Exxon Valdez Oil Spill
Restoration Project Final Report

Rocky Creek Cutthroat Trout Habitat Enhancement

Restoration Project 94043B2
Final Report

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Study History: This project was initiated under Restoration Project 94043. No other reports or publications have been issued on this project. The implementation of the habitat enhancement work was carried out in 1994 and monitoring was done in 1995. *Exxon Valdez* oil spill funds are not available for further monitoring, but additional monitoring will be done by the US Forest Service to document the effects of these enhancement structures on the Rocky Creek cutthroat trout population. Supplemental reports may be issued.

Abstract: The 1989 *Exxon Valdez* oil spill adversely affected cutthroat trout (*Oncorhynchus clarki*) populations in Prince William Sound. Most of the populations are small and could be especially sensitive to environmental impacts. It was felt that if the small anadromous population in Rocky Creek could be enhanced, it could better withstand adverse impacts in the future. Preserving populations is especially important since little is known about cutthroat genetics in the Sound, and unique stocks may be present. Surveys indicated that the limiting factors to cutthroat production in the system are spawning area and rearing habitat for first-year fish. In 1994, 18 instream structures were built in two small tributaries to create spawning and rearing area. In 1995, monitoring showed that the structures had generally created the desired pools and spawning areas and that cutthroat trout spawning had occurred at one of the structures. Pink salmon (*Oncorhynchus gorbuscha*) and coho salmon (*Oncorhynchus kisutch*) were observed spawning at some of the structures in September. These structures will be monitored for the next several years to determine how the habitat is being utilized and how the cutthroat trout population has responded.

Key Words: *Exxon Valdez*, cutthroat trout, *Oncorhynchus clarki*, habitat enhancement, instream structures, spawning, rearing habitat.

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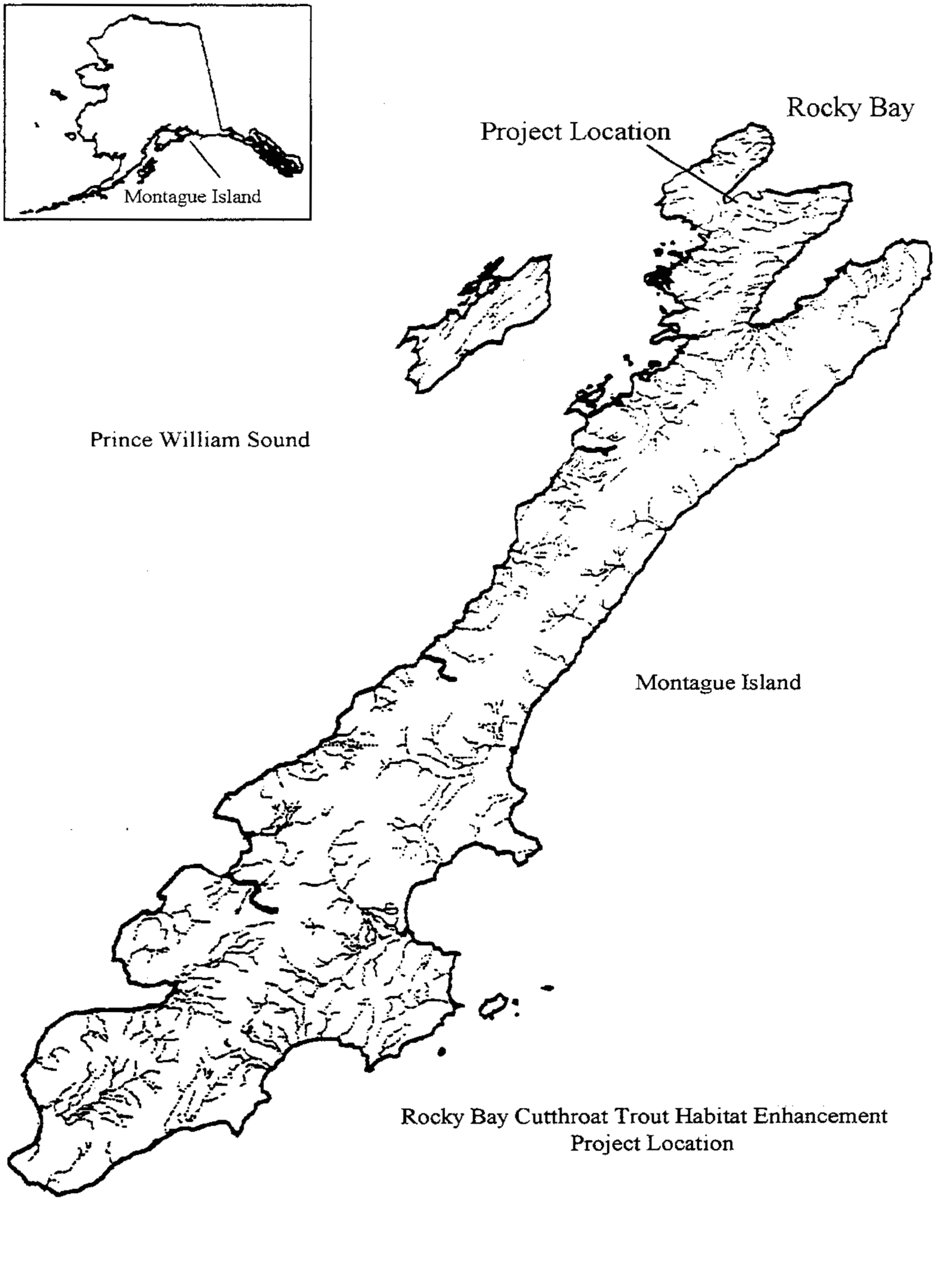
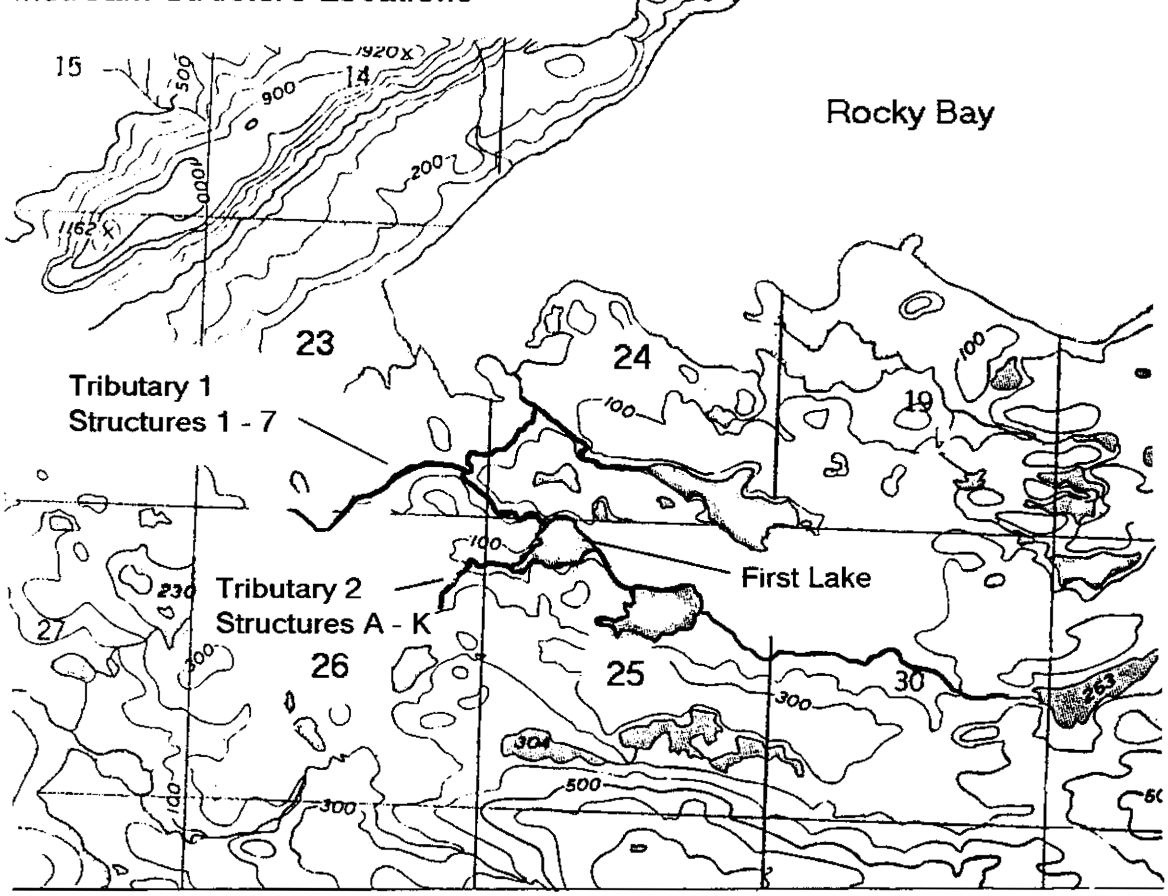


Rocky Bay Cutthroat Trout Habitat Enhancement
Project Location

Rocky Creek Cutthroat Trout
Habitat Enhancement Project 95043
Instream Structure Locations



Location: Seward B-1 Quadrangle, Seward Meridian
T 3N, R 13E, Sections 23, 24, 25, 26.
Structures on Tributaries to Rocky Creek, Montague Island

Executive Summary

Introduction

Studies by the Alaska Department of Fish and Game showed that anadromous cutthroat trout (*Oncorhynchus clarki*) were adversely affected by the *Exxon Valdez* oil spill. Since populations of cutthroat trout in Prince William Sound are naturally small and variable, they are especially sensitive to the effects of catastrophic events. Protection of these populations is also important because little is known about cutthroat trout genetics in the Sound. The populations are at the northern limit of the range of cutthroat trout and are relatively isolated from other stocks. It is quite possible that unique genetic adaptations and strains have developed in this area. Genetic studies are planned to begin in 1996, but until more is known, it is essential to preserve the existing cutthroat populations.

The degree of injury to the Rocky Creek population is uncertain, but it was felt that the best way to protect the stock from lingering effects of the spill or events in the future would be to enhance the population through habitat improvement. Surveys in the Rocky Creek watershed indicated that spawning area and first-year rearing habitat were the factors limiting cutthroat trout production. By increasing the amount of spawning and rearing area, cutthroat production would be improved. The population should then be better able to recover from the effects of the spill and withstand impacts that could occur in the future.

Methods

Habitat surveys conducted in 1991, 1992, and 1994 indicated that the lack of good spawning and rearing habitat was limiting cutthroat trout production in the Rocky Creek system. In 1994, 18 log and boulder structures were built on two small tributaries to create spawning and rearing habitat. The structures are designed to scour pools, create backwaters, trap spawning gravel above the structures, and create spawning areas in the tailouts of the pools. First-year fish use the backwaters and edges of the pools for rearing and the deeper areas of the pools for overwintering habitat.

Habitat maps were drawn of the structure sites before and after the structures were built to document the changes in habitat. To monitor the response of the cutthroat population, a spawning survey was conducted in May 1995. In September 1995 a crew inspected the sites for use by juvenile fish, modified the structures as needed, and remapped the areas. Additional habitat and population monitoring will need to be conducted in the future. The structures are still in the process of scouring pools and collecting gravel, and the cutthroat population has not had time to fully respond.

Results

Most of the structures are performing as planned and creating the habitat as intended. Two structures designed to create backwater areas have not been fully effective, however. The structures have created an additional 1,074 sq. ft. of pool habitat and 14 sq. ft. of undercut bank. Spawning area cannot yet be calculated since gravel is still being trapped above most of the structures, and the pools are still enlarging. When the pools have stabilized, gravel will collect in the pool tailouts, forming additional spawning areas. During the May spawning survey, one cutthroat trout redd was found in the tailout of a pool created by a structure. In September, no cutthroat juveniles were observed. Pink salmon had used some of the structure areas for spawning, and it appeared that coho salmon were going to use several areas as well.

Discussion

The use of one of the structures by spawning cutthroat trout is encouraging because it shows that the structures are creating the kind of spawning area that was intended. Most of the structures are still forming the pools and trapping gravel, however, so we anticipate greater use in the future. The presence of pink and coho salmon also indicates that the spawning areas are developing. Our experience with other structure work is that it takes several years for the pools to fully develop and stabilize.

Although no cutthroat trout juveniles were observed at the structures, it is possible there were some in areas where they were not readily visible. Since only one redd was observed at the structure sites and the population is not expected to respond for several years, an exhaustive search for juveniles was not undertaken.

The presence of coho salmon may be a problem, however. Juvenile coho are quite aggressive and can outcompete juvenile cutthroat for the preferred habitat. One report indicates that cutthroat production can be lowered by the presence of coho juveniles. This is why cutthroat generally spawn in smaller tributaries and headwaters where coho are less likely to be found. In our initial surveys we did not see any sign of coho adults or juveniles and thought that the streams would be too small for coho spawning. Approximately 20 adult coho were found in the first tributary, and one was found in the second. It appears that there will be coho juveniles to compete with cutthroat in the first tributary, and cutthroat production may be affected. The gradient of the second tributary is higher than the first, and the stream is not as suitable for coho spawning. It does not appear that many coho will move up this stream to look for spawning areas, and competition from coho juveniles may not be a serious problem.

It may take the cutthroat population a generation (3-4 years) or more to respond to this enhancement project. Although no further oil spill funds are available, we will continue to monitor the population and make reports available as new findings are made. Based on reports in the literature and experience with other projects, we feel confident that this project will improve cutthroat trout spawning and help juvenile cutthroat trout in their critical early life history stages. This should bolster the Rocky Creek cutthroat population and help protect it against impacts in the future.

INTRODUCTION

Prince William Sound is the northern limit of the range of cutthroat trout (*Oncorhynchus clarki*). Although there is not much information available about cutthroat trout in this area, the Alaska Department of Fish and Game has found that many of the stocks are small and display high annual fluctuations in production (Whitmore et al. 1991). Because of this, these populations may be susceptible to over-exploitation by anglers, and presumably, may be sensitive to other adverse impacts.

Another problem is that little is known about cutthroat genetics in Prince William Sound. Some initial electrophoretic studies indicate that there are significant differences between cutthroat trout from the Cordova area, which includes Boswell Bay on the eastern edge of the Sound and Martin Lake 50 miles farther east, and cutthroat from the rest of Alaska and the Pacific Northwest (Gordon Reeves, Thomas Williams, USDA PNW Research Station, personal communications). Thus, it is highly possible that some unique genetic strains exist in the Sound because of their relative isolation from other stocks and the harsher environmental conditions this far north. In a similar situation, Brown et al. (1994) expressed concern that unique stocks of coho salmon (*Oncorhynchus kisutch*) in central California could be lost due to environmental disasters. As with cutthroat trout in the Sound, these coho salmon populations are small and reside in the extreme limit of the range of the species. Thus, until more is known about the cutthroat trout populations and genetics, it will be especially important to protect the stocks against adverse impacts.

Following the 1989 *Exxon Valdez* oil spill, studies by the Alaska Department of Fish and Game showed that growth rates for cutthroat trout were significantly lower in oiled areas versus non-oiled areas (Hepler et al. 1993). Although there is some question as to how much the Rocky Bay population was affected (Hepler et al. 1990; Hepler et al. 1993), it was shown that the adult anadromous population was quite small, with less than 100 individuals outmigrating from the system from 1989 to 1991.

Forest Service surveys indicated that there is a large amount of habitat for older fish in the lakes of the Rocky Creek system, but spawning area and rearing area for young-of-the-year fish is lacking. Cutthroat trout prefer to spawn and rear in smaller streams or headwaters where water velocities are reduced and coho salmon spawning generally does not occur Trotter (1989). This reduces competition between cutthroat and coho salmon juveniles (Pauley et al. 1989, Trotter 1989), which is important since coho juveniles will outcompete cutthroat juveniles and force them into less desirable habitat (Tripp and McCart 1983, Glova 1984). In the Rocky Creek watershed, however, the amount of ideal cutthroat trout habitat is limited. It was felt that if spawning and rearing habitat could be improved or increased in the smaller tributaries where coho were not present, the cutthroat population could be increased. With a larger population, cutthroat would be better able to withstand the effects of oil spills or other adverse impacts in the future.

PROJECT DESCRIPTION

The project sites are in two tributaries of Rocky Creek, which flows into Rocky Bay on the north end of Montague Island. The tributaries are both small groundwater fed streams. The tributaries are surrounded by fens and have good flows even during summer low flow conditions. The streams are from 5 to 15 feet wide with an average depth of 6 - 10 inches. The gradient for the project area on the first tributary is mainly 0 - 0.5%, while the area on the second tributary is mostly 0.5 - 2%. The substrate is composed of shales and other sedimentary rock forming gravels (.16 - 2.5 inches) and cobbles (2.5 - 10 inches). There are, however, very few logs, boulders, or other features which would form the pools and backwaters which are the preferred habitats of young cutthroat trout (Trotter 1989, Moore and Gregory 1988, Tripp and McCart 1983). Tailout areas of pools also provide good spawning areas, but these are lacking in these streams.

The goal of this project is to enhance the spawning and rearing habitat with instream structures. The structures would create the habitat normally made by large woody material in other streams, increasing the stream complexity and providing the pool and lateral habitat that are important for cutthroat trout spawning and rearing (Moore and Gregory 1988). Similar habitat enhancement projects have successfully increased the densities of young-of-the-year cutthroat trout (Moore and Gregory 1988) and the number of cutthroat trout parr and other salmonids (House and Boehne 1985).

There are a number of different structures that can be used depending on the desired effect and the site-specific channel characteristics. Some structures, such as V-shaped log weirs or single-log weirs, work by slowing down water velocities and accumulating spawning gravels above the structures. Water moving over or around the structures will also create pools used for summer and winter rearing areas. Additional spawning area is formed in the tailouts of the pools. Pool tailouts are particularly good for spawning since the slope forces water into the gravel, helping to oxygenate the eggs and carry off metabolic wastes (Bjornn and Reiser 1991). Some structures, such as log barbs, are used primarily to create quiet backwaters to provide rearing habitat for young fish. Deflectors form backwater pools and lateral pool areas. Since the lack of spawning and rearing area is thought to limit cutthroat trout production in these streams, the creation of additional habitat with these structures should lead to an increase in the population.

METHODS

Habitat surveys in the Rocky Creek watershed were conducted in 1978 and 1980 prior to the construction of a fish ladder, with more recent surveys in 1991, 1992, and 1994. The surveys showed that cutthroat spawning area was limited due to large substrates, high flows, or, in the case of the two streams where the structures were built, the lack of instream material to trap gravels or form pools. Another problem in some streams was the high number of juvenile coho salmon. While the two project streams were surveyed, the crew looked for coho juveniles, but none was seen.

Prior to the building of the structures the streams were checked for the presence of pink salmon, pink salmon carcasses, or redds. During the public comment period there had been concern that construction could interfere with pink salmon spawning. However, no salmon, carcasses, or redds were present in these streams.

The structures were built out of logs or boulders by a crew of four people using hand tools and small power tools, such as chain saws, gas powered drills, and a gas powered winch. No vehicles or heavy equipment were used. Logs were selected that were close to the site and could be moved without causing damage to the banks or stream. The logs were generally 10 to 15 feet long and 12 to 18 inches in diameter.

The structures were held in place by cabling the logs to stumps at the site, pinning the logs to the streambed with four-foot lengths of rebar, placing the log in trenches dug into the bank, or some combination of these methods. The ends of the structure and the banks were lined with large rocks to prevent erosion.

To document the conditions before construction at each structure site a habitat map was drawn. This map contained information on the width of the stream, the bankfull width, habitat types, depths, and spawning area. The information was collected on the upstream and downstream sides of the structures.

In May and September 1995 the structures were monitored to determine whether they were creating the desired pool, rearing, and spawning areas. The areas were resurveyed and mapped to document the changes in habitat, substrate, and channel morphology. At four of the sites the structures had not yet scoured sufficiently large pools. At these sites the existing pools were enlarged by moving some embedded boulders, and if needed, the structures were modified. The presence of cutthroat trout, redds, or other salmonids was determined visually.

The quality of the spawning substrate was rated in the spawning areas created by the structures. Cutthroat prefer smaller spawning gravel in the 0.5 - 1.0 inch range. The area was rated excellent if it contained 70 - 100% gravel (0.16 - 2.5 inches) and less than 10% fine material (<0.16 inches). Good areas had 50 - 80 % gravel, but greater amounts of fine material.

Areas were rated fair if there was 40 - 50% gravel, with the rest being cobble (2.5 - 10 inches) or fine material. All of the areas rated poor had less than 20% gravel and had high percentages of cobble or boulder (> 10 inches). Most of the areas rated as poor were in the second tributary where the gradient was steeper. We expect additional gravel to collect above the structures and in the pool tailouts at these sites, but it may take several years for the gravel to accumulate and stabilize.

Monitoring will continue in the future. Population estimates of the juvenile cutthroat trout using the newly created habitat will be conducted using mark and recapture techniques. Spawning surveys will be made in the spring with the presence of redds and spawning adults being noted.

RESULTS

At the present, insufficient time has passed for the structures to have noticeably affected the cutthroat trout population, but for the most part, the project appears to be working as planned. All of the structures have withstood the high flows associated with the fall storms and the spring runoff. Most of the structures are performing well, collecting spawning gravel, forming pools, and creating spawning areas in the pool tailouts (Table 1, Appendix 1).

The log V-weirs (structures G and I) scoured relatively larger and longer pools than the other structures, mostly because their design concentrates flow toward the center of the channel. Structure G appears to be trapping spawning gravel above the structure and in the pool tailout below. Before the structure was built, the substrate was estimated to be 10% gravel and 90% cobble. The gravel content has increased to 30% above and 20% below. The substrate is still too large for spawning, but it appears to be improving. The substrate at structure I was already optimal and has not changed. All that was needed at that location was to create a pool and tailout area for improved spawning.

The single log weirs, (1, 2, 5, 6, 7, A, C, H, J) and the boulder weir (B) all created plunge pools which are wide, but generally narrow. It appears that additional high flows are needed to develop these pools more fully. Pools were also created above the structures, or existing pools were deepened except at structures 1 and 5 where no change was noted. Spawning gravel accumulated above structures A, B, H, 6, and 7. At structure 7, the gravel content went from 0 - 40%, but only small amounts of gravel were trapped at the other sites. No major changes in substrate were noted at 1, 2, 5, C, and J, or below any of the structures. The substrate at structure J was already excellent above and below.

The two wing deflectors, structures 3 and K, created some quiet backwater areas and limited pool areas. The spawning areas at these sites are fair and poor respectively, but the main purpose of these structures is to provide backwater areas for rearing area for young-of-the-year fish. The log barbs, structures 4, E, and F, were also intended to provide backwater rearing areas. Structures E and F created backwater areas, but the barbs at 4 became partially submerged in the substrate and were ineffective.

Structure D was built to maintain an adequate flow in the main channel during low streamflows, but allow water into the overflow channel at higher flows. This structure appears to be functioning properly. The structure prevents the possible dewatering of approximately 40 ft. of stream.

Overall, approximately 1,074 sq. ft. of pool habitat and 14 sq. ft. of undercut bank have been created by the structures. The amount of spawning habitat has increased, but the structures are still collecting gravel and creating pools and tailouts. Until the areas have stabilized and we get a better idea of how the annual flow conditions affect the transport of gravel, we will not be able to fully assess the amount of spawning area created.

Table 1. Types of structures built, habitat created, spawning quality in areas created, and comments. Numbered structures are located on the first tributary and the lettered structures are on the second tributary. Lower case letters indicate above (a) and below (b) the structures.

Structure Type	Habitat Created Length, Width, Depth (ft.)	Spawning Quality	Comments
First Tributary			
1a. Single log weir	No change	Good	Pink salmon redds.
1b.	2x4x0.6 pool	Excellent	Tailout still forming.
2a. Single log weir	Increased pool depth 0.5.	Fair	Coho present.
2b.	2x9x0.5 pool	Fair	Pink salmon redds.
3. Wing deflector	10x.5 undercut bank 2x4x0.5 pool	Fair	Coho present. Substrate large.
4. Two log barbs	No change	Fair	Not working yet.
5a. Single log weir	No change	Fair	Small area good.
5b.	3.5x7x0.6 pool	Fair	Pink salmon redd.
6a. Single log weir	11x12x0.7 pool	Good	Coho salmon present.
6b.	5x10.5x0.5 pool	Poor	Pool still forming.
7a. Single log weir	No change	Good	Gravel trapped.
7b.	2x6x0.5 pool	Poor	Pool still forming.

Table 1 cont. Types of structures built, habitat created, spawning quality in areas created, and comments. Numbered structures are located on the first tributary and the lettered structures are on the second tributary. Lower case letters indicate above (a) and below (b) the structures.

Structure Type	Habitat Created Length, Width, Depth (ft.)	Spawning Quality	Comments
Second Tributary			
A a. Single log weir	No change	Poor	Little gravel above.
A b.	4x4x0.6; 3x4x0.4 pools	Poor	Removed boulders.
B a. Boulder weir	Increased depth 0.5	Poor	% gravel low.
B b.	3x11x0.7 pool	Poor	No gravel in tailout.
C a. Single log weir	5x11.5x0.8 pool	Fair	Coho salmon present.
C b.	2x11.5x0.5 pool	Poor	Substrate large.
D. Diversion structure	Appears to successfully direct water to main channel at low flows.		
E. Log barb	3x3x0.6 pool	Poor	Excavated rocks.
F. Log barb	Small backwater area	Poor	Effect limited.
G a. V log weir	3.5x10x0.4 pool	Fair	Substrate large.
G b.	4x4x0.8 pool	Poor	Tailout still forming.
H a. Single log weir	6x12.5x0.6 pool	Poor	Some gravel trapped.
H b.	7x10x0.6 pool	Poor	% gravel low.
I a. V log weir	8x20x0.9 pool	Excellent	Pink salmon redds.
I b.	15x17x0.9 pool	Excellent	Cutthroat redd.
J a. Single log weir	9x5.5x0.5 pool	Good	Pink salmon redds.
J b.	6x5.5x0.8 pool	Good	Pink salmon redds
K. Wing deflector	4x2x0.7 pool	Poor	Excavated boulders.

Although the habitat being created by the structures is still in a transitional stage, there has already been some use by cutthroat trout and other salmonids. In May 1995, at structure I on the second tributary, a cutthroat trout redd was observed in the tailout of the pool formed by the structure. No spawners were present, but the redd was newly made and this is the only species spawning at that time of year. In September 1995, at structures 2 and 5 on the first tributary and structures I and J on the second tributary, pink salmon had used the gravels above and below the structures for spawning. Coho salmon were observed at structures 2, 5, 7, and C. They were not engaged in spawning activities, but they were paired up (except at C where only one fish was present). No juvenile cutthroat trout were seen at the structures.

DISCUSSION

At this point the results of the project look favorable. We have documented cutthroat trout spawning in one of the pools created by the structure and expect the other structures to be used as the spawning areas develop more fully. The use of the structures by pink salmon and coho salmon in the fall suggests that the spawning habitat has improved. With a few exceptions, the structures are creating the pools and other rearing habitat as intended. The movement of water over and around the structures should also help to keep these small streams from freezing in the winter and provide overwintering areas. Although no juvenile cutthroat were seen at the structure sites, there may have been some in the gravel, undercut banks or other areas not easily seen. Since only one redd had been documented at a structure, and the population is not expected to fully respond for several years, an exhaustive search for juveniles was not undertaken.

Looking at the pool data listed in Table 1., one will notice that most of the depths range from 0.4 to 0.9 ft. Although this may appear to be somewhat shallow, our observations in other streams (unpublished USFS data) and reports in the literature (Pauley et al., 1989; Trotter, 1989) show that cutthroat trout use areas such as these for spawning. It should also be noted that the pools will continue to deepen and enlarge. With a similar project, we found that it took several years, with the accompanying high flows during spring runoffs, for the pools to fully develop (unpublished USFS report). Thus, additional pool habitat and better overwintering area should be formed.

The main question is how the cutthroat population will respond to the additional habitat. In the first few years the new habitat may only serve to redistribute the usual number of spawners and fry in the tributaries. However, if this reduces overcrowding or competition in the previously utilized areas, or if cutthroat are not forced to use marginal habitat for the lack of better areas, then egg and fry survival could be increased. In time this will lead to increased numbers.

If the structures prove to be effective in increasing the cutthroat population, this work could be extended to other streams with small cutthroat populations in Prince William Sound, such as the unnamed creek on Green Island. Similar work in other areas has proven effective in increasing salmonid spawning and rearing (House and Boehne 1985, Payne and Copes 1986, Moore and Gregory 1988, Fuller 1990), so we do feel confident this work will also be successful.

One concern we have is the presence of coho salmon in the streams where the structures were built. As mentioned earlier, coho juveniles will outcompete cutthroat juveniles and may reduce cutthroat production in the streams (Tripp and McCart 1983, Glova 1984). We observed approximately 20 adult coho in the first tributary and one in the second tributary. Although we had not seen coho salmon in the first tributary during previous surveys, it appears that coho will be there to compete with the cutthroat. This does not make the habitat unsuitable for cutthroat trout, but production may be lower than it would be without competition. In the second tributary, the gradient is generally higher, the stream narrower, and the depths shallower. The presence of only one coho suggests that this stream is not as attractive to coho salmon and competition may not be a serious problem.

If other habitat enhancement projects are planned in the future, it may be best to choose areas more similar to the second tributary. Judging from personal observations in other streams, cutthroat trout will spawn in the smaller pools and pockets of gravel found in the steeper sections of small streams. These areas may be too small, or the gravels too shallow, for coho salmon redds. When planning for this project, we felt that the first tributary would not have coho salmon because of its small size and its apparent lack of coho juveniles. Evidently, coho salmon will utilize very small streams if the spawning conditions are suitable otherwise.

The presence of pink salmon is not a problem since the adults spawn at different times than cutthroat trout (Scott and Crossman 1973), so there is no competition for spawning area. Also, the pink salmon juveniles migrate out of the system soon after emerging from the gravel, so there is no juvenile competition. If anything, the pink salmon eggs and fry may prove to be a food source for cutthroat trout (Armstrong 1971).

While the primary goal of this project is to enhance a population adversely affected by the oil spill, it is also important to emphasize that this project could help preserve a unique genetic stock. Studies cited by Pauley et al. (1989) indicate that anadromous cutthroat can be genetically discrete at the small stream level and are precise in their homing abilities. Thus, there may be significant genetic differences among the populations in different streams in Prince William Sound. Hepler et al. (1990) reported, however, that cutthroat did migrate between stream systems, with some fish recaptured up to 55 km (34 miles) from the stream where they were tagged. While there is no evidence that these fish were spawning in other streams, it is possible that there is straying and genetic intermixing among the populations. Until more is known about cutthroat genetics, however, it will be important to manage each population as a unique stock.

Additional genetic information should be available in the next several years. Genetic studies are being conducted to determine the differences among coastal cutthroat trout stocks throughout their range (Gordon Reeves USDA Forest Service Forestry Sciences Laboratory Corvallis, OR; Thomas Williams, Oregon State University, personal communication). In southcentral Alaska, samples have been collected from Boswell Bay on the eastern edge of Prince William Sound and Martin Lake, approximately 50 miles east of Boswell Bay and the Sound. The preliminary results show that these populations are similar, but there are significant differences between these populations and those in the rest of Alaska and the Pacific Northwest. Interestingly, a group of populations in southeast Alaska shows a greater similarity to populations in the Pacific Northwest than other Alaskan populations (Thomas Williams, personal communication). Thus, the studies of populations in Prince William Sound, scheduled for 1996, could provide some surprising results.

In any case, whether the Rocky Creek population represents a unique stock or is a part of a larger intermixing population, this habitat enhancement project should bolster the population, and in doing so, help protect the cutthroat trout from impacts in the future.

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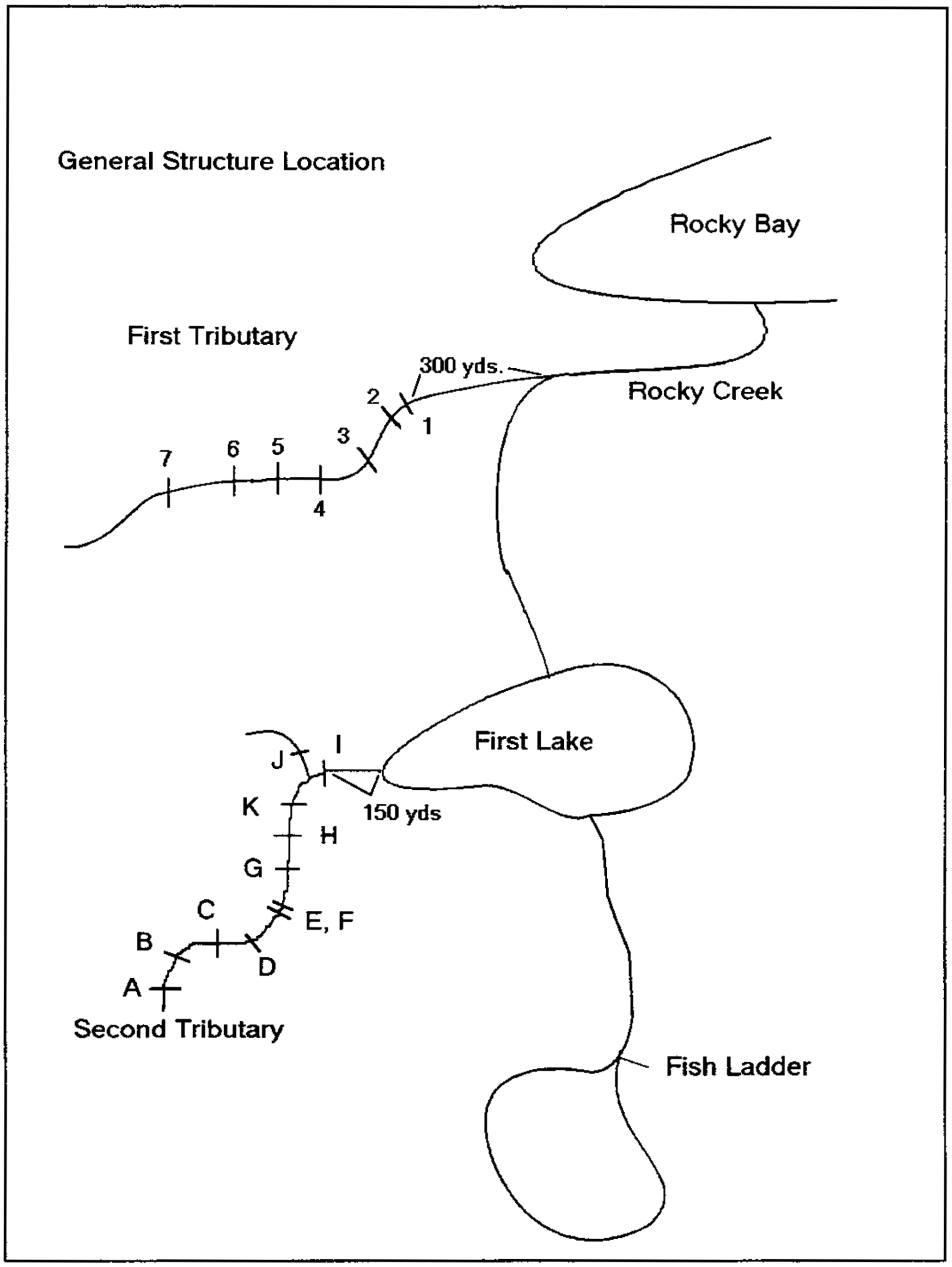
Appendix 1. The following diagrams show the instream structures built on two tributaries of Rocky Creek, Montague Island. Habitat features, the structures, and changes in habitat caused by the structures are illustrated. The figures are not drawn to scale.



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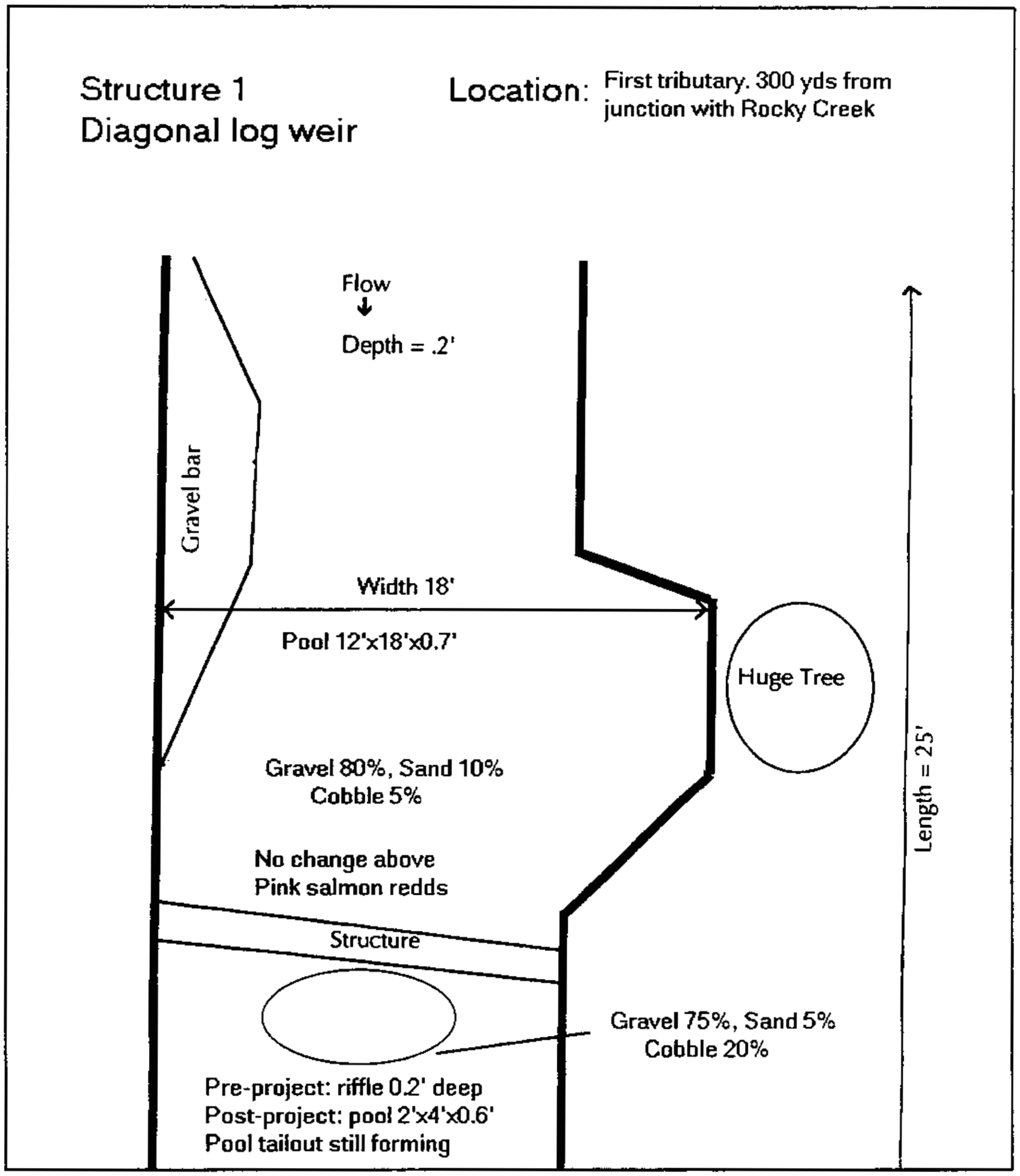

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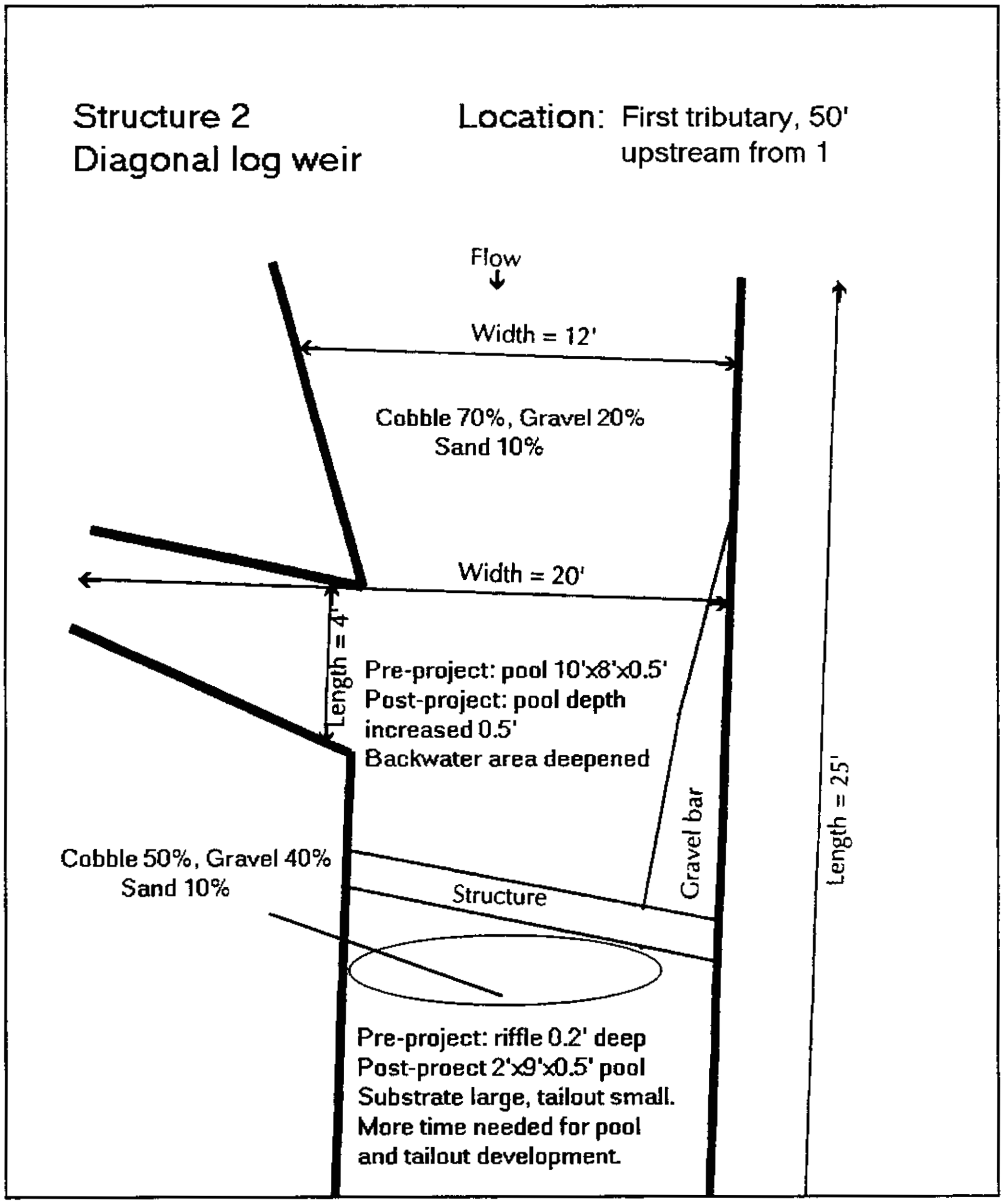

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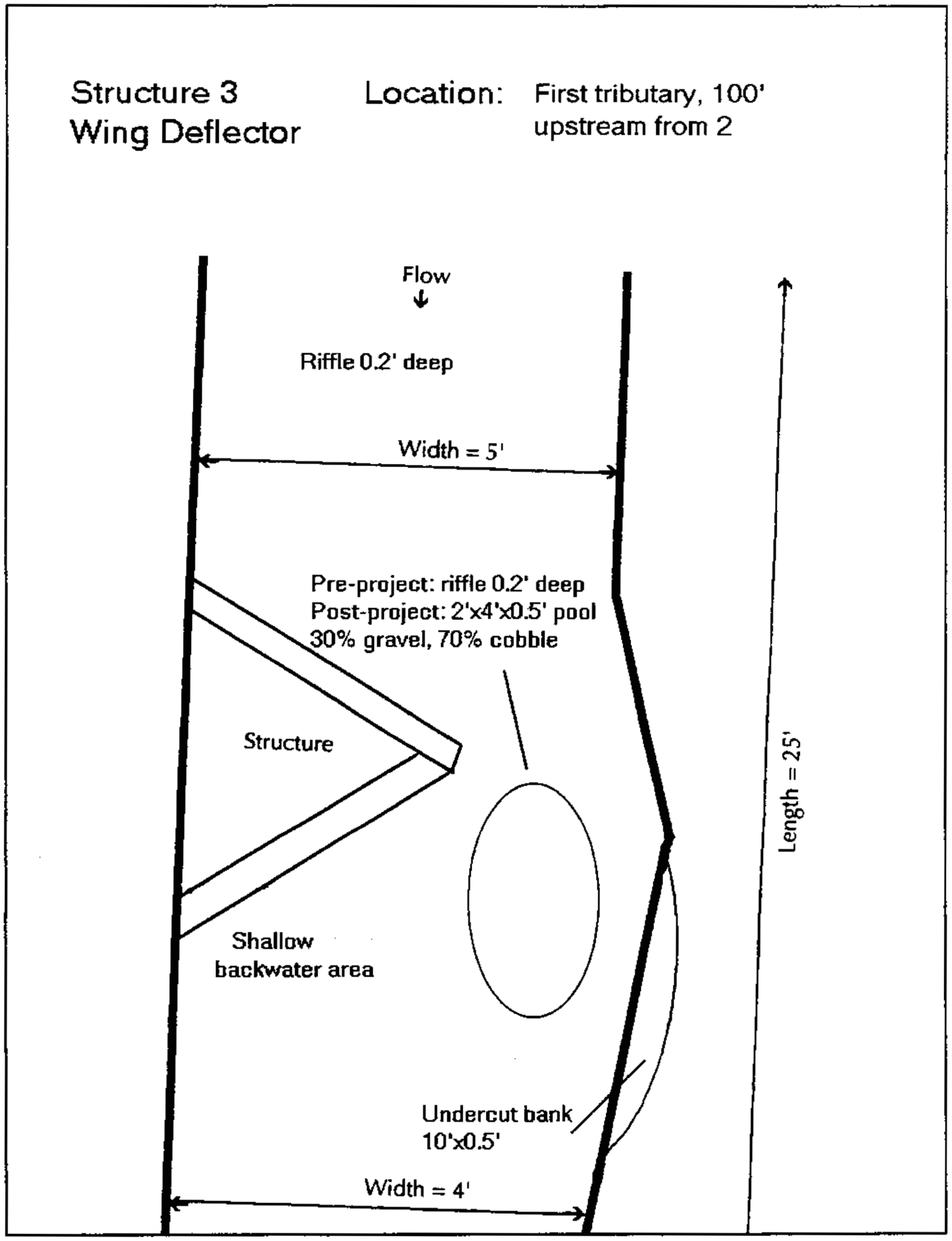

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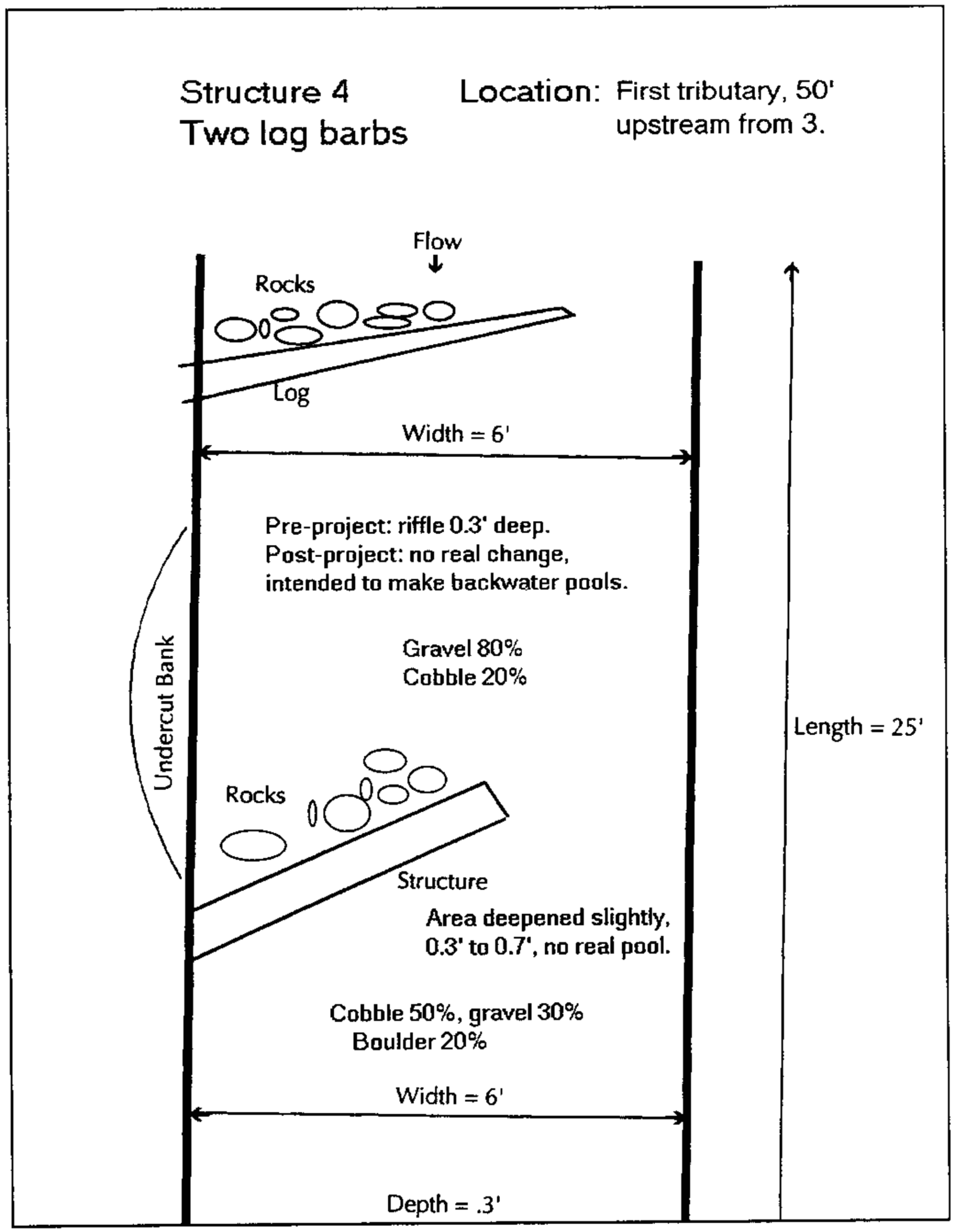

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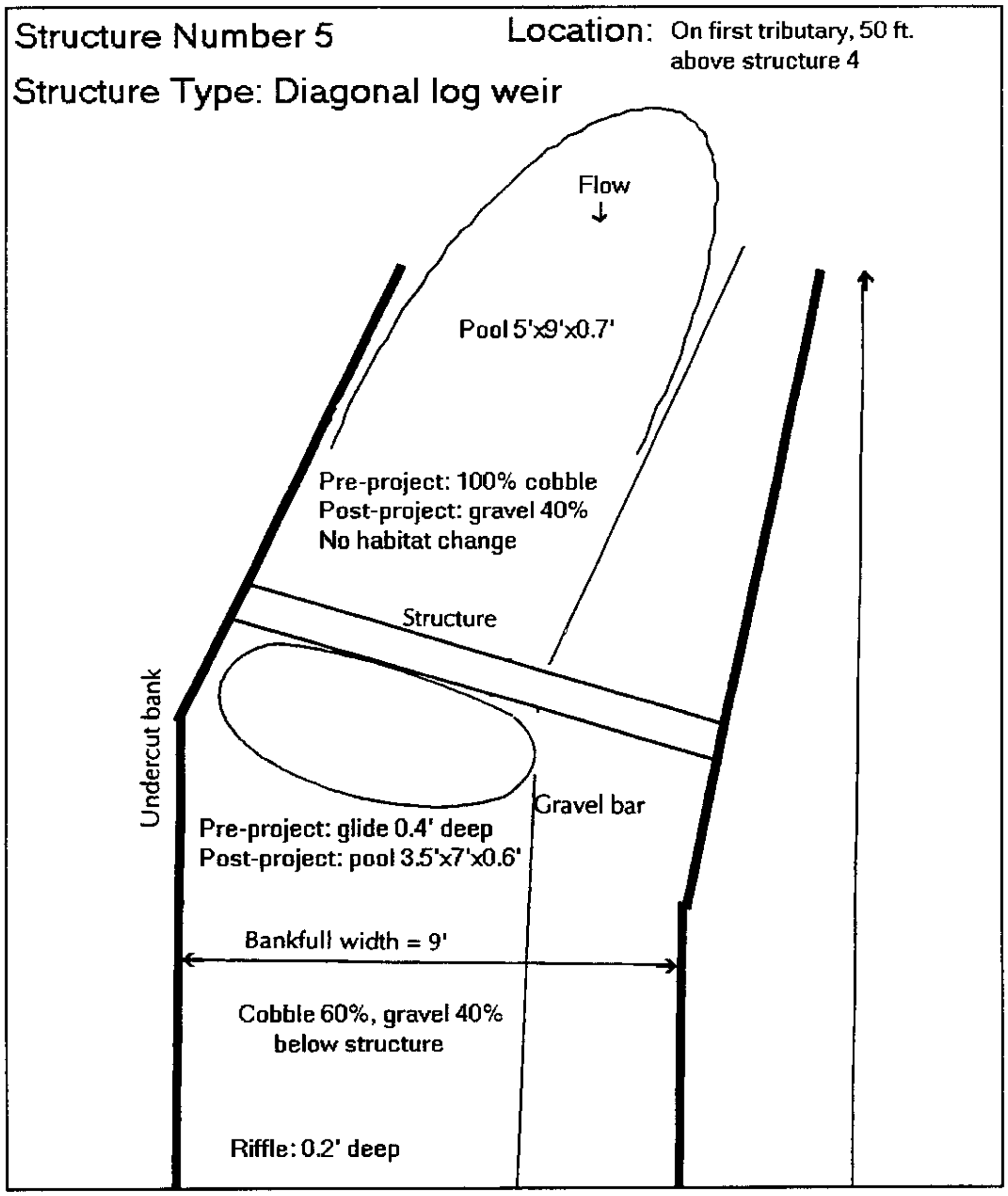

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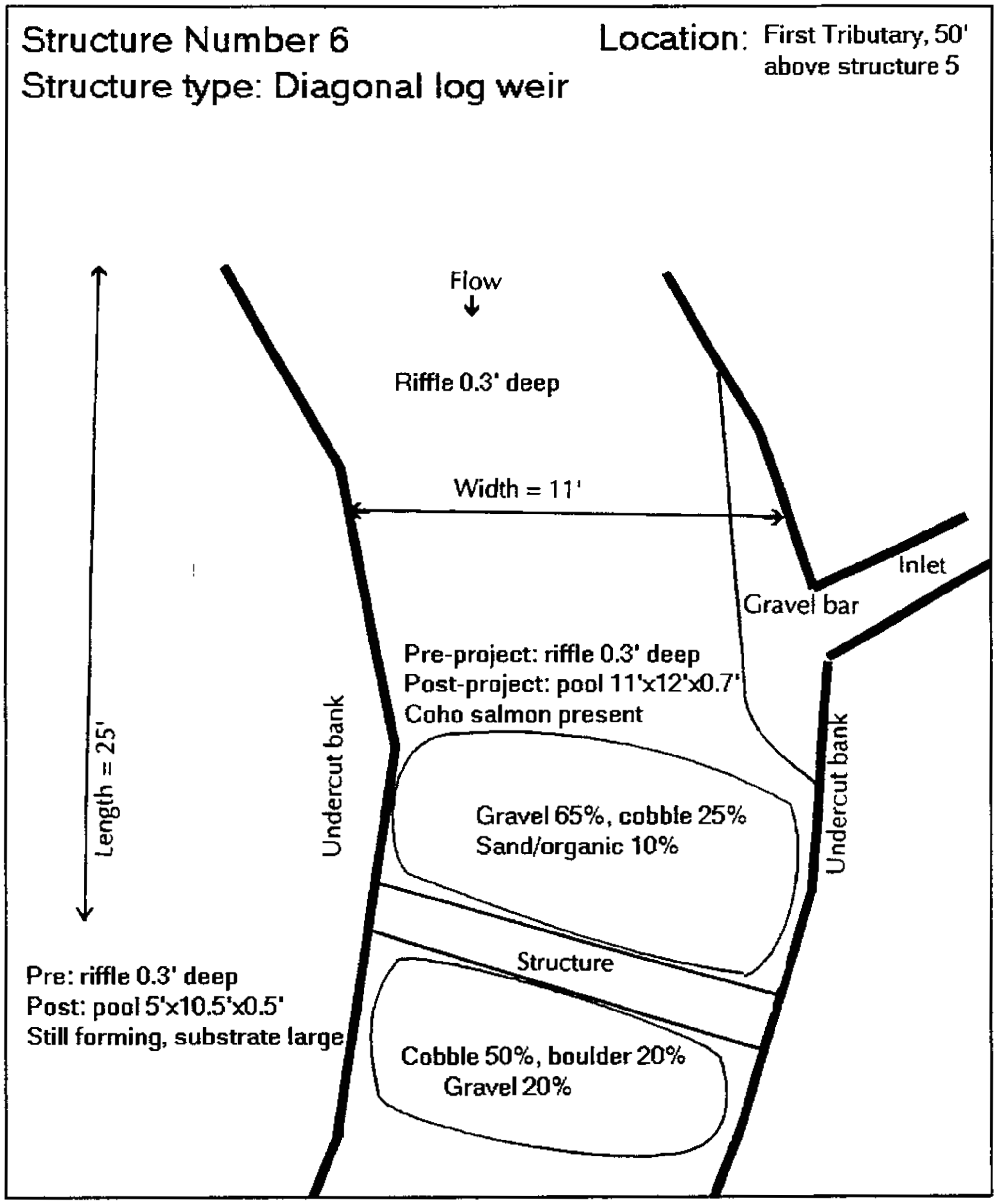

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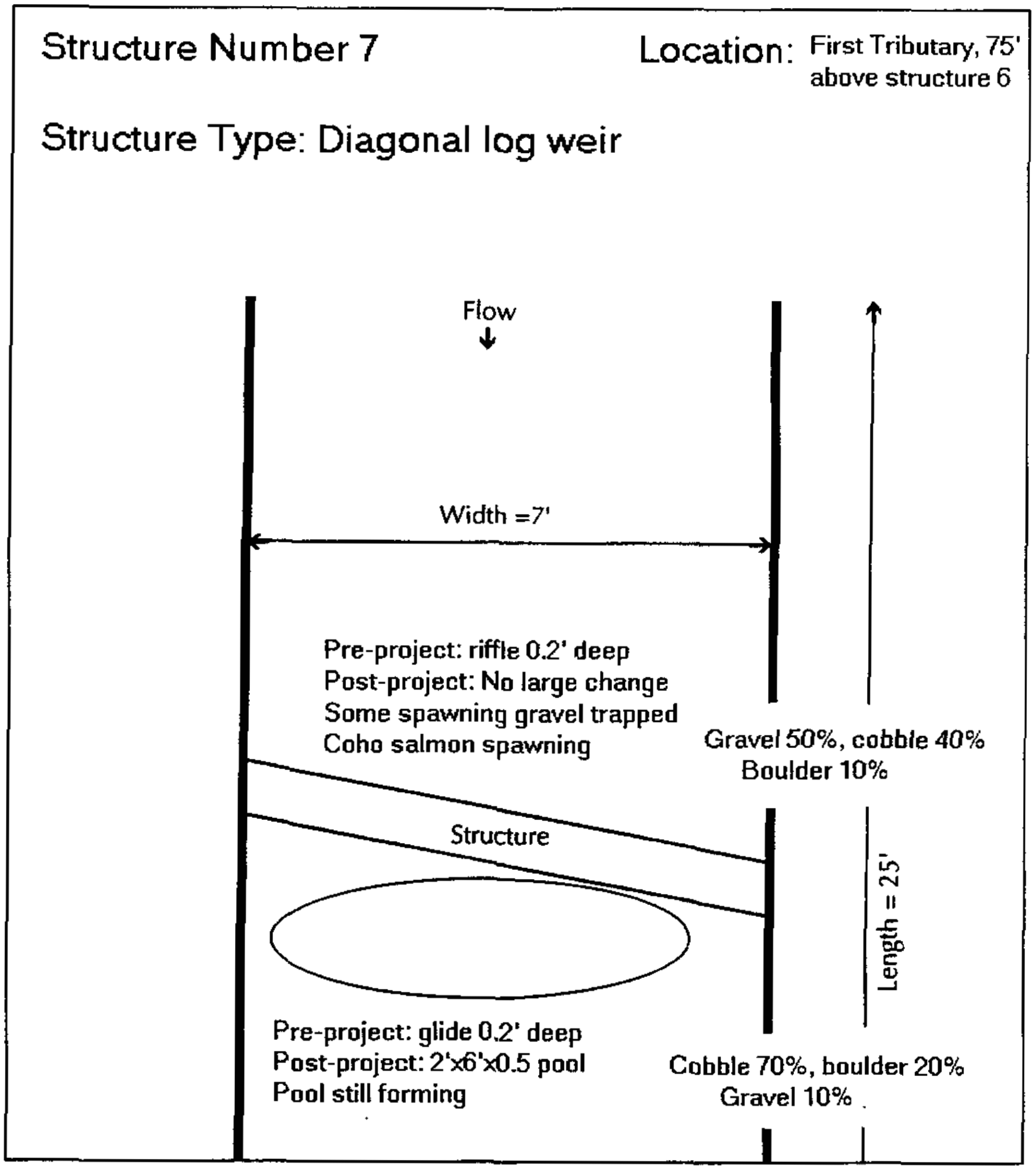

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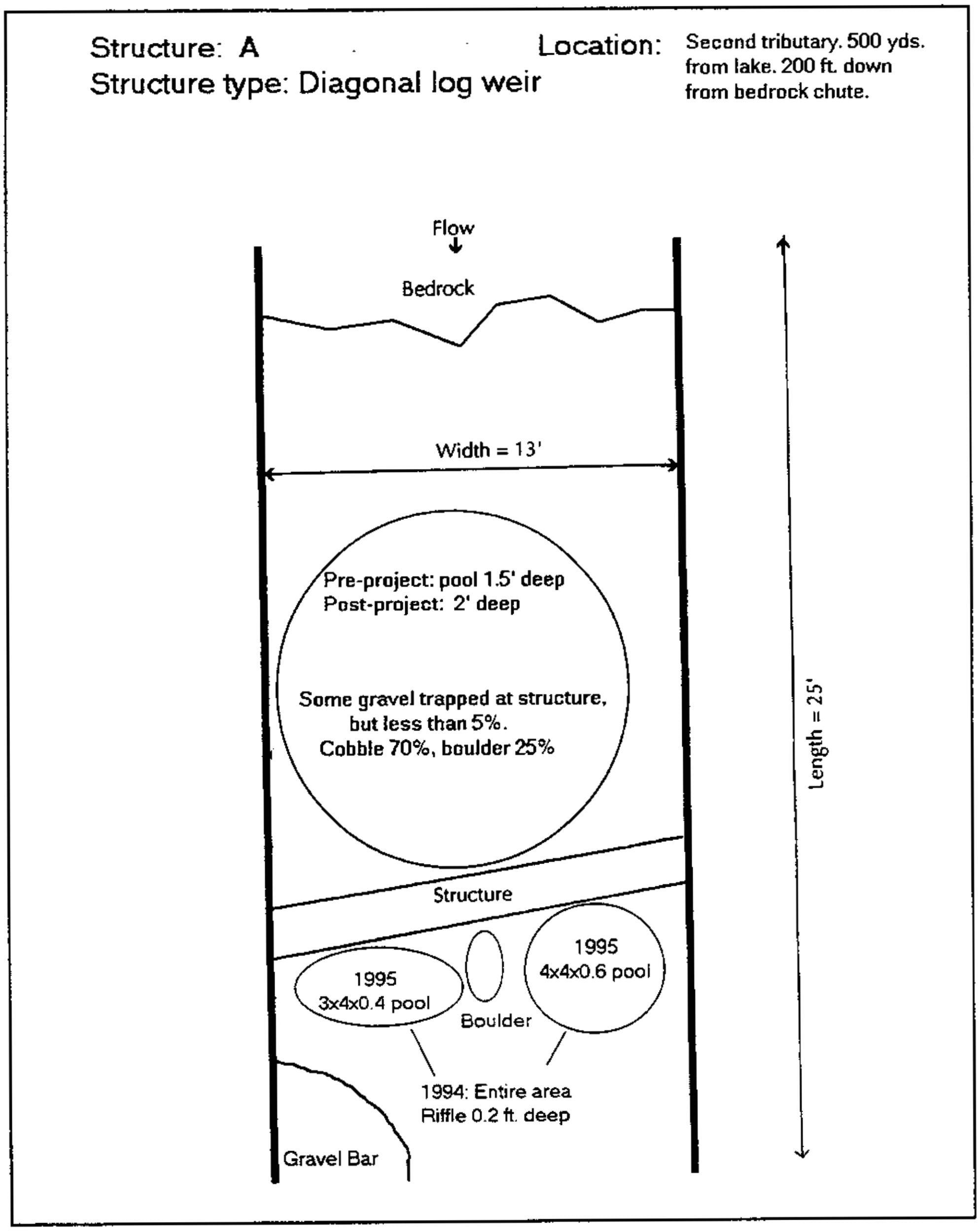

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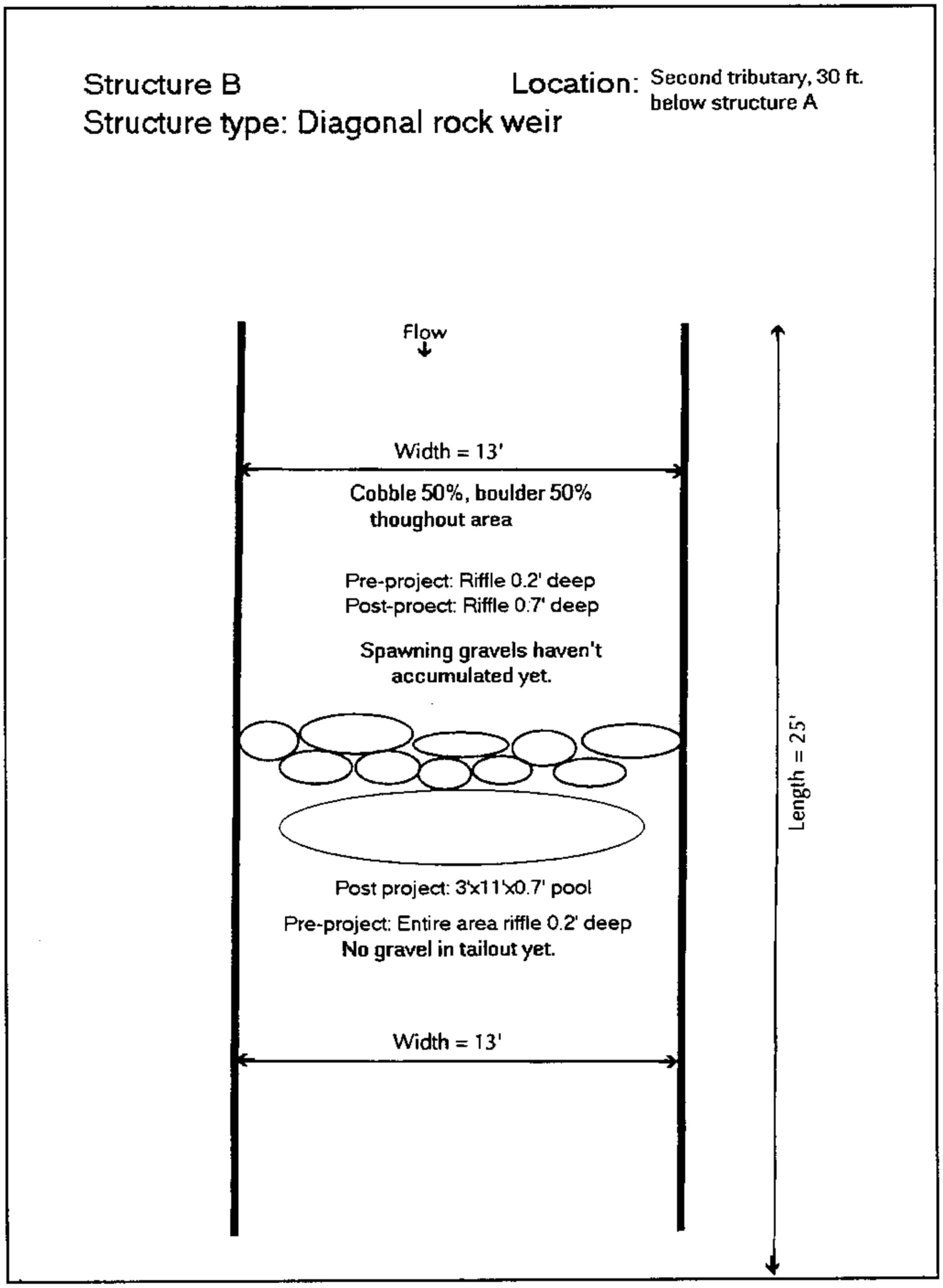

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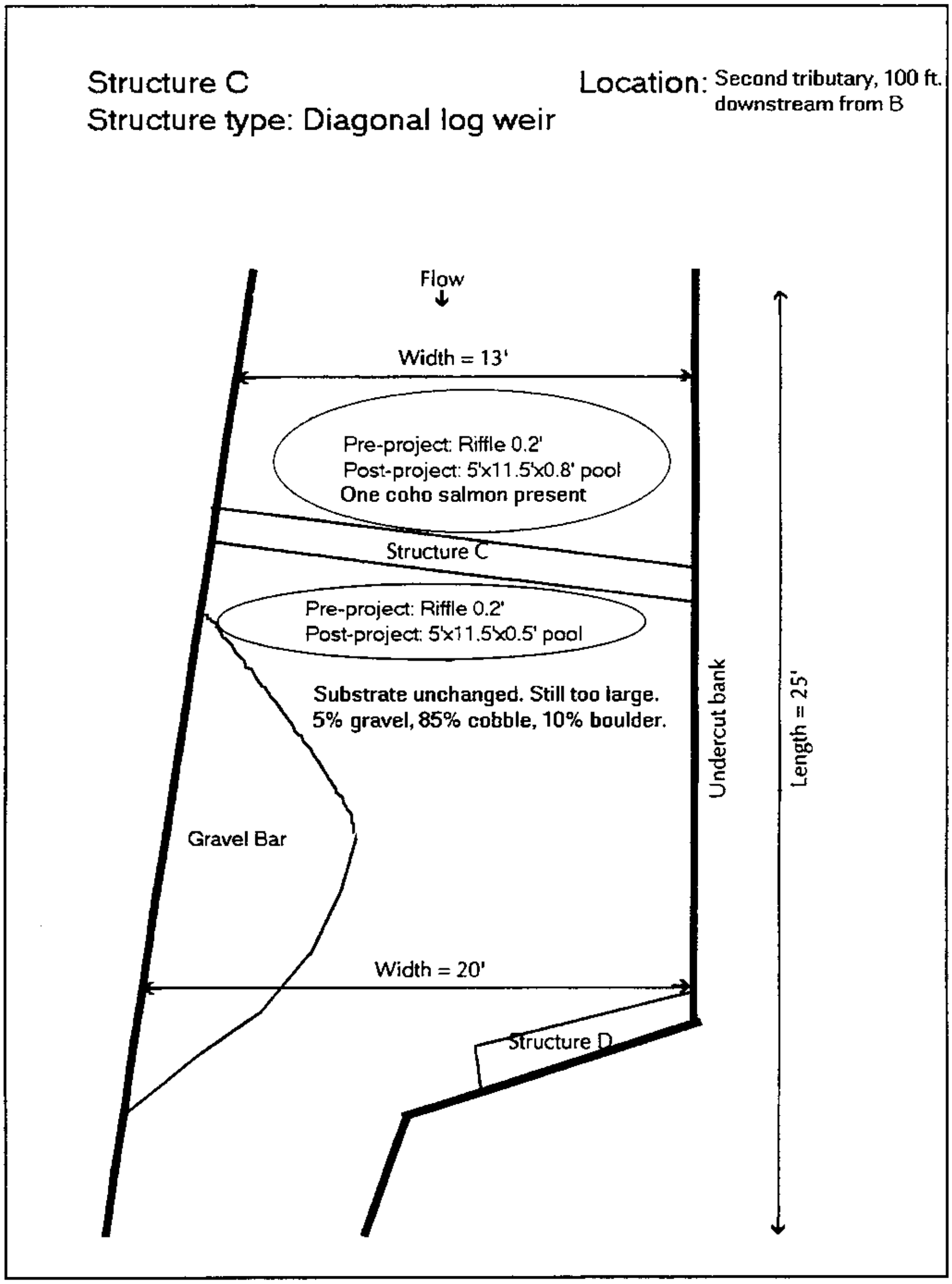

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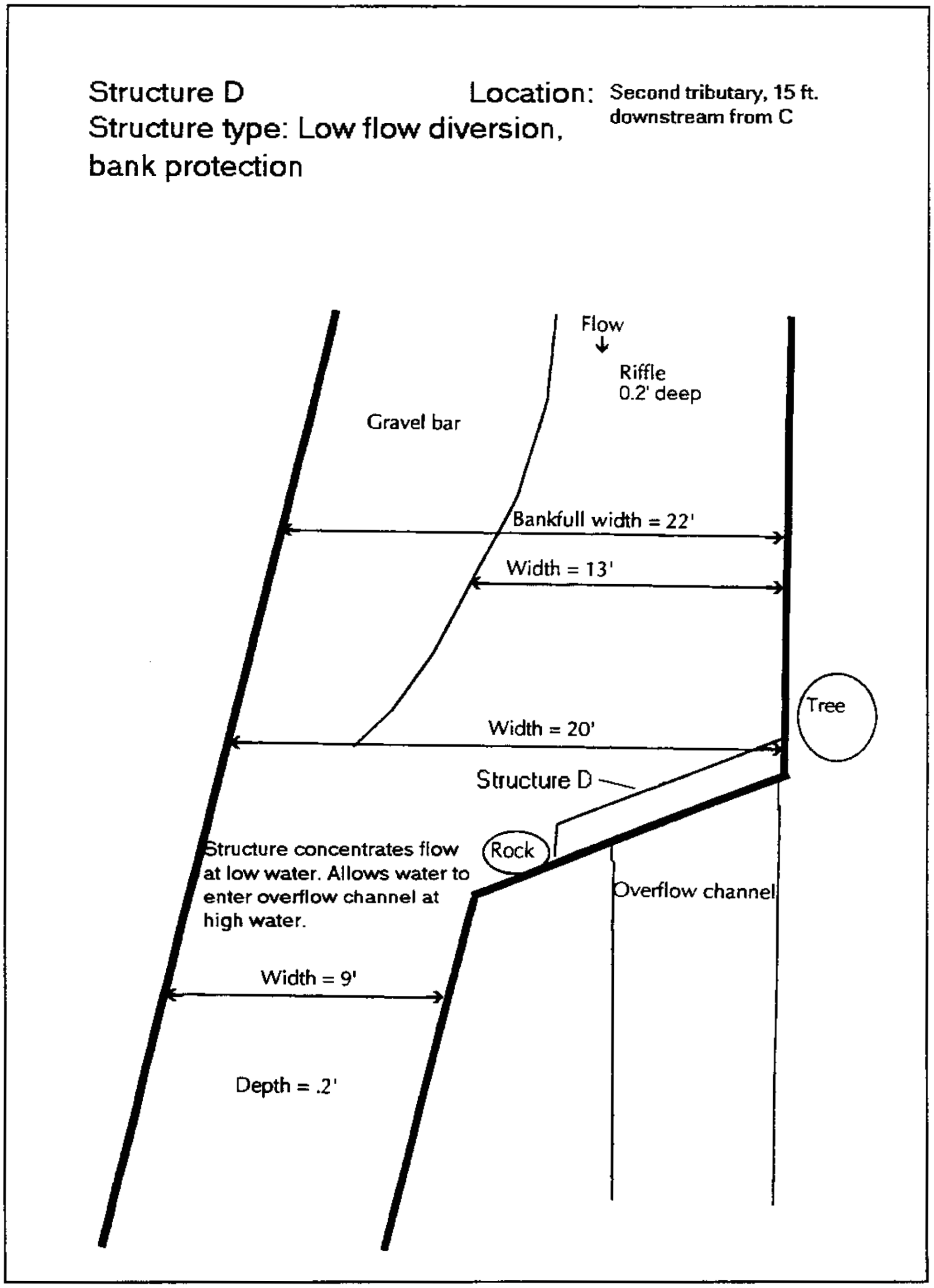

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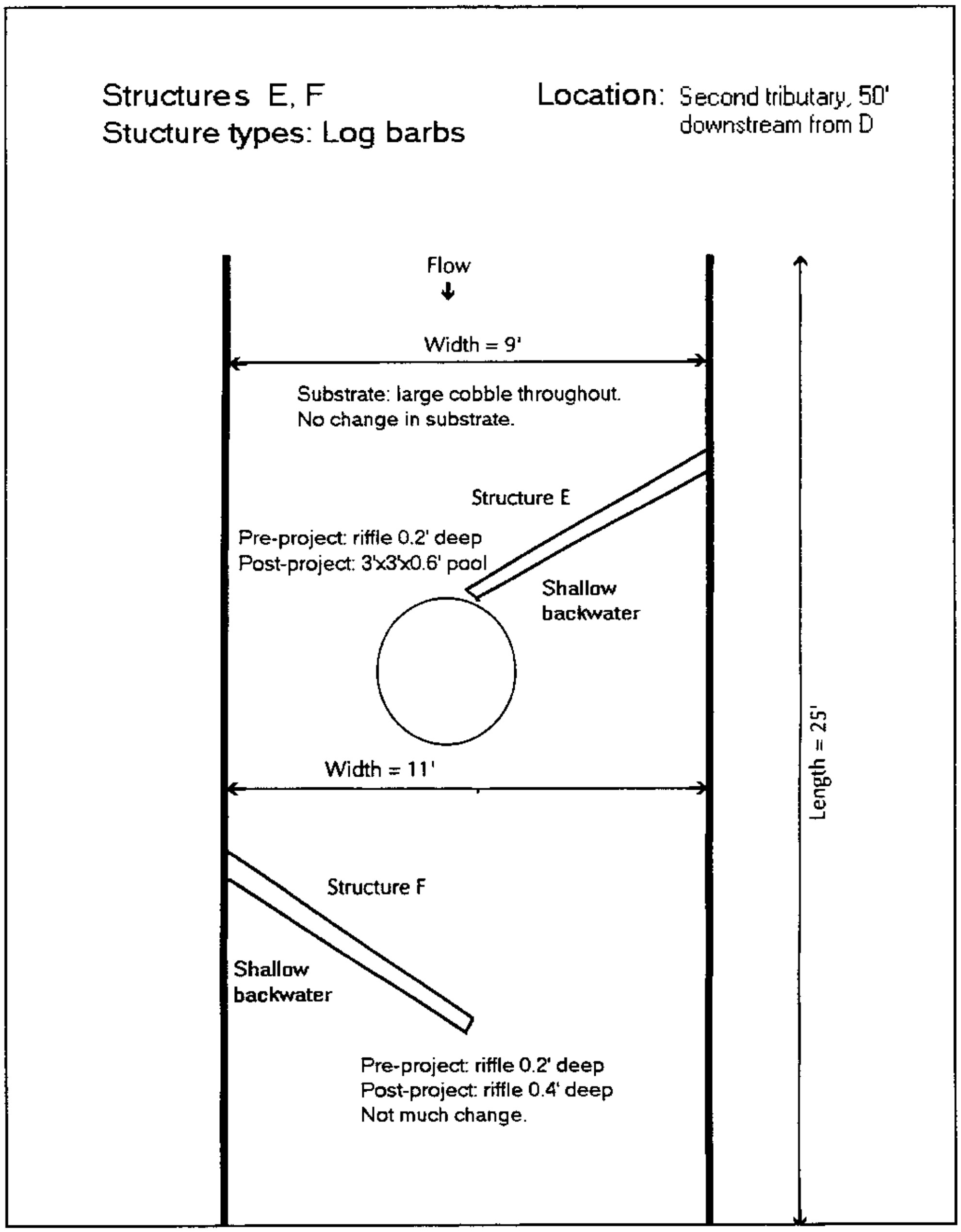

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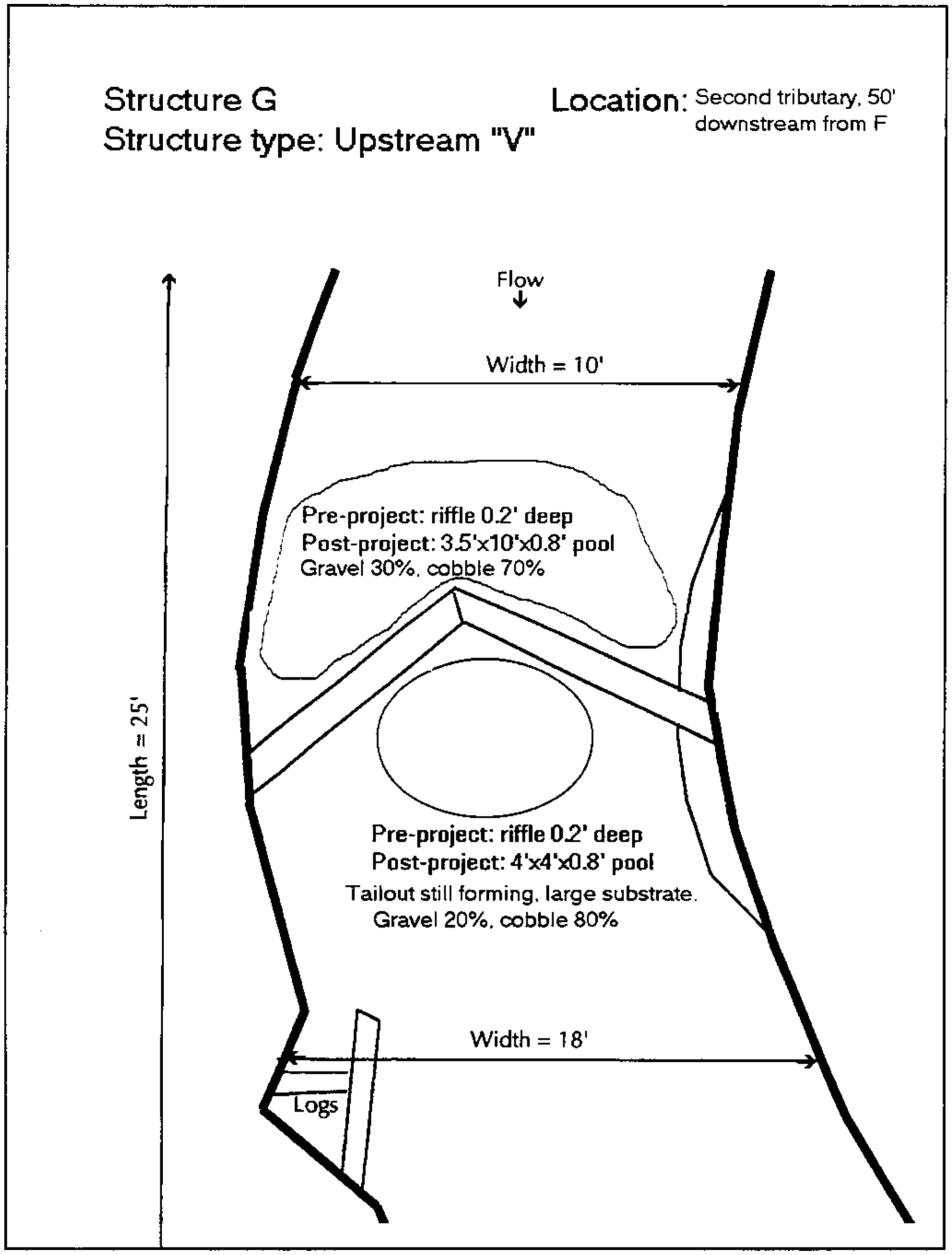

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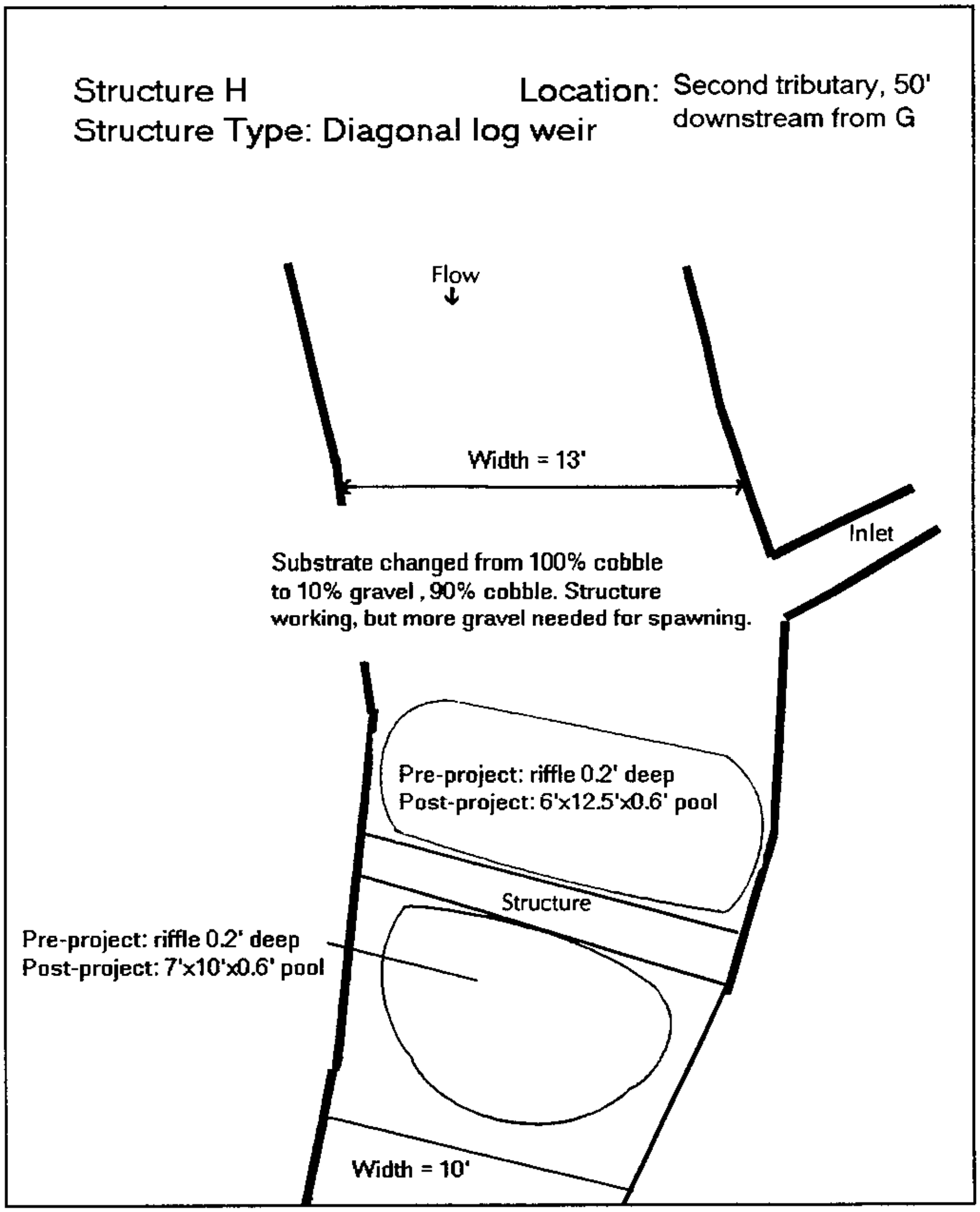

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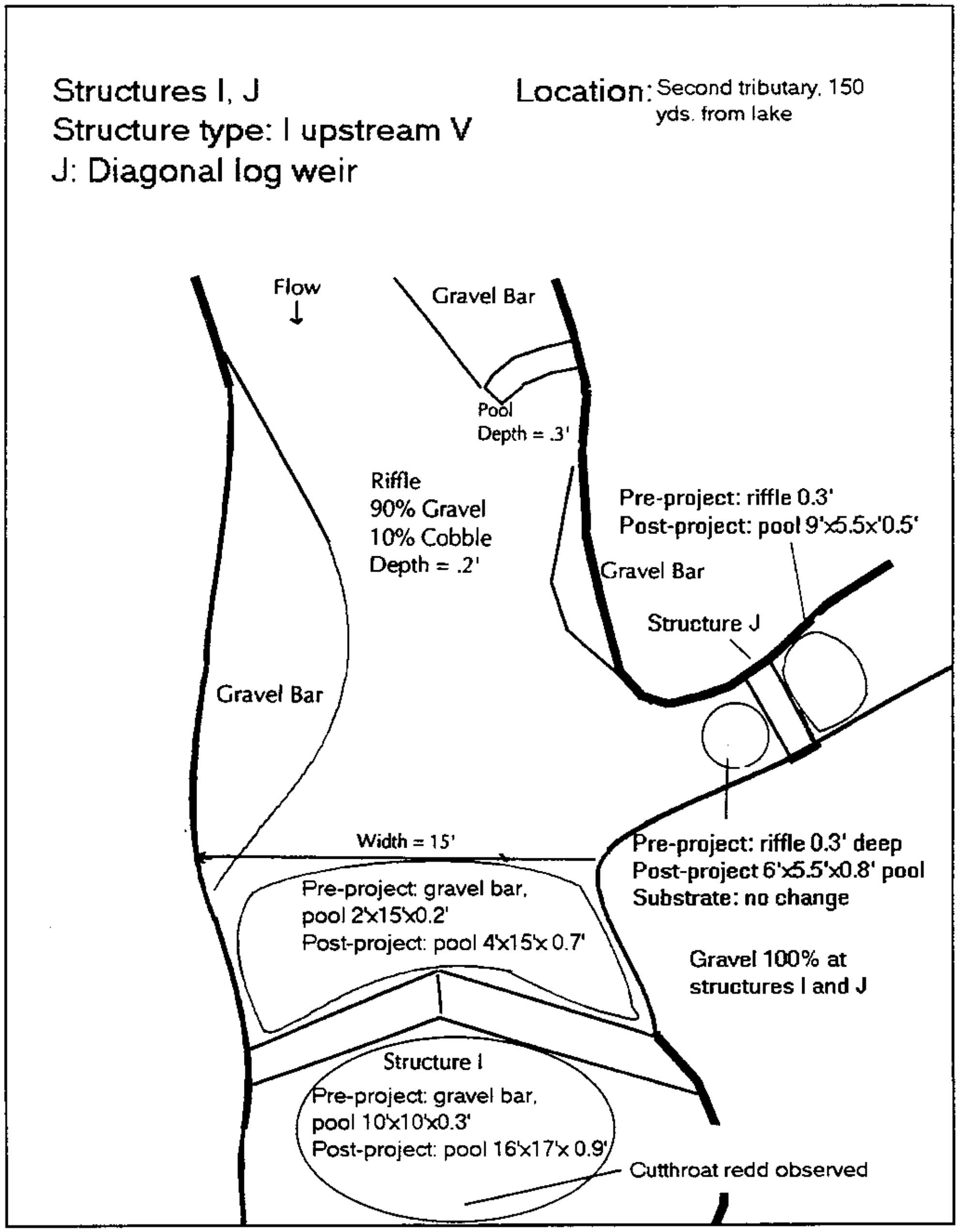

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