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HYDRAULIC DESIGN AND CONSTRUCTION DETAILS OF SALMON SPAWNING CHANNEL IMPROVEMENT AREAS ON INDIAN CREEK AND HARRIS RIVER

by

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INTRODUCTION

This report presents the general hydraulic considerations associated with the design of improved pink salmon spawning areas in natural streams.

The objective of the proposed improvements is to increase the productivity of pink salmon eggs and larvae in spawning beds. Research findings have shown that the survival of these eggs and larvae can be improved materially by providing suitable gravel and stream flow conditions. Two major aims in obtaining such suitable gravel conditions are the removal of fines from the spawning bed and the provision of stability against bed shift. Investigations by Canadian agencies have indicated that practical facilities constructed to provide these conditions under regulated flow conditions have led to substantial increases in the productivity of young fish to the migrant fry stage. The present project deals with the application of known techniques to obtain such improved spawning conditions on unregulated streams without the installation of fixed structures.

The spawning areas to be constructed are on Indian Creek and Harris River, on Prince of Wales Island, within the Tongass National Forest, Alaska. The work is to be performed by the Fisheries Research Institute of the University of Washington, under contract with the United States Forest Service.

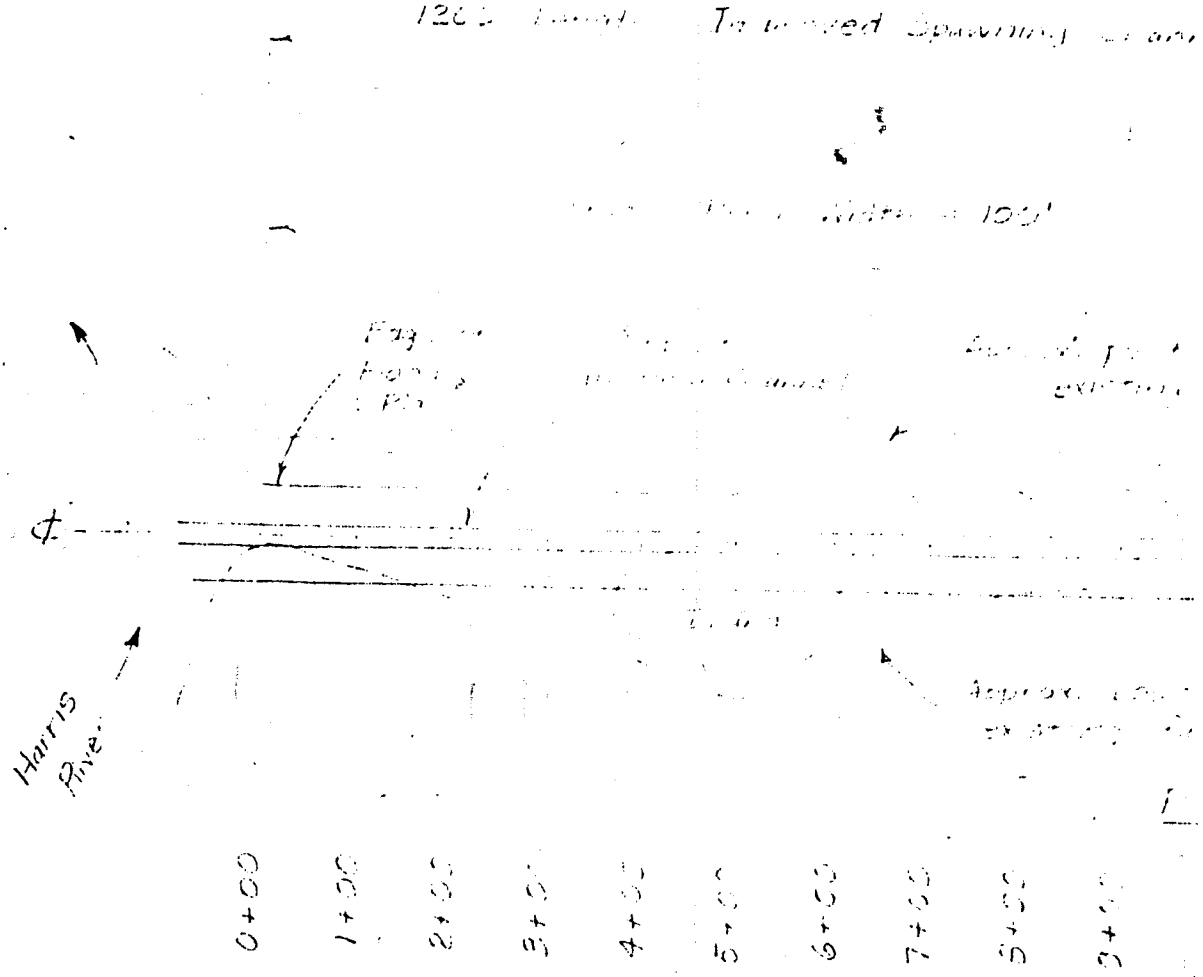
HYDRAULIC DESIGN SPECIFICATIONS - INDIAN CREEK

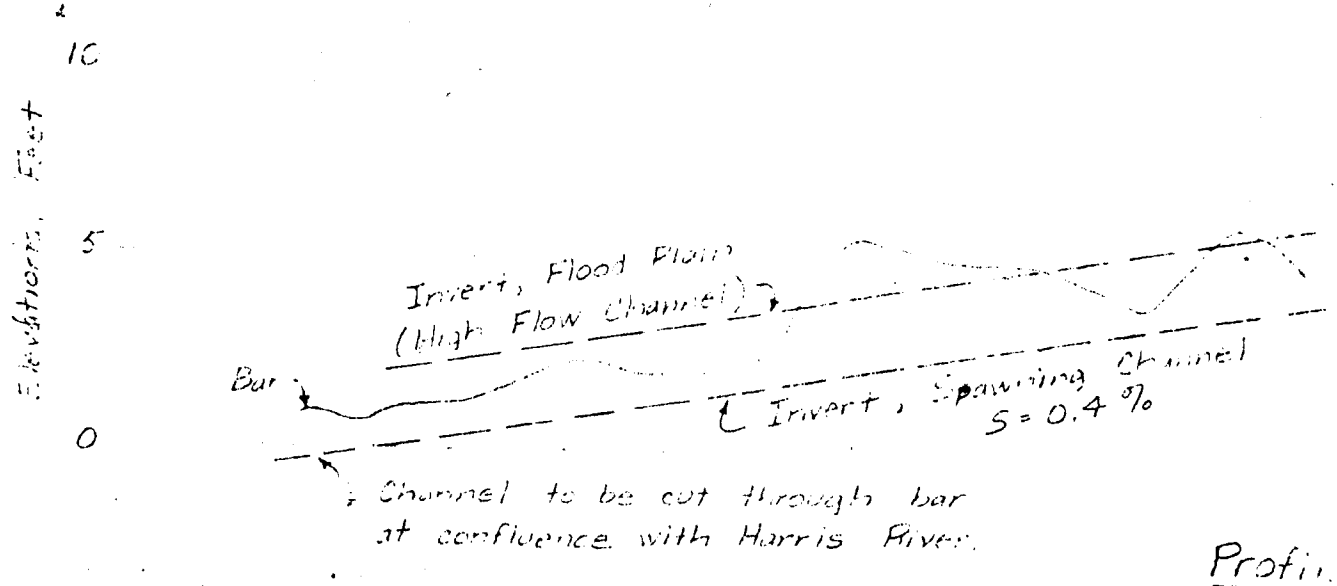
The improved spawning channel will be located in the intertidal zone. No stream-flow regulation will be provided, so the channel must pass the entire range of discharges without causing channel erosion. On the basis of available hydrologic data, discharge of Indian Creek varies from 5 to 1,000 cfs during the periods of spawning, egg incubation, and larval development.

The following low flow specifications have been selected to satisfy the biological requirements of pink salmon:

Minimum discharge.	5 cfs
Minimum depth.	4 inches
Minimum surface velocity	1 fps

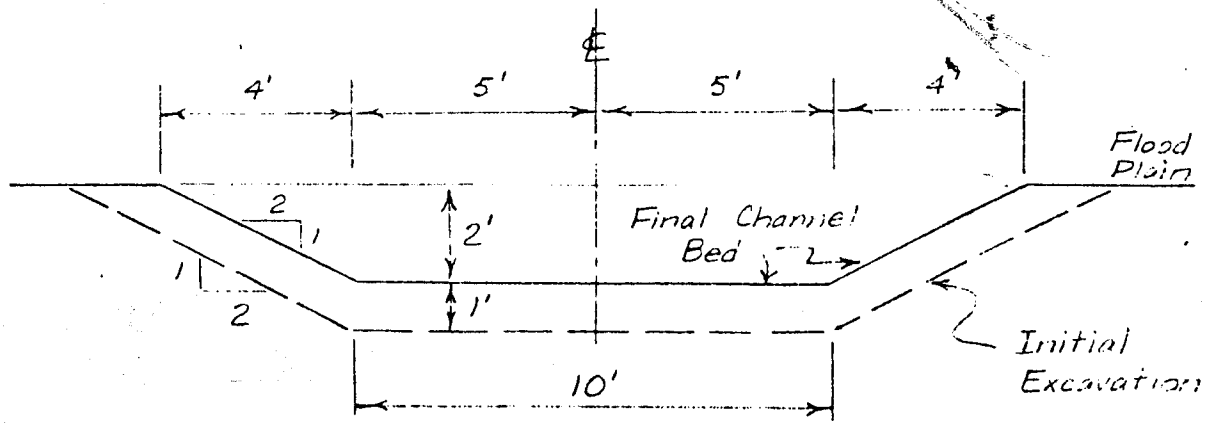
The minimum discharge is estimated to be the lowest expected during the spawning season; the depth and surface velocity are expected to provide adequate environmental conditions for development of eggs and larvae.



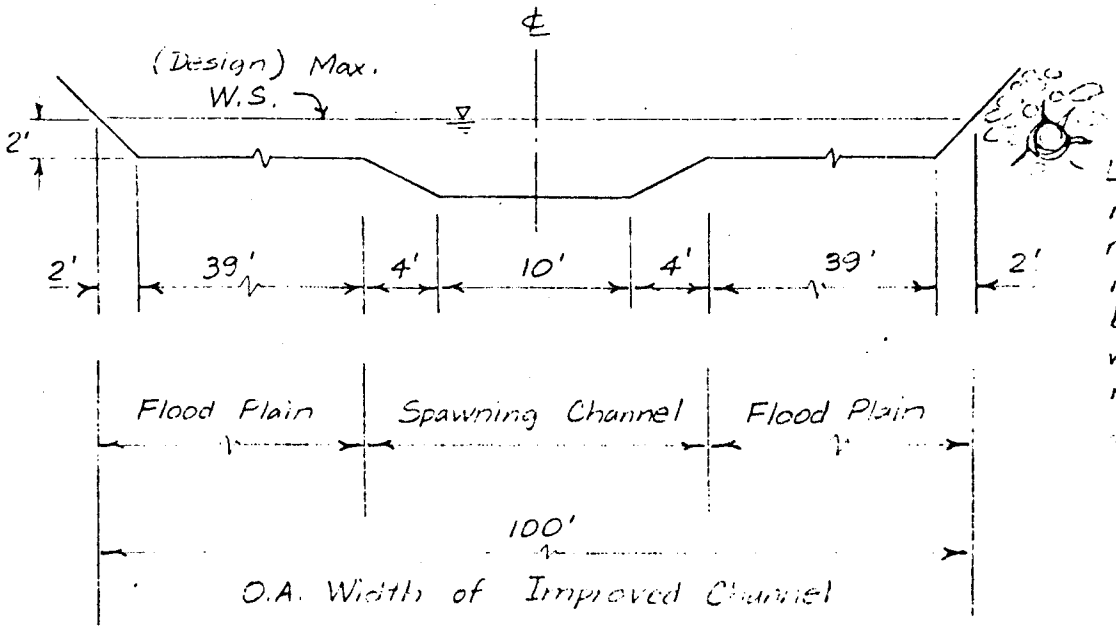


Profi

Note: Elevations based on datum (arbitrary) referenced to 4 temp. bench marks.



Detail of Spawning Channel



Cross - Section of Channel

INDIAN CREEK
SPAWNING CHANNEL IMPROVEMENT
FIG. 2 : CROSS - SECTION DETAILS
JUNE 1961 C.E.N.

Flood Plain Channel

A plain with no transverse slopes will be used for the high flow channel to simplify construction and to provide a maximum flow capacity.

Nominal widths of the flood plain indicated on Figure 1 are, as shown in Figure 2, based upon the water surface width at an assumed 4-foot depth over the spawning channel invert. Side slopes are indicated as 1 : 1; these will be allowed to vary with construction material; no local misalignments in bank edges are to be allowed.

Where new channel walls are to be built, they will be formed of gravel embankments with a total height at least 7 feet above spawning channel invert. These embankments are to include logs laid parallel to the stream and anchored with large cobbles. This is especially important in the approach channel curve and for some distance downstream from the curve. Where new banks are to be cut through soil, these will be lined with a gravel cover. No overhanging trees or stumps are to be allowed along the banks of the flood plain.

The flood plain will be excavated to grade prior to the final cut for the spawning channel. Soft spots on this flood plain will be covered with protective gravel layers. The performance of the high flow channel will be watched during and after high flows. As a maintenance precaution, sand bags will be kept available to be used to close off new channels which may tend to erode in the less resistant flood plain during periods of high discharge.

HYDRAULIC DESIGN - INDIAN CREEK

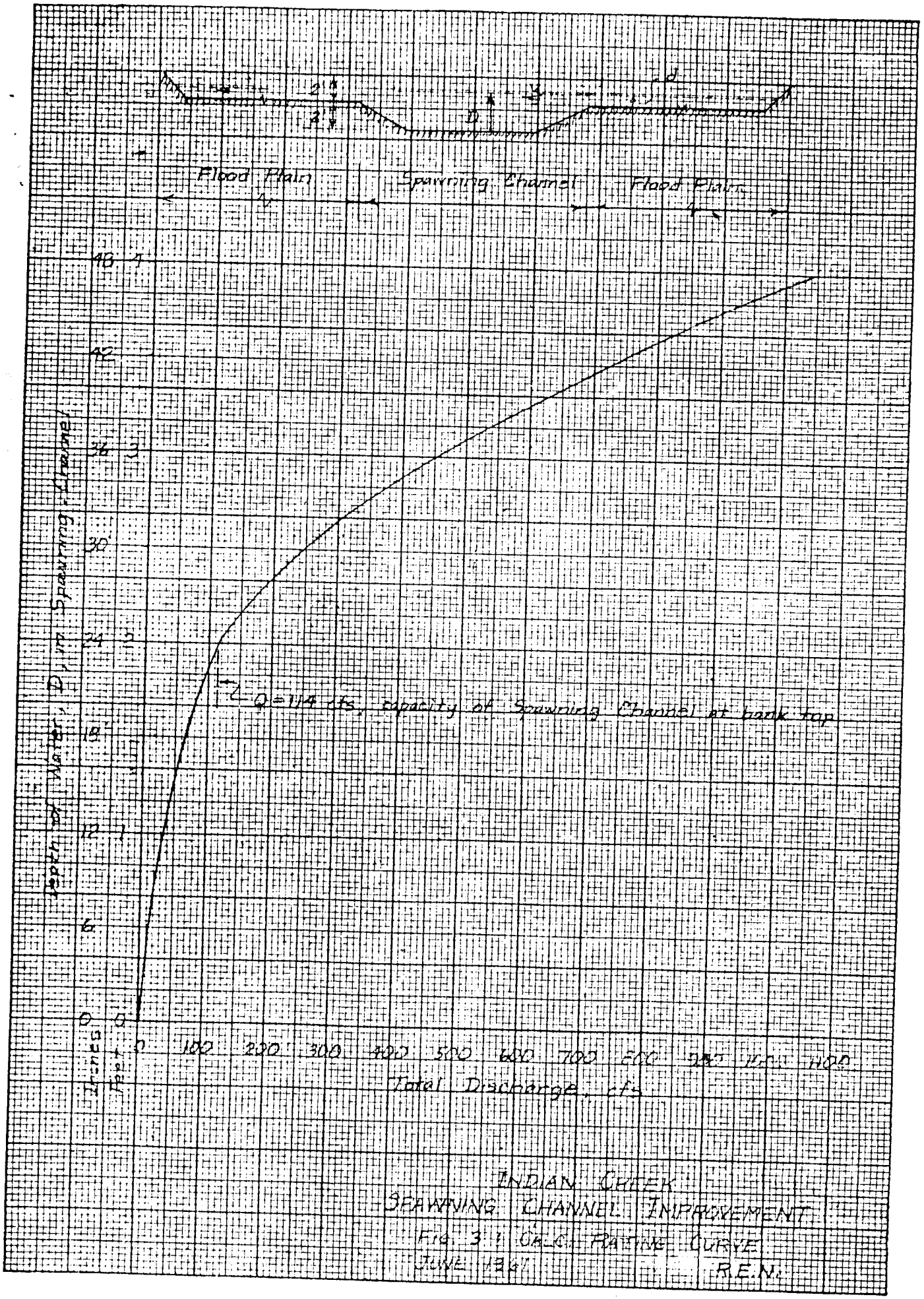
Velocities and Discharges

Hydraulic characteristics of the improved section are calculated, on the assumption of uniform flows, with the use of the Manning formula:

$$V = \frac{1.486}{n} R^{2/3} S^{1/2}$$

where V = average velocity, fps
R = hydraulic radius, ft
S = slope (=0.4% = 0.004)
n = resistance coefficient

Following common practice, the spawning channel and the flood plain are treated separately. For the former graded section, 'n' is selected as 0.030; for the latter, less controlled section, n = 0.040. This procedure yields highest velocities in the spawning (central) channel; the flood plain discharge is treated simply as a 2-dimensional flow in a 39-foot wide channel on each side of the centerline. Shear stresses between flood plain and spawning channel flows are neglected. Flow contributions by the area over the side banks of the flood plain are neglected.



INDIAN CREEK
SPAWNING CHANNEL IMPROVEMENT
FIG. 3 / CALC. RATING CURVE
JUNE 1967 R.E.N.

Stream Bed Stability

The channel hydraulic characteristics have been dictated by the bed texture, natural gradient, and, even more specifically, by the low flow criteria. These latter require a narrow low flow channel which must, in high water periods, carry a relatively large percentage of the total flow. Low flow requirements and bed stability tend toward opposite requirements.

An approximate stream bed stability analysis is presented, based upon the empirical Shields bed load entrainment function. For uniform bed roughness of diameter d, the Shields function predicts motion of bottom particles when

$$\frac{\tau}{\gamma (S_s - 1) d} \geq 0.06$$

for the range of flow parameters in this channel. Here,

τ = bottom shear stress, psf
γ = specific weight of water, 62.4 pcf
S_s = particle specific gravity (taken as 2.65)
d = particle size (diameter), ft.

The bottom shear is here estimated by the two-dimensional equation, $\tau = \gamma y S$, where y = the depth of water, in feet, over the bed area considered.

Results of this calculation are given in Table II. For various gravel diameters within the design size range, the maximum depth over the bottom for local bed stability is listed. These results are also expressed in terms of total stream flow for bed stability in the spawning channel and in the flood plain, considered separately.

TABLE II

Limiting Stream Flows for Bed Stability

Gravel Diameter		Maximum Water	Corresponding Limiting Total Flow Q - cfs	
Inches	Feet	Depth y, Feet	Spawning Channel Stability	Flood Plain Stability
3/4	.0625	1.55	70	750
1	.0833	2.06	130	1100
1-1/2	.1250	3.10	500	-
3	.2500	6.20	>1000	-
6	.5000	12.40	-	-

The above results are, at best, very approximate. They indicate that bed shift of the smaller gravels may be expected in the spawning channel for relatively low flows. If the bed gravels interlock, however, the tendency to shift will be reduced. As the gravel will be worked over and shifted by the spawning salmon, provision cannot be made for obtaining a permanent compaction by tractor treads during the finish grading operation.

The flood plain appears to be relatively safe from gravel shift, but will of course be subject to the removal of fines. Its banks, containing reinforcement and large stones, should be stable. A certain amount of maintenance will most likely be necessary to keep the low flow channel banks from meandering, especially in the curve upstream from the finished spawning area.

HARRIS RIVER SPAWNING AREA IMPROVEMENT

In the intertidal area of the Harris River a natural channel exists which is similar to that to be constructed on Indian Creek. In the spawning bed section of this stream, due primarily to a very small gradient and a natural flood plain, the bed gravel has shown a high degree of stability against shift.

The quality of the gravel within an area approximately 300 feet long by 50 feet wide is to be improved. Gravel finer than 3/4-inch size and larger than 12-inch size will be removed to a depth of about 6 inches.

This work is to be performed by the end loader - mechanical vibrating screen combination to be used in finishing the Indian Creek spawning area. The exact location of the area to be improved will be determined in the field. The channel will be located approximately as shown in Figure 5.