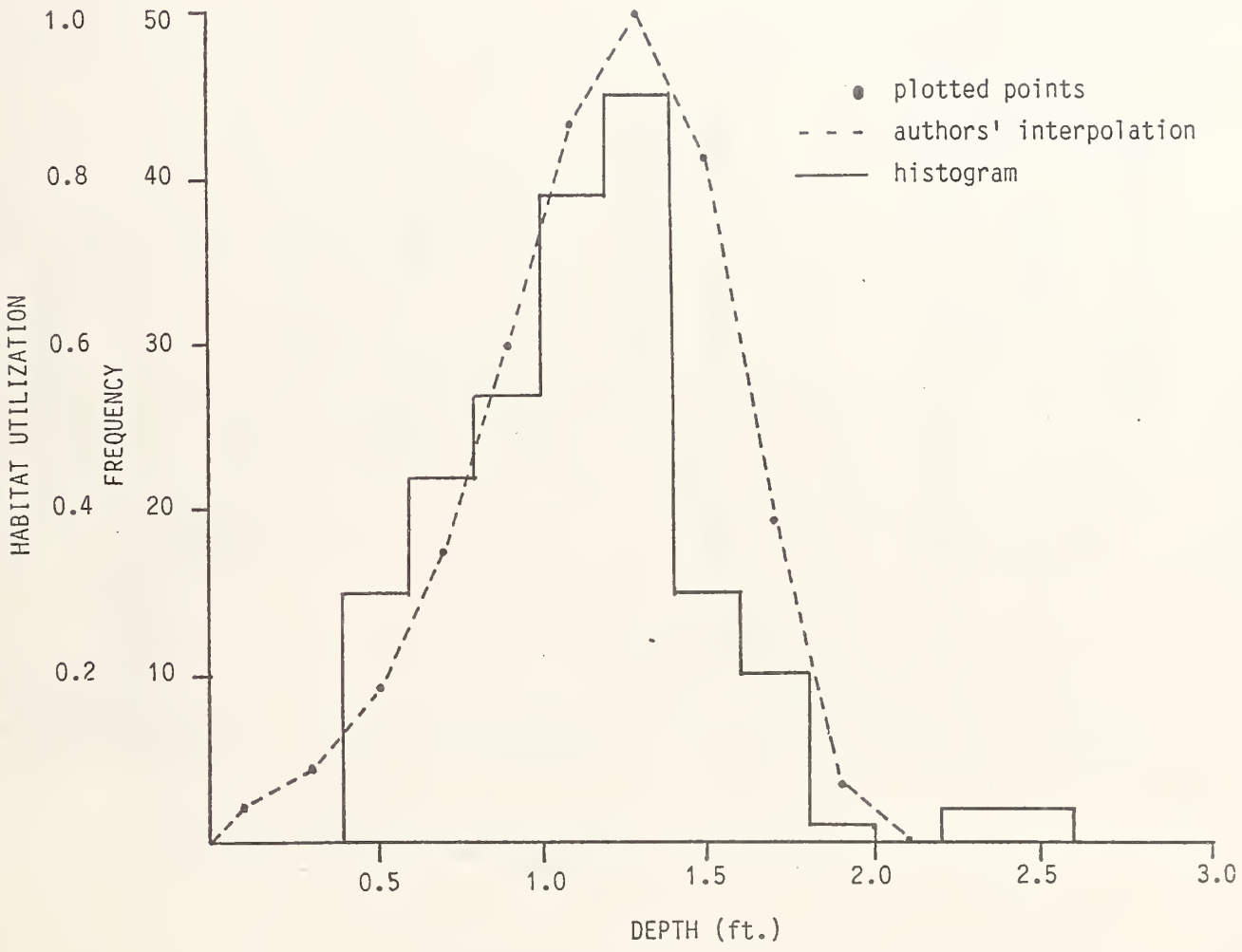


Figure 10. Habitat utilization curve and histogram, mean column velocity in cm/sec, 1986 and 1987 data.

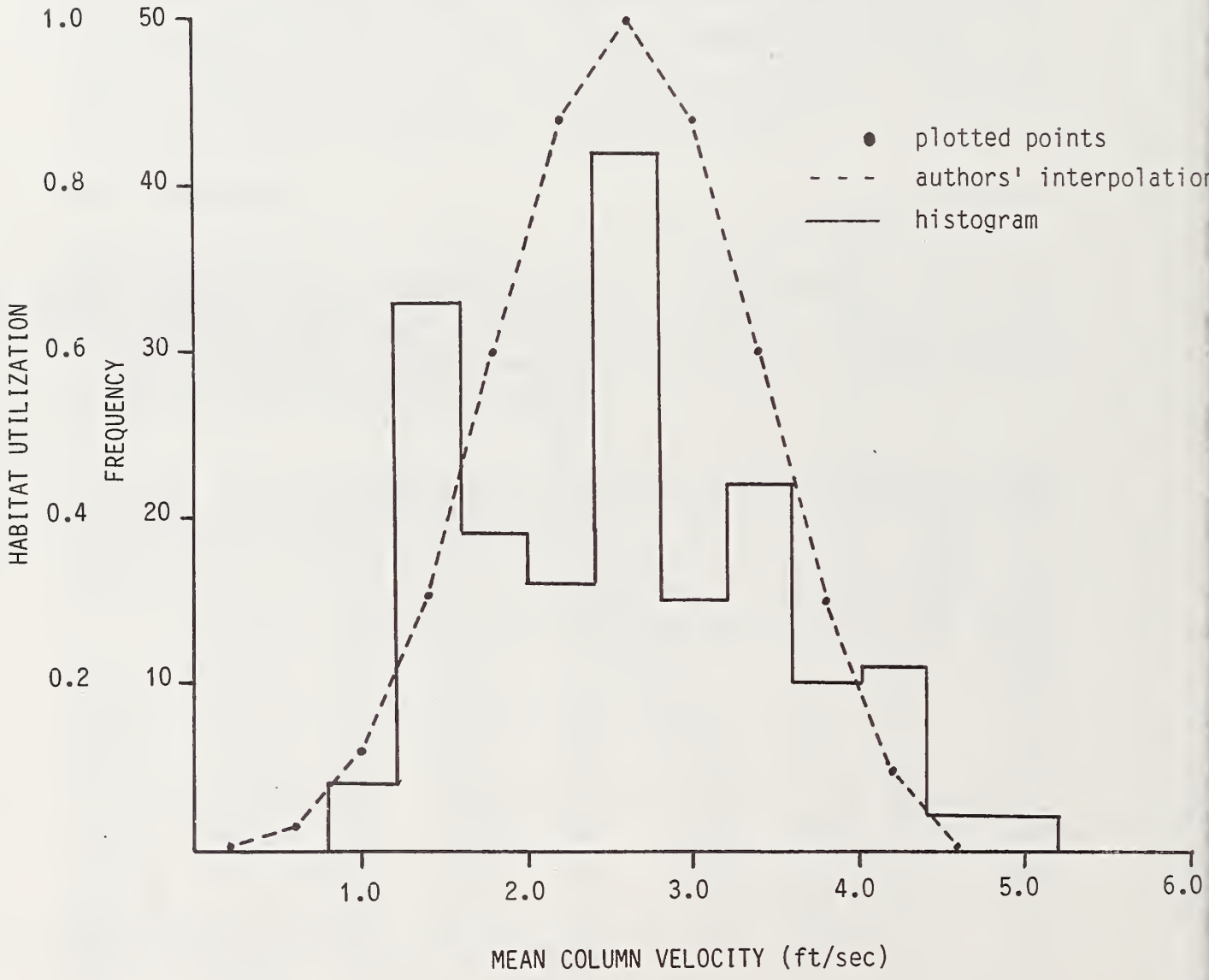
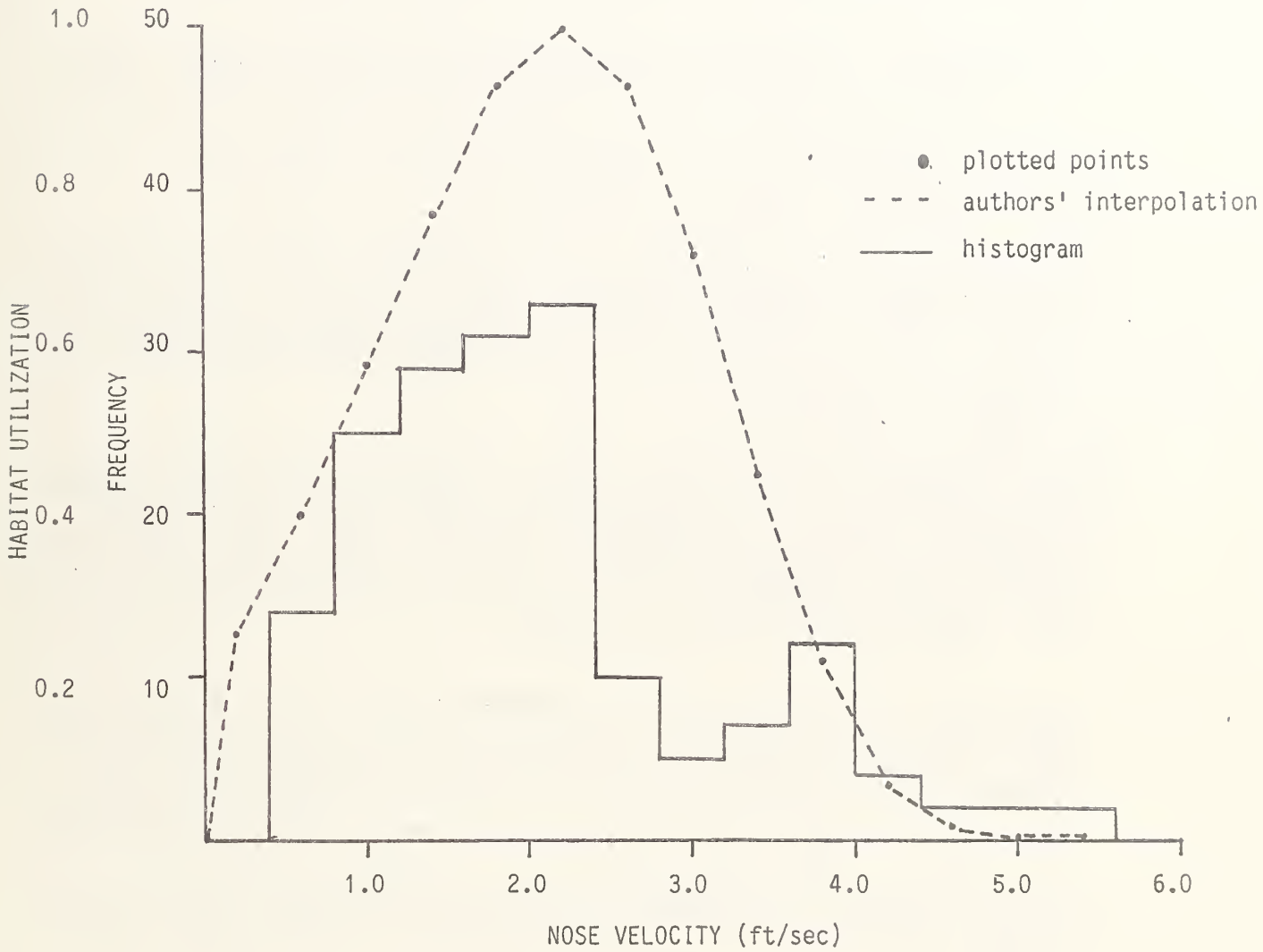


Figure 11. Habitat utilization curve and histogram, nose velocity in cm/sec, 1986 and 1987 data.



Traps 5 and 6 yielded fewer fry than expected based upon the number of spawning acts observed in these locations. The investigators believe this is because these two sites had higher velocities during the fry trapping period than other sites. The higher velocities may have resulted in significant egg drift during spawning or affected the traps' performance. Hundreds of Arctic grayling fry were observed in back water areas near trap 5 indicating that this area produced fry.

The results of the trapping indicate that the Arctic grayling spawned successfully in the area influenced by the spawning habitat enhancement structure (traps 2 and 3), in areas upstream of subreach 1 (trap 6), and in subreach 3 (traps 7 and 8).

The numbers of fry captured decreased toward the end of the trapping period. This may indicate that the emergence period was ending or it may be due to the decreasing air and water temperatures which were experienced at this time.

The mortality of fry in the drift nets was 94%, while the mortality associated with the fry emergence traps was 15%. Total overall fry mortality from trapping was 52%. A total of 2,390 Arctic grayling fry were trapped in the eleven day period.

Wells (1976) captured 1,975 Arctic grayling fry over an eighteen day period using a drift net with a two-foot wide opening placed in the vicinity of survey stake 6. This is an average of 109 fry per day. A total 1,054 fry were captured in the drift net at this location during 1987 over an eleven day period for an average of 95 fry/day. A marked consistent difference in daylight and evening drift was not observed.

DISCUSSION

The 1987 field effort was successful in meeting each of the outlined objectives. In addition, due to the low flow conditions, the spawning habitat data collected this year indicates that Arctic grayling are more adaptable to varying habitat conditions than the 1986 data indicated.

Based upon the literature review and last year's experience, the arrival of the migrating Arctic grayling was expected when the afternoon water temperature in Middle Creek approached 7°C. This occurred on May 8, however the fish did not arrive at this time. The spawning migration began on May 29, 1987 when the high water temperature was only 5.5°C. It appears that the grayling had not reached the appropriate state of sexual maturity when the water temperatures were in the 7-8°C range in early May. When the fish did become ripe later in the month they began moving into the stream even though the temperature was lower than that observed in 1986.

The radio-tracking efforts clearly showed that Arctic grayling will move through subreach 2 into subreach 3 in search of spawning habitat. This was further confirmed by the presence of several untagged fish observed in subreach 3. This task may have been somewhat easier in 1987 due to the lower river stage.

The observation of spawning yielded several interesting results. The most significant being that the area influenced by the spawning habitat structure was used extensively for spawning. Spawning was observed in this area and the areas near stakes 10-11 and 13-14 which received the heaviest spawning use at the rate of 11 spawning acts per 30 minutes.

Spawning was also observed at upstream locations, both in subreach 1 and 3, where spawning was not observed in 1986 or by previous investigators.

In several instances during the 1987 spawning run cutthroat trout and Arctic grayling were observed spawning in the same area. This was particularly true at survey stake 14 and at the tail of a pool near marker 19. This phenomenon was never observed during 1986 when these species seemed to clearly divide up the available spawning habitat with the cutthroat preferring shallower, faster water with larger substrate. This observation, combined with the movement of Arctic grayling further upstream to spawn, and the apparent decrease in

spawning habitat indicate that Arctic grayling spawning habitat was somewhat limited in 1987. As a result fish appear to have moved farther upstream looking for suitable habitat or else used habitat that was marginal in 1986 relative to what was available. With the lower flows and limited habitat which were present in 1987, conditions that were marginal in 1986 provided the only available spawning habitat. This may account for the extensive use of habitat created by the spawning enhancement structure.

The success of spawning in the enhancement area is borne out by the fry emergence trap data. Trap 3 located in the spawning enhancement structure produced 693 fry over the 10 day period. Trap 4, located between survey stakes 10 and 11, produced 351 fry over the same period. It appears that the sampling dates may have only caught the tail end of emergence at trap 4, as very few fry emerged over the last 5 days. Generally speaking it appears that these two traps produced similar numbers of fry.

The fry emergence data also indicate that recruitment in 1987 was similar to that reported by Wells for 1975. They further show that Arctic grayling spawned successfully, to a limited degree, in subreach 3. This bears out the conclusion of the 1986 report that a limited amount of habitat suitable for Arctic grayling spawning exists in subreach 3.

Over the course of this two year study spawning habitat data has been collected and used to generate spawning habitat suitability curves based on a total of 175 spawning observations. These data have been used to design a spawning habitat enhancement structure. Information has been gathered which shows that man-created spawning habitat can be used successfully by spawning Arctic grayling. It has been demonstrated that recruitment from created spawning areas is comparable to that from naturally occurring areas. Finally, it has been shown that Arctic grayling will swim up through subreach 2 to reach spawning habitat in subreach 3.

RECOMMENDATIONS

All of the parts of the puzzle are now in hand showing that habitat can be created to mitigate for the loss of spawning habitat downstream of survey stake 16. The remaining task is to select the proper structure and location to construct permanent spawning areas.

The sill type of structure used to create spawning habitat during 1987 suffers from several weaknesses. The type of structure installed in Middle Creek has been described as a "V" shaped gravel trap (Reeves and Roelofs 1982). This type of structure serves to trap gravel suitable for spawning use by salmonids which build redds during spawning. It is used on the west coast for gravel accumulation rather than pool formation (Rosgen and Fittante 1986). As gravel is recruited from upstream reaches and accumulates behind the log sill, it results in a reduction in depth and an increase in velocities. This creates physical habitat characteristics that do not meet the habitat preferences of spawning Arctic grayling. In addition, sediments may be expected to accumulate at the top of the pool created by the log sill which would result in silt and debris being deposited upstream of the dam. These sediments may blanket and destroy riffle areas which are important for spawning and aquatic insect production (Keer Wood Leidal Associates Ltd. et al. 1980). Some sediment was already apparent upstream of the log sill installed in Middle Creek in 1987.

A permanent upstream control structure is the preferred option. The upstream structure is used to control flow through both the downstream reach of stream and on adjacent side channels which may be developed solely for creating suitable spawning habitat for Arctic grayling. The major flood events can be passed through the structure to provide scouring of sediments from the channel. Flows can be controlled as required to provide additional depth or velocity. Flow can be altered to insure that the eggs are covered throughout the incubation period. The life span of such a structure is much longer since it will not silt in. The longer life span and greater flexibility of the permanent upstream structure are great advantages over the downstream sill. It

will be remembered that the favored spawning area in 1986 and for many years prior to that (Wells, pers. comm.) is located at survey stake 14. This area is created by an upstream fallen log.

The best opportunity to create spawning habitat appears to be an abandoned side channel that leaves the stream at approximately survey stake 21 and re-enters near stake 19. A permanent structure could be placed at the head of this side channel and used to divert water into the channel. A detailed survey of this channel would need to be undertaken to determine its length, width, gradient, substrate particle size distribution and other characteristics. Based on this information a preliminary decision could be made as to the suitability of using this side channel and the amount of habitat that would be created.

If this side channel does not appear to be suitable based on a preliminary review, or additional habitat is required for mitigation, other upstream side channels, such as that identified near transect "o" could be investigated.

In addition to developing the side channel habitat it will be important to prepare operations guidelines for the side channel. These would describe how the channel is to be operated (relying heavily on the habitat suitability criteria developed in this study) and maintained.

LITERATURE CITED

Farnes, Phil. SCS Snow Survey Supervisor. Personal communication, 1987.

Fraley, J. J., M. A. Gaub, J. R. Cavigli. 1986. Emergence trap and holding bottle for the capture of salmonid fry in streams. N. Am. J. Fish. Man. (6) 119-121.

HKM Associates. 1985. Middle (Hyalite) Creek dam rehabilitation feasibility study. Prepared for Montana Department of Natural Resources and Conservation, Helena, Montana.

Keer Wood Leidal Associates Ltd. and Lister and Associates Ltd. 1980. Stream enhancement guide. Prepared for Government of Canada, Department of Fisheries and Oceans, Vancouver, British Columbia. 82 pp.

Reeves, G. H. and T. D. Roelofs. 1982. Rehabilitating and enhancing stream habitat: field applications. In: Meehan W. (ed.). Influence of forest and rangeland management on andromous fish habitat in western North America. U.S.D.A. Forest Service, Gen. Tech. Rpt. PNW-140. 38 pp.

Rosgen, D. and B. L. Fittante. 1986. Fish habitat structures - a selection guide using stream classification. In: Miller, J. G., J. A. Arway and R. F. Carline (eds.). Proceedings of the Fifth Trout Stream Habitat Improvement Workshop, August 11-14, 1986. Lock Haven University, Lock Haven, Pennsylvania. pp. 163-179.

Wells, Jerry. Regional Fisheries Biologist, Montana Department of Fish, Wildlife and Parks. Personal communication, 1987.

APPENDIX A

Permit Application

MONTANA FISH AND GAME COMMISSION

NOTICE OF CONSTRUCTION OR HYDRAULIC PROJECT AFFECTING FISHING WATERS

(Submit in Duplicate)

TO: MONTANA FISH AND GAME COMMISSION
Mitchell Building
Helena, Montana 59601

Helena, Montana

November 5, 19 86

Pursuant to the provisions of Section 26-1502, R.C.M. 1947, YOU WILL PLEASE TAKE NOTICE that preliminary plans*, two copies of which are enclosed herewith, have been completed for a construction project or hydraulic project, hereinafter more fully described, which may or will affect or change in some way the natural existing shape and form of a stream or its banks or tributaries.

SPONSORING AGENCY

Address: Montana Department of Natural Resources and Conservation
Water Resources Division-Engineering Bureau
Capitol Station
Helena, Montana 59620

Official in charge: Robert Clark
Title: Project Engineer
Contact Person: Same
Title:
Tel. No.: 444-6646

Submitted by: _____
(signature)

STREAM, RIVER OR LAKE INVOLVED

(Describe by name, if named)
West Fork of Hyalite (Middle) Creek

PROJECT IDENTIFICATION

Project Name: West Fork Arctic Grayling Spawning Habitat Enhancement Project No.: _____
Type of Project: Instream structures to enhance arctic grayling spawning

PROJECT LOCATION

County: Gallatin
Between: Hyalite Reservoir and West Fork of Hyalite Creek
(reference to towns, local landmarks, bridges, etc.)
Project begins, or is located in, Township 4 South Range 6 East Section 23

PROJECT FEATURES

(check applicable items)

Bridges:	_____	Channel Realignment:	_____
Dredging for:		Channel Bank Modifications:	_____
Flood Control	_____	Hydraulic Structures:	_____
Materials Source	_____	Storage Dams	_____
Channel Clearance	_____	Diversion Dams	_____
Stream Culverts:	_____	Water Supply Intakes	_____

Other: (explain) See attachments (Figures 1-2, Map 1, narrative)

PROJECT SCHEDULING

Contract Letting — Tentative date: Completed
Begin Construction — Tentative date: 11-15-86
Probable Project Construction Period: 11-15-86 to 11-18-86

DATA SUBMITTED HEREWITH

(please check)

Plans	X	Engineering Report:	_____
Sketches	X	Other:	_____

Has previous correspondence on this project been directed to the Montana Fish and Game Commission? Yes _____ No _____ Jerry Wells (MDPWP) visited site on 10-23-86. Mr. Wells provided consultation on proposed project and agreed verbally to work described.

*Two sets of preliminary plans or sketches of construction projects in the vicinity of stream, rivers or lakes must accompany this notice. If plans or sketches are not available, please explain: _____

Note: Receipt of this form will be acknowledged by letter.

FG-124—5M Trip. 5-74

Western Business Forms, Billings, Montana
Complied with 82—1137 R.C.M.

ACTIVITY

Three separate arctic grayling spawning enhancement structures will be constructed using naturally occurring materials. The first structure (Figure 1) located near 7+00 (Map 1) will consist of a log crib structure with a downstream-facing "V" configuration. Sill logs will be buried in the streambed. Notches may be cut in the logs to direct flows on the left downstream side of the island that will be favorable for grayling spawning. Flows around the right downstream side will be similarly controlled to avoid unnatural erosion of the right downstream bank. There may be very minor excavation on the left downstream bank side of the island to provide depths of two to three feet for cover for resting grayling. Several cubic yards of gravel (one to three inches in diameter) may be placed in this same area. This size material is preferred by grayling for spawning.

The second site (Figure 2) will be located at approximately 11+00 (Map 1). Just upstream of this site a naturally occurring log jam extends from the left downstream bank to mid-channel. The substrate at this site is suitable for arctic grayling spawning obviating the need to place gravel substrate.

Water depth will be increased here by placing the sill just downstream of the log jam. The log sill structure will be constructed as described above.

The third site (Figure 2 and Map 1) is located upstream of survey marker 12+00. In the location substrate appears to be suitable for grayling spawning, but velocities are too high and water depths too shallow. The log sill structure will reduce velocities and increase water depths.

PURPOSE

The purpose of this project is to demonstrate the ability to create arctic grayling spawning habitat that will be used successfully. This is part of an overall plan to rehabilitate the Hyalite Reservoir Dam which is in need of repair. Arctic grayling live in the reservoir and spawn in the principal tributary (West Fork of Hyalite Creek). The spawning areas would be inundated by the proposed rehabilitation. Thus the necessity to demonstrate that suitable spawning habitat can be created upstream. The arctic grayling is a Class A Montana Species of Special Concern.

DISCHARGE OF DREDGED OR FILL MATERIAL

There would be no discharge of dredged or fill material.

NAMES AND ADDRESSES OF ADJOINING PROPERTY OWNERS, LESSEES, ETC., WHOSE PROPERTY ALSO ADJOINS THE WATERWAY

The lands adjoining the waterway in the area of the proposed project are owned by the State of Montana, Department of Natural Resources and Conservation, Capitol Station, Helena, Montana. Upstream lands adjoining the waterway are owned by the U.S. Forest Service, Gallatin National Forest, Bozeman, Montana.

APPLICATION FOR DEPARTMENT OF THE ARMY PERMIT

(33 CFR 325)

OMB APPROVAL NO. 0702-0036
Expires 30 June 1986

The Department of the Army permit program is authorized by Section 10 of the River and Harbor Act of 1899, Section 404 of the Clean Water Act and Section 103 of the Marine, Protection, Research and Sanctuaries Act. These laws require permits authorizing activities in or affecting navigable waters of the United States, the discharge of dredged or fill material into waters of the United States, and the transportation of dredged material for the purpose of dumping it into ocean waters. Information provided on this form will be used in evaluating the application for a permit. Information in this application is made a matter of public record through issuance of a public notice. Disclosure of the information requested is voluntary; however, the data requested are necessary in order to communicate with the applicant and to evaluate the permit application. If necessary information is not provided, the permit application cannot be processed nor can a permit be issued.

One set of original drawings or good reproducible copies which show the location and character of the proposed activity must be attached to this application *(see sample drawings and instructions)* and be submitted to the District Engineer having jurisdiction over the location of the proposed activity. An application that is not completed in full will be returned.

1. APPLICATION NUMBER *(To be assigned by Corps)*

3. NAME, ADDRESS, AND TITLE OF AUTHORIZED AGENT
None

Telephone no. during business hours
A/C ( ) _____ *(Residence)*
A/C ( ) _____ *(Office)*

2. NAME AND ADDRESS OF APPLICANT
Montana Dept. of Natural Resources and Conservation
Water Resources Division-Engineering Bureau
Mr. Robert Clark
Capitol Station, Helena, Montana 59620

Telephone no. during business hours
A/C ( ) _____ *(Residence)*
A/C (406) 444-6646 *(Office)*

Statement of Authorization: I hereby designate and authorize _____ to act in my behalf as my agent in the processing of this permit application and to furnish, upon request, supplemental information in support of the application.

SIGNATURE OF APPLICANT | DATE

4. DETAILED DESCRIPTION OF PROPOSED ACTIVITY

4a. ACTIVITY Three separate arctic grayling spawning enhancement structures will be constructed using naturally occurring materials. The first structure (Figure 1) located near 7+00 (Map 1) will consist of a log crib structure with a downstream-facing "V" configuration. Sill logs will be buried in the streambed. Notches may be cut in the logs to direct flows on the left downstream side of the island that will be favorable for grayling spawning. Flows around the right downstream side will be similarly controlled to avoid unnatural erosion of the right downstream bank. There may be very minor excavation on the left downstream bank side of the island to provide depths of two to three feet for cover for resting grayling. Several cubic yards of gravel (one to three inches in diameter) may be placed in this same area. This size material is preferred by grayling for spawning. (Continued on separate page).

4b. PURPOSE The purpose of this project is to demonstrate the ability to create arctic grayling spawning habitat that will be used successfully. This is part of an overall plan to rehabilitate the Hyalite Reservoir Dam which is in need of repair. Arctic grayling live in the reservoir and spawn in the principal tributary (West Fork of Hyalite Creek). The spawning areas would be inundated by the proposed rehabilitation. Thus the necessity to demonstrate that suitable spawning habitat can be created upstream. The arctic grayling is a Class A Montana Species of Special Concern.

4c. DISCHARGE OF DREDGED OR FILL MATERIAL
There would be no discharge of dredged or fill material.

5 NAMES AND ADDRESSES OF ADJOINING PROPERTY OWNERS, LESSEES, ETC., WHOSE PROPERTY ALSO ADJOINS THE WATERWAY

The lands adjoining the waterway in the area of the proposed project are owned by the State of Montana, Department of Natural Resources and Conservation, Capitol Station, Helena, Montana. Upstream lands adjoining the waterway are owned by the U.S. Forest Service, Gallatin National Forest, Bozeman, Montana.

6. WATERBODY AND LOCATION ON WATERBODY WHERE ACTIVITY EXISTS OR IS PROPOSED

The waterbody is the West Fork of Hyalite (Middle) Creek immediately upstream of Hyalite Reservoir.

7. LOCATION ON LAND WHERE ACTIVITY EXISTS OR IS PROPOSED

ADDRESS:

T4S, R6E, Section 23
STREET, ROAD, ROUTE OR OTHER DESCRIPTIVE LOCATION

Gallatin (COUNTY) Montana (STATE) 59715 (ZIP CODE)

LOCAL GOVERNING BODY WITH JURISDICTION OVER SITE

8. Is any portion of the activity for which authorization is sought now complete? ☐ YES ☒ NO
If answer is "Yes" give reasons, month and year the activity was completed. Indicate the existing work on the drawings.

9. List all approvals or certifications and denials received from other federal, interstate, state or local agencies for any structures, construction, discharges or other activities described in this application.

ISSUING AGENCY	TYPE APPROVAL	IDENTIFICATION NO.	DATE OF APPLICATION	DATE OF APPROVAL	DATE OF DENIAL

10. Application is hereby made for a permit or permits to authorize the activities described herein. I certify that I am familiar with the information contained in this application, and that to the best of my knowledge and belief such information is true, complete, and accurate. I further certify that I possess the authority to undertake the proposed activities or I am acting as the duly authorized agent of the applicant.

SIGNATURE OF APPLICANT _____ DATE _____ SIGNATURE OF AGENT _____ DATE _____

The application must be signed by the person who desires to undertake the proposed activity (applicant) or it may be signed by a duly authorized agent if the statement in Block 3 has been filled out and signed.

18 U.S.C. Section 1001 provides that: Whoever, in any manner within the jurisdiction of any department or agency of The United States knowingly and willfully falsifies, conceals, or covers up by any trick, scheme, or device a material fact or makes any false, fictitious or fraudulent statements or representations or makes or uses any false writing or document knowing same to contain any false fictitious or fraudulent statement or entry, shall be fined not more than $10,000 or imprisoned not more than five years, or both.

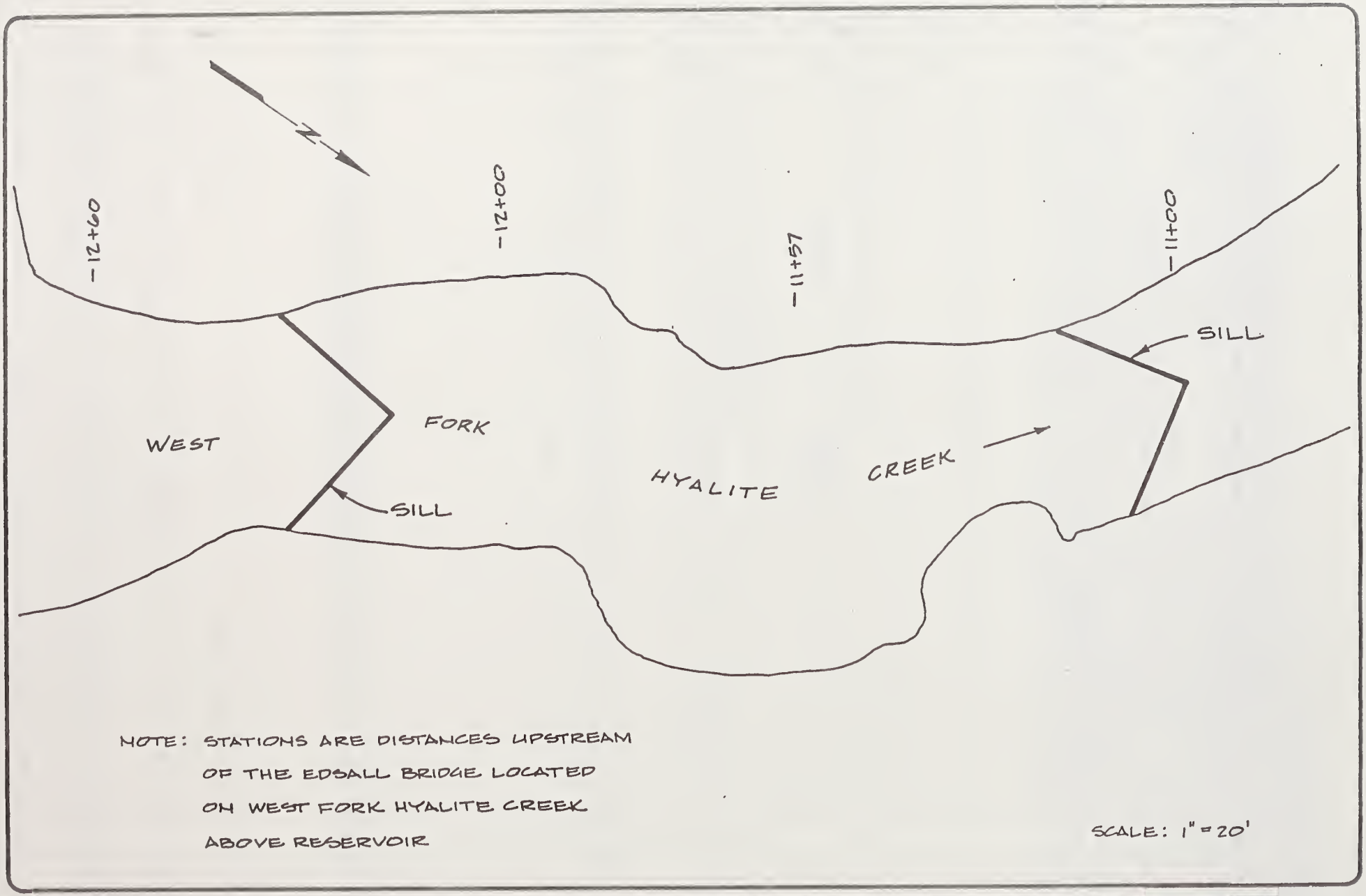
Do not send a permit processing fee with this application. The appropriate fee will be assessed when a permit is issued.

4a. ACTIVITY (Continued).

The second site (Figure 2) will be located at approximately 11+00 (Map 1). Just upstream of this site a naturally occurring log jam extends from the left downstream bank to mid-channel. The substrate at this site is suitable for arctic grayling spawning obviating the need to place gravel substrate.

Water depth will be increased here by placing the sill just downstream of the log jam. The log sill structure will be constructed as described above.

The third site (Figure 2 and Map 1) is located upstream of survey marker 12+00. In the location substrate appears to be suitable for grayling spawning, but velocities are too high and water depths too shallow. The log sill structure will reduce velocities and increase water depths.



NOTE: STATIONS ARE DISTANCES UPSTREAM OF THE EDSALL BRIDGE LOCATED ON WEST FORK HYALITE CREEK ABOVE RESERVOIR

SCALE: 1" = 20'

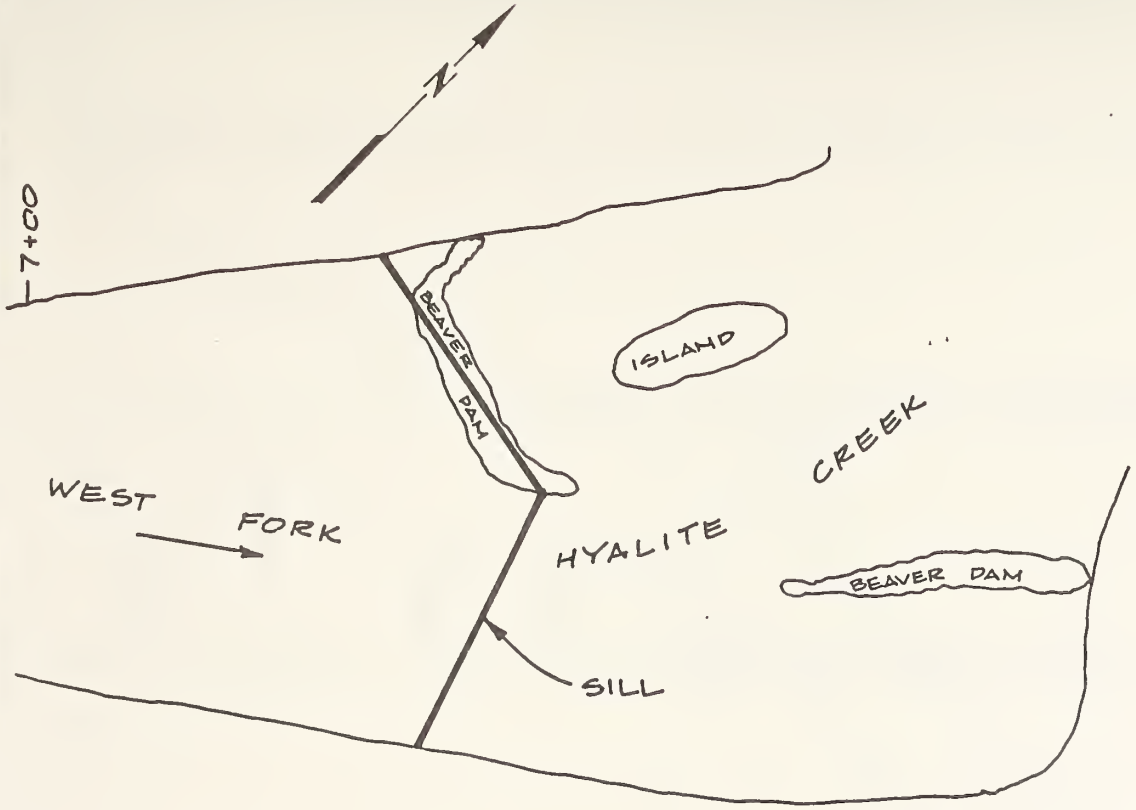
HYALITE CREEK

PROPOSED GRAYLING MITIGATION MEASURES

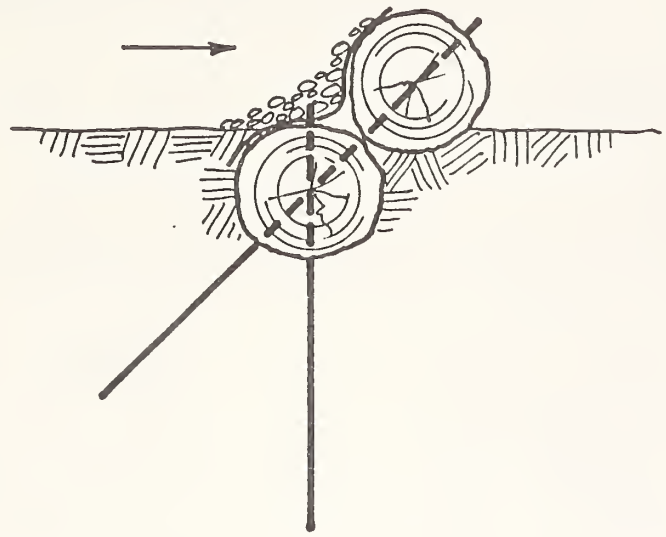
FIGURE 1

HKM ASSOCIATES
ENGINEERS · PLANNERS

8M087.121 | NOV 1986



SILL DETAIL



NOTE: STATIONS ARE DISTANCES UPSTREAM OF THE EDSALL BRIDGE LOCATED ON WEST FORK HYALITE CREEK ABOVE RESERVOIR

SCALE: 1" = 20'

HYALITE CREEK

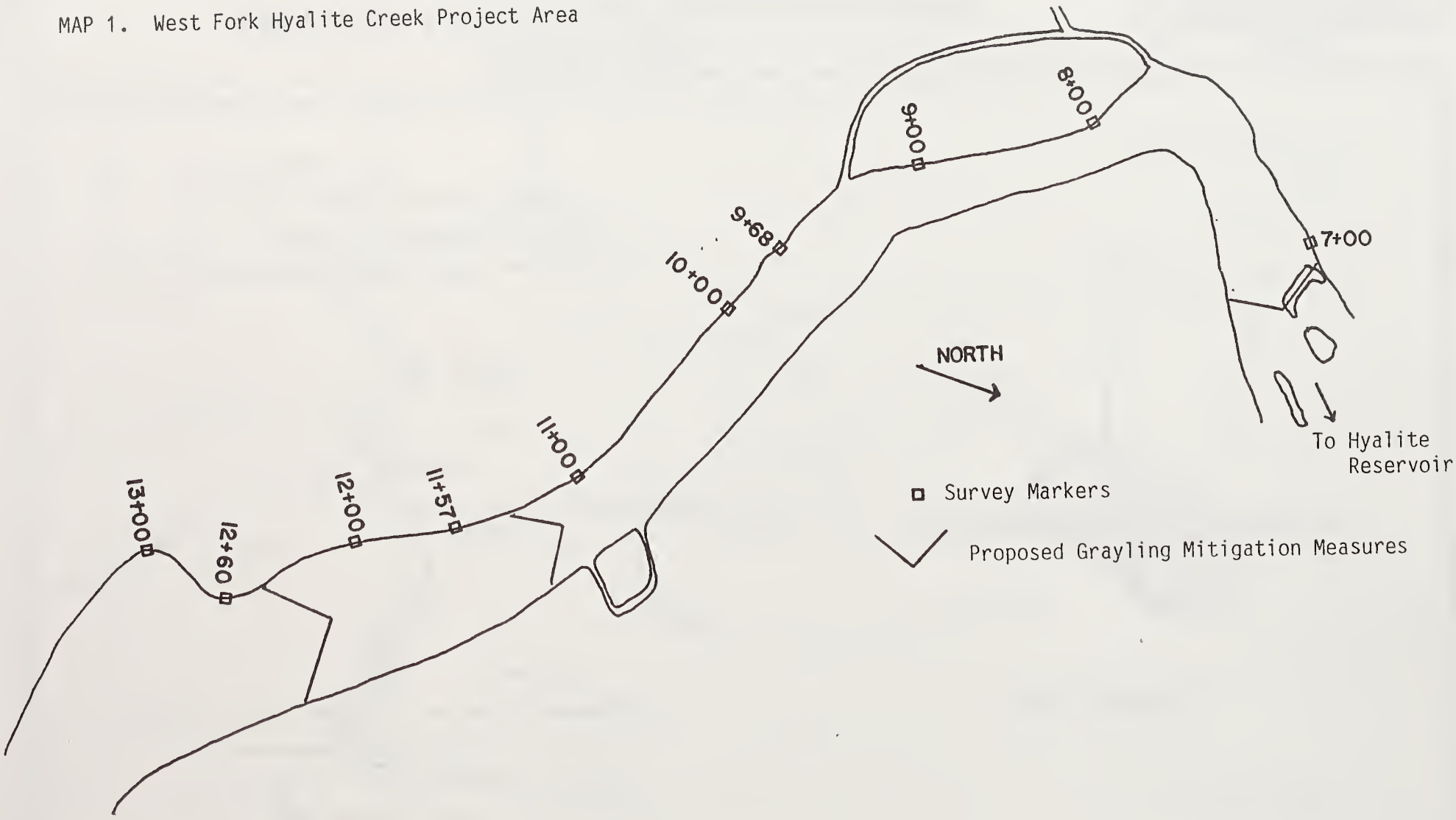
PROPOSED GRAYLING MITIGATION MEASURES

FIGURE 2

HKM ASSOCIATES
ENGINEERS · PLANNERS

8M087.121 | NOV 1986

MAP 1. West Fork Hyalite Creek Project Area



	1	2	3	4	5	6
1	1986 DATA					
2	DEPTH (FT)	6/10 VELOCITY	NOSE VELOCITY			
3	2.45	4.35	1.2			
4	1.44	1.75	0.9			
5	1.41	4.5	2.4			
6	1.01	3.3	2.4			
7	1.1	1.68	1			
8	1.35	3.35	1.25			
9	1.35	3.35	1.25			
10	1.18	3.4	1.1			
11	1.05	3.3	1.94			
12	1.05	3.3	2.05			
13	1.16	4.26	1.99			
14	1.19	4.05	2.26			
15	1.16	2.8	1.9			
16	1.45	5.1	2.3			
17	1.51	3.85	1.06			
18	1.38	4.22	2.9			
19	1.4	4.26	2.24			
20	1.38	3.83	1.13			
21	1.25	2.35	1.43			
22	1.13	3.55	1.36			
23	1.13	3.55	1.36			
24	1.34	3.53	1.29			
25	1.1	3.3	1.9			
26	1.1	3.4	1.52			
27	1.25	4.03	2.06			
28	1.05	3.35	2.04			
29	1.05	3.35	2.04			
30	1.05	3.35	2.04			
31	1.05	2.89	1.98			
32	1.03	3.42	1.87			
33	1.31	3.82	2.47			
34	1.25	4.04	1.2			
35	1.15	3.8	2.55			
36	1.7	4.24	1.75			
37	1.15	4.31	1.67			
38	1.11	3.93	2.37			
39	1.11	3.24	1.17			
40	1.25	3.55	2.13			
41	1.42	2.6	1.67			
42	1.62	2.1	1.25			
43	2	2.23	1.51			
44	1.75	2.15	1.17			
45	1.4	2.23	2			
46	1.6	1.72	1.55			
47	1.65	1.51	1.27			
48	1.76	1.37	1.02			
49	1.2	2.48	2.01			
50	1.2	2.48	2.01			
51	2.22	2.43	1.21			
52	1.8	2.75	1.75			
53	1.28	2.15	1.78			

APPENDIX B

1986 and 1987 Habitat Utilization Data

	1	2	3	4	5	6
54	1.5	2.08	1.93			
55	1.78	1.73	0.78			
56	1.75	1.82	1.2			
57	1.42	2.04	1.79			
58	1.64	1.46	1.09			
59	1.2	1.6	1.45			
60	1.58	2.6	1.7			
61	0.42	2.85	2.32			
62	0.55	2.46	1.65			
63	0.89	3.43	2.41			
64	0.98	2.95	2.1			
65	0.54	3.48	2.5			
66	0.58	3.7	2.57			
67	0.97	3.8	1.64			
68	0.52	3.37	1.81			
69	0.81	2.38	1.77			
70	0.62	2.68	2.1			
71	0.55	2.93	2.27			
72	0.68	2.82	2.2			
73	0.71	2.84	2.06			
74	0.95	3.63	2.07			
75	0.95	2.99	1.65			
76	MEAN DEPTH	MEAN 6/10 VELOC.	MEAN NOSE VEL			
77	1.2338356	3.0615068493151	1.763424657534			
78	S.D.	S.D.	S.D.			
79	0.3892323	0.8555905550374	0.481214375819			
80						
81	1987 DATA					
82	1.75	1.7	1.25			
83	1.6	1.65	1.29			
84	0.8	1.26	1.2			
85	0.8	1.26	1.2			
86	0.85	1.32	0.747			
87	0.85	1.32	0.747			
88	0.85	1.32	0.747			
89	0.85	1.32	0.747			
90	0.85	1.32	0.747			
91	0.85	1.32	0.747			
92	0.85	1.32	0.747			
93	0.85	1.32	0.747			
94	0.85	1.32	0.747			
95	1.05	1.26	0.78			
96	1.05	1.26	0.78			
97	0.6	1.09	0.818			
98	0.6	1.09	0.818			
99	1.1	1.44	0.968			
100	1.3	1.62	1.2			
101	0.8	2.55	1.7			
102	0.8	2.55	1.7			
103	1.35	2.68	2.2			
104	1.35	2.68	2.2			
105	1.35	2.68	2.2			
106	1.35	2.68	2.2			

	1	2	3	4	5	6
107	1.3	2.5	1.54			
108	1.3	2.5	1.54			
109	1.3	2.5	1.54			
110	1.3	2.5	1.54			
111	1.3	2.5	1.54			
112	1.3	2.5	1.54			
113	0.9	1.35	1			
114	0.97	1.23	0.86			
115	0.8	0.84	0.72			
116	0.88	1.16	0.78			
117	0.78	1.29	0.97			
118	0.78	1.54	1.23			
119	1.23	1.62	1.29			
120	1.15	1.54	1.29			
121	1.2	1.62	1.29			
122	1.25	1.62	1.29			
123	1	1.75	1.33			
124	1.25	1.72	1.11			
125	0.65	1.58	1.29			
126	0.8	2.61	2.05			
127	1.3	1.75	1.51			
128	1.3	2.55	1.92			
129	1.3	2.55	1.92			
130	1.4	2.55	1.84			
131	1.25	2.86	1.96			
132	1.3	2.55	1.75			
133	0.7	3.15	5.5			
134	0.75	3.28	3			
135	0.7	2.8	3.8			
136	1	3.28	4.9			
137	0.8	2.8	3.3			
138	1.05	2.8	4.4			
139	1.05	2.8	4.5			
140	1.1	2.8	3.3			
141	1.1	2.8	3.3			
142	0.95	2.45	4.4			
143	0.95	2.8	4.5			
144	0.95	2.8	3.3			
145	1.25	2.6	3.3			
146	1.25	2.6	3.3			
147	0.7	2.3	3.8			
148	0.7	2.3	3.8			
149	1	2.1	3.3			
150	0.6	1.6	1.76			
151	0.6	2	2.2			
152	0.6	2	2.2			
153	0.6	2	2.2			
154	0.7	1.8	2.2			
155	0.6	2.1	2.7			
156	0.8	2.5	2.9			
157	0.8	2.8	2.9			
158	0.6	2.8	2.1			
159	0.6	2.8	2.7			

	1	2	3	4	5	6
160	0.7	2.5	2.9			
161	1.4	2.3	2.3			
162	1.3	2.3	3.9			
163	1.4	4.9	2.3			
164	1.2	4.1	5			
165	1.35	4.6	5.4			
166	1.2	3.8	4.4			
167	1.2	3.1	4.4			
168	1.3	3.8	3.8			
169	1.3	4.2	3.9			
170	1.5	2.9	4			
171	1.5	2.9	4			
172	1.5	2.9	4			
173	1.5	2.9	4			
174	1.5	2.9	4			
175	1.4	2.2	3.9			
176	1.1	1.5	2.8			
177	1.1	1.5	2.8			
178	1.1	1.5	2.8			
179	1.3	1.3	1.8			
180	1.3	1.3	1.8			
181	1.3	1.3	1.6			
182	MEAN	MEAN	MEAN			
183	1.0554	2.2217	2.31227			
184	S.D.	S.D.	S.D.			
185	0.8220977	1.296286450877	#DIV/0!			
186						