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Mapping Instream Habitat on the San Juan River Using Airborne Videography

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16. ABSTRACT

Concerns have been raised over the potential impacts of the Animas/LaPlata project and the regulation of Navajo Dam. Flow depletions in the San Juan River may adversely affect the remnant population of the native fish, particularly the endangered Colorado squawfish and razorback sucker. A multiyear research program is currently being conducted on the San Juan River as a result of a Jeopardy Opinion delivered by the U.S. Fish and Wildlife Service on Animas/LaPlata and the subsequent Reasonable and Prudent Alternative that was accepted. A multidisciplinary research team composed of representatives from the affected agencies is currently investigating the relationship between flow and survival of native fish species in the San Juan. This study explores the relationship between flow and important native fish habitats on the San Juan River in New Mexico and Utah. Specifically, it examines the number and area of backwaters and side channels and their relationship to flow levels. Airborne videography is used for this study instead of more expensive aerial photography. The data suggest strong relationships between flow and backwater and side channel area. Backwater area was maximized at the lowest flows and side channel area was maximized at peak flow.

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I

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CONTENTS

Page

Introduction . . . 1

Conclusions . . . 2

Methods . . . 2
- Study site . . . 2
- Video acquisition . . . 3
- Image processing . . . 3
- Interpretation . . . 4
- Riverflows . . . 5

Results . . . 6
- Reach 1 . . . 6
- Reach 2 . . . 7
- Reach 3 . . . 9
- Backwater and side channel distribution . . . 10

Discussion . . . 10

Recommendations . . . 12

References . . . 13

TABLES

Table
1 1991 San Juan River flow on videography acquisition dates . . . 6
2 Videography analysis results – Reach 1 . . . 7
3 Videography analysis results – Reach 2 . . . 9
4 Videography analysis results – Reach 3 . . . 10

FIGURES

Figure
1 Location map of study site . . . 15
2 Examples of backwater form and location . . . 16
3 Examples of side channel size and location . . . 17
4 1991 water year hydrograph of San Juan River at Shiprock, NM, gauge 09368000 . . . 18
5 1991 water year hydrograph of San Juan River at Four Corners, CO, gauge 09371010 . . . 19
6 1991 water year hydrograph of San Juan River near Bluff, UT, gauge 09379500 . . . 20
7 Reach 1 (RM 158 – 119) habitat to flow relationships . . . 21
8 Reach 1 habitat to flow relationships continued . . . 22
9 Reach 2 (RM 118 – 68) habitat to flow relationships . . . 23
10 Reach 2 habitat to flow relationships continued . . . 24
11 Reach 3 (RM 67 – 52) habitat to flow relationships . . . 25
12 Reach 3 habitat to flow relationships continued . . . 26
13 Distribution of total backwater area per mile as flow changes . . . 27
14 Distribution of total side channel area per mile as flow changes . . . 28
15 Example of high flow habitat active and inactive . . . 29
16 Example of side channel cut-off and backwater formation due to flow . . . 30
17 Emergence of submerged habitat with decreased flow Top – 4,530 ft^3/s, bottom – 653 ft^3/s . . . 31

APPENDIX

Habitat totals per mile by flow and reach . . . 32

INTRODUCTION

The Animas/LaPlata is a water development project (Project) in southern Colorado and northern New Mexico in the San Juan River Basin. The Project was authorized by the Colorado River Basin Project Act of September 30, 1968, as a participating project under the Colorado River Storage Act of April 11, 1956. Subsequent authorization for the construction, maintenance, and operation of the Project was granted under the Colorado River Basin Act and the Colorado Ute Indian Water Rights settlement of 1988. However, concern over the impact of water depletions by the Project on endangered species resulted in a Jeopardy Opinion under the ESA (Endangered Species Act) by the U.S. Fish and Wildlife Service (Service). Subsequently, a Reasonable and Prudent Alternative was crafted which allowed the Project to proceed providing that a multiyear research plan was developed and implemented, depletions were limited until results of the research could be obtained, and Navajo Dam operated to produce test flows mimicking a natural hydrograph. In addition, in July 1991 the U.S. Bureau of Reclamation (Reclamation) requested consultation under the ESA on the operation of Navajo Dam and agreed to release test flows during the 7-year research period so that flow effects on the endangered fish and other native and non-native fishes below Navajo Dam could be determined.

This study is part of an interdisciplinary research effort addressing biological, hydrologic, and sediment issues. This study, using videographic techniques, assesses flow levels in the San Juan River versus habitat quantity (main channel and low velocity habitats such as backwaters and side channels) needed for several life stages of the native fish. Studies conducted by the Service concluded that backwaters in the Green River are preferred habitat for YOY (young-of-the-year) Colorado squawfish (Holden and Stalnaker, 1975; Holden, 1977; Tyus and McAda, 1984; Tyus et al., 1987). Squawfish spawn during mid to late summer and their larvae become distributed in shallow backwater habitat, reducing predation and protecting them from adverse flow events (Tyus et al., 1987). This evidence suggests that maximizing backwater habitat during summer will increase the survival rate of young Colorado squawfish and, therefore, would be an important factor in the management and preservation of the species. Studies conducted by Pucherelli et al., 1990a and 1990b, document backwaters per river mile in the San Juan River to be three times less than backwaters in the Green River. This evidence suggests that squawfish may be using the more available side channel habitat as well as backwaters.

A technique was required to accurately map backwater habitat in response to various San Juan River flows. The IFIM (instream flow incremental method) has not proven adequate to calculate backwaters on large turbid and hydrologically complex rivers such as the Green River (Rose and Hann, 1989). Rose and Hann's finding would apply to the San Juan because of similar conditions. Therefore, alternative methods were employed. Pucherelli et al., 1990a, 1990b, and 1987, used aerial photographs and a GIS (Geographic Information System) to map backwater habitat and changes in river morphology as a function of riverflow.

This study examines the pretest flow operation relationship between flow and the number and area of backwaters and side channels on the San Juan River in New Mexico and Utah. The objective is to collect several years of habitat data from different flow scenarios and establish a data base to assist in determining the optimal San Juan River flows needed to maximize low velocity habitat. As an alternative to the more expensive aerial photographs and GIS, airborne videography is being used.

CONCLUSIONS

This study demonstrates the utility of airborne videography to quantify San Juan River flow to low velocity habitat relationships.

The data collected for 1991 show a strong relationship between flow and backwater and side channel habitat. Maximum backwater habitat occurred with flow in the range of 653 to 1,210 cubic feet per second. Maximum side channel habitat was found with flow to be in the range of 2,350 to 4,530 cubic feet per second. A compromise flow derived from these data which would provide the most of both backwaters and side channels together would be a flow in the range of 1,210 to 2,380 cubic feet per second.

Use of airborne videography is continuing to validate the findings in this report, as well as to collect data for Navajo Dam test flow operation.

METHODS

Study Site

The entire study site is located on the San Juan River from the Hogback Diversion, 8.7 miles east of Shiprock, New Mexico, downstream to Mexican Hat, Utah, (see location map on fig. 1). The Hogback Diversion is located at river mile 158.8 and Mexican Hat, Utah, is at river mile 51.8, giving about 108 river miles total for the study. The study site is divided into three reaches for this report. These reaches were chosen for three reasons: first, stream gauges are located at or near the beginnings of the reaches so the riverflow can be specifically characterized for each reach; second, these reaches tend to be natural breaks for habitat characteristics; and third, these reaches are also physically easy to identify on the ground and on a map. Reach 1 starts at the Hogback Diversion and ends at the start of river mile 119, which is at the U.S. highway 160 bridge near the Four Corners Monument. Reach 2 extends from this point to the start of river mile 68. River mile 68 is located where the river enters the Lime Ridge anticline, which is also near the confluence with Chinle Creek. The remainder of the study site is Reach 3, which starts at the beginning of river mile 68 and ends at the start of river mile 52, which is close to the U.S. Highway No. 163 bridge at Mexican Hat.

Reach 1, the most braided section of the study site, contains the most side channel area and number of the three reaches. Reach 1 also has the most vegetation, which may account for the lower amount of backwater habitat compared to Reach 2, where islands are less stabilized. Reach 2 has a large quantity of side channel as well as backwater habitat. The channel is narrower in Reach 2 than in Reach 1 as empirically noted by the number of double passes required for the video to cover the river in Reach 1. Reach 3 is the San Juan Canyon area and

has the least amount of low velocity habitat area. Any habitat in this reach occurs between where the river emerges from Raplee Ridge anticline and Mexican Hat, Utah.

Video Acquisition

Acquisition of the airborne videography for this study is done using the Reclamation Bell Jet Ranger helicopter based in Salt Lake City, Utah. The use of a helicopter allows for flat turns so that the camera remains vertical, reducing one source of error. A Sony DXC M7 CCD video camera with a 12:1 zoom lens set at full wide angle is mounted on the underside nose of the helicopter with a Tyler remote controllable mount. The recording deck is a Sony 3/4-inch VO 8800, U-matic SP. The helicopter is equipped with a radar altimeter to allow the pilot to maintain a constant altitude above the river.

Prior to the video acquisition mission, ground reference measurement points are set up. These points take the form of either target panels placed a known distance apart near the river, or bridges that cross the river which are measured to give a known ground length. San Juan videography is acquired at an altitude of 2,000 feet above the river. This altitude allows for full bank coverage with one pass for the majority of the river. A flying height of 2,000 feet results in a scale of about 1:2260 for the videography, as viewed on the computer monitor. As an aid to interpretation, the video analyst rides in the helicopter at the time of acquisition. The analyst views the taped scene with a small black and white monitor during the flight and records comments onto the audio track. Because of the size and quality of the flight monitor, these taped comments provide important ground information that may only be evident when viewed with the eye during the flight. An example of this information might be shallow water areas that may not be discernible from wet sand when viewed on the tape. Another use for the audio commentary is to periodically give an altitude reading from the radar altimeter, especially when more than a 100-foot deviation from nominal altitude occurs. In the laboratory, audio information can be used to make calibration adjustments to the captured video frames.

Image Processing

The videographic tape is then analyzed/interpreted using PC based MIPS (Map and Image Processing System) software which has video frame capture capability. The tape is viewed using a Sony VP-9000 video tape player that is connected to a 19-inch color monitor and the computer video capture board. The analyst runs the video tape and, at the desired point in the tape, captures a video frame with the software set in the video frame capture mode. The aspect relation of the computer monitor lines/columns is then corrected to give square pixels. The video frame is now in a digital raster form that can be stored and interpreted with other software functions. The raster pixel size is now ready to be calibrated using the ground reference features. A frame containing a bridge or calibration panels is captured and a caliper tool is placed over the known distance with a mouse. The pixel size for the entire raster is then set by entering the dimension of the feature. This calibration is then used for the following captured frames until the calibration is changed because of flying height change. The 2,000-foot flying height yields a pixel size of 1-meter ground distance on a side. Habitat areas are then delineated on screen with a planimeter function that computes the area of a polygon made with a cursor positioned by a mouse. The software produces an ASCII text file containing labels and the dimensions and areas of the digitized habitat polygons. The interpreted rasters are stored on rewriteable optical disks. The 19-inch color monitor is viewed during the interpretation process to assist the video analyst because it has higher resolution than the computer monitor. A section of tape is played and reversed as needed during the interpretation to take advantage of changing sun reflection and perspective. One advantage videography has over aerial photography for river habitat quantification is its ability to observe motion. The ability to see the velocity of the water is a great aid, for instance, in distinguishing a side channel that marginally qualifies for that designation from the main channel. Change in perspective is another advantage videography has. This change in perspective is helpful in the case of overhanging vegetation where the changing position may allow identification of otherwise hidden features. Also, it causes the sun glint to travel along the water, making shallow water easier to distinguish from wet sand.

Interpretation

River habitat interpretation requires development of basic criteria for categorizing each of the different habitat types. Because a wide variety of subtle variations occur within habitat types, especially side channels, the initial definition has to be refined as more and more variations are encountered. The following habitat categories were interpreted from the 1991 videography:

- Backwaters
- Side channels
- Isolated pools
- Main channel

The main criterion used for defining a backwater was that the velocity of the water was zero. A backwater could have only one connection to a main channel or side channel so no flow through occurred. A backwater could occur along the bank of a main channel or side channel. They also could occur in islands or sandbars within the main channel or side channels. Figure 2 shows examples of backwater form.

Side channels observed on the 1991 videography of the San Juan River included small ephemeral side channels 40 square meters in area to large, nearly permanent features with areas of 90,000 square meters. The primary criteria used to identify side channels were:

- Width of less than 50 percent of the main channel
- Reduced flow velocity and volume
- Course deviated from the main channel and then rejoined
- The angle at which the channel deviates from the main channel was not streamlined (greater than 45 degrees) with respect to the main channel flow.

These criteria worked well for identifying the larger classic side channels (secondary channels). Smaller, less well-defined, and ephemeral side channels were also identified by widths

significantly smaller than the main channel and by reduced flow. The courses of these side channels were found to not deviate far from the main channel if at all. These ephemeral side channels often occurred between the bank and an island/sandbar where there is a narrow channel with water flowing through. On sandbars they were found where the current at a higher flow scoured out, or deposition created a small channel. As flow receded and exposed the sandbar, the side channel appeared.

These side channels were ephemeral and sometimes disappeared to form isolated pools as the flow receded or reappeared with increased riverflow. All side channels were placed into one category for this report. A flow-through category will be added for 1992 data interpretation, but this type of habitat can be found in these data by extracting the side channels with the appropriate size. Figure 3 shows examples of types of side channels as identified from videography.

Isolated pools are water features that form because of drop in flow that creates a pool of still water isolated from water flowing in the river. Isolated pools occur most frequently in side channels, but can form in backwater areas. Isolated pools are formed in a side channel when the flow decreases to the point where the side channel flow becomes cut off. Portions of the side channel that are deeper than the rest of the side channel and cannot drain become isolated pools. Isolated pools are observed to form in backwaters when flow drops the level of the river below the sediment levee at the mouth of the backwater, stranding the water in the backwater area.

Riverflows

Videography acquired for the 1991 effort serves as baseline data for comparison to following years. It was decided that seven acquisition missions would be flown in an attempt to represent the hydrograph for 1 full year before Navajo Dam was operated to mimic a natural hydrograph. The first video acquisition was done prior to peak runoff. The remainder of the acquisition missions were flown starting at peak spring runoff and followed the descending limb of the hydrograph. Table 1 gives the dates and riverflow when the videography missions were flown. Helicopter schedule conflicts and a rapid decline in riverflow allowed for only five of the scheduled seven video acquisition missions.

USGS stream gauges were used to plan the scheduling of the video acquisition missions. The gauge near Shiprock, New Mexico, which initially was to be the primary gauge, proved to be unreliable, giving only sporadic readings. The gauge at Farmington, New Mexico, was monitored and plotted in an effort to predict when the desired flow would occur with at least one week lead time for scheduling. The Bluff gauge near Mexican Hat, Utah, was also monitored for this purpose. The Four Corners gauge at the start of Reach 2 does not have a telemetry link to give daily readings. Table 1 gives the video acquisition dates and the mean flow at the gauges. Hydrographs for the three USGS gauges with video acquisition points are given on figures 4 through 6.

Videography will be acquired during the 1992 season, which is the first year of test flow operation of Navajo Dam. The range of flows will be greater than those in 1991 with a higher peak flow in the spring. An attempt will be made to acquire videography at about the same flows as those collected in 1991 in addition to the higher peak flow.

Table 1. – 1991 San Juan River flow on videography acquisition dates.

Flow	Date	Shiprock 09368000 Reach 1 ft³/s	Four Corners 09371010 Reach 2 ft³/s	Bluff 093795000 Reach 3 ft³/s
1	04/22/91	2,320	2,560	2,140
2	05/17/91	3,830	4,530	4,320
3	06/05/91	2,380	2,350	2,540
4	07/02/91	1,310	1,210	1,200
5	07/18/91	678	653	676

RESULTS

Reach 1

Analysis of the 1991 videography revealed Reach 1 to be the portion of the San Juan River which contained the most side channel and backwater habitat area. Table 2 details the results of the videography analysis for Reach 1. The general trend was for decreased side channel area with decreased flow. The trend for backwaters was increased area with decreased flow. Main channel and total surface area changed in relation to flow as expected, that is, less surface with decreased flows.

Both side channel area and number decreased with a receding flow from the peak. Side channel area was maximized at the peak measured flow (3,830 cubic feet per second) giving 912,709.7 square meters. At low flow (678 cubic feet per second), side channel area was 354,659.2 square meters (61-percent decrease).

The relationship of backwater area to flow for the first four flows remained fairly constant at an average of 29,875.9 square meters. At the low flow (678 cubic feet per second), backwater area jumped to 65,073.1 square meters, a significant increase of 117 percent. Table 2 shows that the number of backwaters from peak flow to flow 3 (2,380 cubic feet per second) dropped off significantly (69 to 25, or a 64-percent decrease) while the area remained fairly constant, indicating numerous small backwaters at peak flow and fewer but larger backwaters at low flow. From 2,380 cubic feet per second to 678 cubic feet per second, the number of backwaters increased substantially to 92 (270-percent increase). Figures 7 and 8 show Reach 1 habitat to flow relationships.

Table 2. – Videography analysis results – Reach 1.

Reach 1 RM 158-119 Hogback Diversion to Four Corners

Flow:	1	2	3	4	5
Acquisition date:	4/22/91	5/17/91	6/5/91	7/2/91	7/18/91
Flow (ft³/s):	2,320	3,830	2,380	1,310	678
Backwaters (BW)					
BW size class (m²)					
<20	11	1	0	3	4
20 to 200	58	34	10	37	52
200 to 500	5	17	5	13	11
500 to 1,000	12	9	5	4	12
>1,000	9	8	5	6	13
Number of BW's	95	69	25	63	92
Avg. No. BW/RM	2.4	1.7	0.6	1.6	2.3
Total BW area	34,686.1	29,664.3	26,815.8	28,337.4	65,073.1
Avg. BW area/RM	867.2	741.6	670.4	708.4	1,626.8
Avg. BW size	365.1	429.9	1,072.6	449.8	707.3
Median BW size	76.8	193.8	295.5	106.5	117.6
Side channels (SC)					
SC size class (m²)					
<1,000	33	19	9	5	7
1,,000 to 3,000	24	24	19	25	14
3,000 to 10,000	19	24	26	16	12
10,000 to 20,000	8	12	12	9	5
>20,000	7	10	9	7	4
Number of SC's	91	89	75	61	42
Avg. No. SC/RM	2.3	2.2	1.9	1.5	1.1
Total SC area	589,650.2	912,709.7	768,075.3	612,600.6	354,659.2
Avg. SC area/RM	14,741.3	22,817.7	19,201.9	15,315.0	8,866.5
Avg. SC size	6,479.7	10,255.2	10,241.0	10,042.6	8,444.3
Median SC size	2,090.5	3,308.2	3,729.8	3,257.3	3,042.0
Iso. pool area	8.161.9	24,426.3	4,563.5	10,624.7	23,906.8
Main channel area	3,850,610.6	4,997,664.4	4,270,054.9	3,922,911.6	3,566,541.3
Total surface area	4,394,687.8	5,886,464.6	5,058,499.0	4,566,666.4	4,009,293.2

Reach 2

Reach 2 showed the same general trend as Reach 1, in that side channel area decreased with decreased flow and backwater area increased with decreased flow. Numbers of backwaters increased with decreased flow after the peak measured flow. Numbers of side channels had a less obvious relationship to flow. Main channel and total surface area responded proportionally to flow (see fig. 10). Table 3 summarizes the results of the analysis.

Side channel area again was maximized at peak flow (4,530 cubic feet per second) giving 644,542.1 square meters, and minimized at low flow (653 cubic feet per second) giving 212,418.3 square meters. Numbers of side channels did not have the decreasing linear relationship to flow that side channel area did (fig. 9), which may indicate that the morphology of the river in Reach 2 is such that side channels can exist over a wide range of flow. Then, at some flow less than 1,210 cubic feet per second, the water drops enough to cut off the side channel and form two backwaters or completely dry up. In other words, the wetted side channel area responds proportionately to flow, but the side channel numbers have a hysteresis effect, or an ability to maintain flow while their surface area drops.

For post-peak flow, backwater area increased from 16,281.1 square meters at 2,350 cubic feet per second to 36,678.0 square meters at 653 cubic feet per second, a 125-percent increase. This trend was also true for post-peak backwater numbers. The number of backwaters increased 200 percent, from 38 to 115. In the discussion section of this report, a possible explanation is given for the large backwater area and number at 4,530 cubic feet per second shown in the backwater graphs of figure 9.

Table 3. – Videography analysis results – Reach 2.

Reach 2 RM 118-68 Four Corners to Chinle Creek					
Flow:	1	2	3	4	5
Acquisition date:	4/22/91	5/17/91	6/5/91	7/2/91	7/18/91
Flow (ft³/s):	2,560	4,530	2,350	1,210	653
Backwaters (BW)					
BW size class (m²)					
<20	14	2	0	14	20
20 to 200	46	46	21	58	60
200 to 500	9	40	10	23	18
500 to 1,000	5	10	2	1	7
>1,000	1	13	5	3	10
Number of BW's	75	111	38	99	115
Avg. No. BW/RM	1.5	2.2	0.7	1.9	2.3
Total BW area	11,401.8	56,420.7	16,281.1	26,418.5	36,678.0
Avg. BW area/RM	223.6	1,106.3	319.2	518.0	719.2
Avg. BW size	152.0	508.3	428.5	266.9	318.9
Median BW size	59.8	232.6	164.6	68.5	63.6
Side channels (SC)					
SC size class (m²)					
<1,000	21	15	8	26	14
1,000 to 3,000	16	19	15	15	13
3,000 to 10,000	22	22	24	30	14
10,000 to 20,000	14	19	13	9	5
>20,000	4	6	5	3	1
Number of SC's	77	81	65	83	47
Avg. No. SC/RM	1.5	1.6	1.3	1.6	0.9
Total SC area	451,239.7	644,542.1	493,995.4	412,898.2	212,418.3
Avg. SC area/RM	8,847.8	12,638.1	9,686.2	8,096.0	4,165.1
Avg. SC size	5,860.3	7,957.3	7,599.9	4,974.7	4,519.5
Median SC size	3,102.5	4,029.4	4,533.7	3,011.6	2,309.6
Iso. pool area	2,260.4	4,787.3	12,409.1	8,461.1	18,436.6
Main channel area	5,330,527.4	6,329,153.6	5,734,264.9	4,875,672.2	4,618,897.6
Total surface area	5,661,402.2	7,010,201.9	6,244,535.7	5,322,778.1	4,886,430.6

Reach 3

This 16-mile reach through the San Juan Canyon had very little backwater and side channel habitat, as shown in table 4 and figure 11. A total of only five side channels occurred in the five flows studied. They occurred at the two lowest flows (1,200 and 676 cubic feet per second). The number of backwaters was highest at the two lowest flows mentioned above, but the greatest amount of backwater area occurred at the prepeak flow of 2,140 cubic feet per second and the peak measured flow of 4,320 cubic feet per second. This was caused by encroachment of the San Juan into the Lime Creek stream channel. Main channel area responded differently to flow in this reach. The narrow channel did not allow for horizontal spreading of the river. Instead of a proportional response to flow, the surface area responded in a step fashion that was not as sensitive to flow changes (fig. 12).

Table 4. – Videography analysis results – Reach 3.

Reach 3 RM 67-52 Chinle Creek to Mexican Hat					
Flow:	1	2	3	4	5
Acquisition date:	4/22/91	5/17/91	6/5/91	7/2/91	7/18/91
Flow (ft^3/s):	2,140	4,320	2,540	1,200	676
Backwaters (BW)					
BW size class (m^2)					
<20	0	0	0	1	0
20 to 200	1	0	0	7	8
200 to 500	0	0	0	0	1
500 to 1,000	1	1	0	0	0
>1,000	1	1	1	0	0
Number of BW's	3	2	1	8	9
Avg. No. BW/RM	0.2	0.1	0.1	0.5	0.6
Total BW area	2,075.5	2,134.1	1,406.0	538.6	936.4
Avg. BW area/RM	129.7	133.4	87.9	33.7	58.5
Avg. BW size	691.8	1067.1	1406.0	67.3	104.0
Median BW size	674.7	1067.1	1406.0	37.0	34.5
Side channels (SC)					
SC size class (m^2)					
<1,000	0	0	0	2	0
1,000 to 3,000	0	0	0	0	2
3,000 to 10,000	0	0	0	1	0
10,000 to 20,000	0	0	0	0	0
>20,000	0	0	0	0	0
Number of SC's	0	0	0	3	2
Avg. No. SC/RM	0	0	0	0.2	0.1
Total SC area	0	0	0	3,507.3	3,648.3
Avg. SC area/RM	0	0	0	219.2	228.0
Avg. SC size	0	0	0	1,169.1	1,824.2
Median SC size	0	0	0	114.1	1,824.1
Iso. pool area	0	0	789.7	378.8	163.5
Main channel area	1,433,957.2	1,397,355.4	1,315,583.4	1,062,757.9	1,081,449.0
Total surface area	1,436,032.8	1,399,489.5	1,317,788.1	1,067,182.6	1,086,197.1

Backwater and Side Channel Distribution

The distribution of backwater and side channel area per river mile along the length of the study area is given in figures 13 and 14, respectively. These two figures give an overview of the changes in habitat location as flow changes.

DISCUSSION

The three USGS stream gauges in the study area were both an advantage and disadvantage for the videography work in this study. The gauges allowed for specific information about the riverflow along the length of the study area. The drawback is that one gauge cannot provide a

reading of flow for the entire river. Nonuniform flow along the river plays a part in video acquisition difficulties.

In Reach 1, the data indicate that maximum side channel habitat area occurred at the highest measured flow (3,830 cubic feet per second). At flow 5 (678 cubic feet per second), side channel area reached its minimum for the flows examined. Backwater area was maximized at flow 5. Backwater area at the other four flows was fairly constant at a level 46 percent less than the maximum. This reach had the most side channel, backwater, and main channel habitat per mile of the three reaches. Upriver from this reach is an area very similar to Reach 1. Investigation of the portion of the San Juan River from the confluence with the Animas River to the Hogback Diversion should be considered.

Reach 2 side channel area was also maximized at the peak flow (4,530 cubic feet per second), and minimized at flow 5 (653 cubic feet per second). With the exception of peak flow, backwater area was maximized at the lowest flow (653 cubic feet per second), and decreased with increased flow. In figure 9, the spike in both the backwater area and backwater number graphs on the right show an anomaly in the trend of maximum backwater area at minimum flow. The large backwater area at peak flow (4,530 cubic feet per second) was most likely caused by the river entering what could be called a high flow habitat zone. As observed on the video of the peak flow, the water encroached on ephemeral tributary stream channels, creating a group of backwaters found only at higher flows. Also observed were side channels becoming active that normally are above the water level. The exact flow where this high flow zone became active cannot be determined from the 1991 data, but it appears to have been between 2,350 and 4,530 cubic feet per second. Figure 15 shows a comparison of this type of area at peak flow and flow 3 (2,350 cubic feet per second).

As the flow drops from 2,350 cubic feet per second to base flow, a steady increase in backwater area occurred as shown in figure 9 and table 3. The formation of this backwater habitat stemmed from two causes. First, the flow reached a threshold where side channels became cut off and formed backwaters; figure 16 is typical of this process. Second, the decreasing flow exposed sediment features that caused the formation of a group of low flow backwaters. Figure 17 is an example of this formation as it occurred at mile 77 between peak flow and low flow.

Reach 3 had distinctly different channel morphology compared to Reaches one and two. As shown in the data presented, backwater and side channel habitat in Reach 3 was minimal and controlled by the geomorphology of the San Juan canyon. Only at flows 1,200 cubic feet per second and lower did low velocity habitat appear in the 1991 data, other than backwaters formed by tributary channel encroachment. The slope of the descending limb of the hydrograph most likely plays an important role in the formation of sandbars within this reach.

Because of the inverse relationship between side channels and backwaters with flow, these data need to be considered along with fish sampling data and telemetry tracking data. Once the most important habitat type for the species/lifestages of concern is determined, videography data can be used to choose an optimum flow. From the 1991 data alone, a range from 653 to 1,210 cubic feet per second will provide maximum backwater habitat in Reaches one and two. Maximum side channel habitat will be provided with flow in the range of 2,350 to 4,530 cubic feet per second. A compromise derived from this data to provide the most of both backwaters and side channels together would be a flow in the range of 1,210 to 2,380 cubic feet per second. In considering the different life stages of the fish, the data may suggest the low flow option (653 to 1,210 cubic feet per second) for YOY fish just after the spawn and increase to the compromise flow of 1,210 to 2,380 cubic feet per second when the biologists agree that the fish have the ability to swim in the side channels.

As seen from video data used for this report, videography provides an efficient means to monitor and quantify river habitat changes. The 108 miles of this study area can be taped in about three hours. Features as small as 4 to 6 square meters can be distinguished, ensuring inclusion of small backwaters. Specific smaller sites can easily be monitored with higher resolution for more detailed mapping if desired. The Remote Sensing and Geographic Information Section is continuing videography work on the San Juan River to validate the above findings and further detail flow to habitat relationships.

RECOMMENDATIONS

Several modifications and additions to the videography study are suggested after analyzing the 1991 video data. The recommendations are as follows:

- Acquire additional video during FY1993 to verify FY1992 reoperation video results, and acquire desired flows that were unable to be collected in FY1992.

- Expand aerial video acquisition in Reach 1 to include the San Juan River from the confluence with the Animas River to the Hogback Diversion. This area has numerous backwaters and side channels which are hypothesized to be important to native/endangered fishes.

- Study temperature differences between main channel and secondary channels using infrared videography. When done in conjunction with the Secondary Channel Characterization study, infrared imagery might help to determine which secondary channels are more productive. Airborne infrared imagery can give overall temperature relationships for large stretches of river.

- Implement detailed site specific videography in conjunction with proposed habitat modeling work by the BIA (Bureau of Indian Affairs). Video images could be rectified and overlaid on BIA base maps to aid detailed habitat mapping and monitor channel change with flow.

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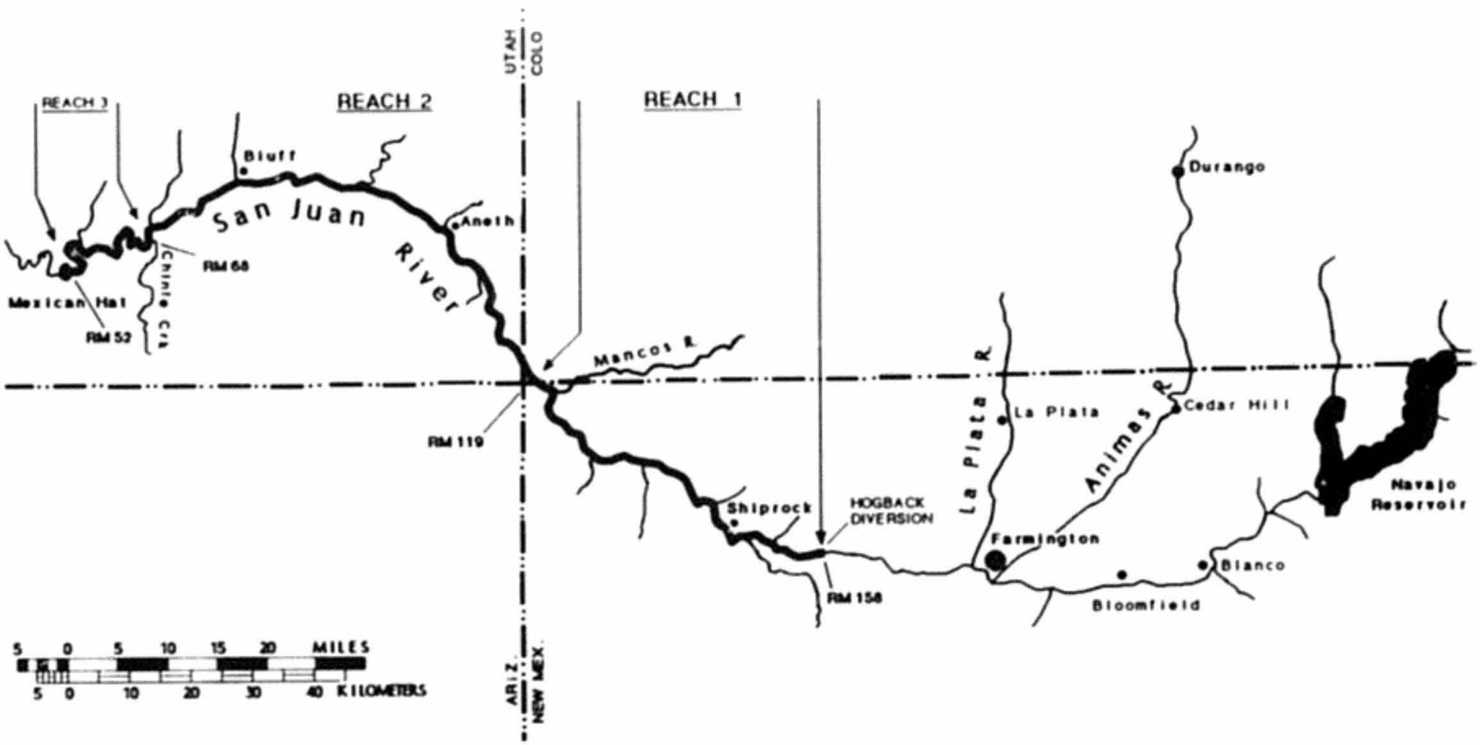


Figure 1. - Location map of study site.

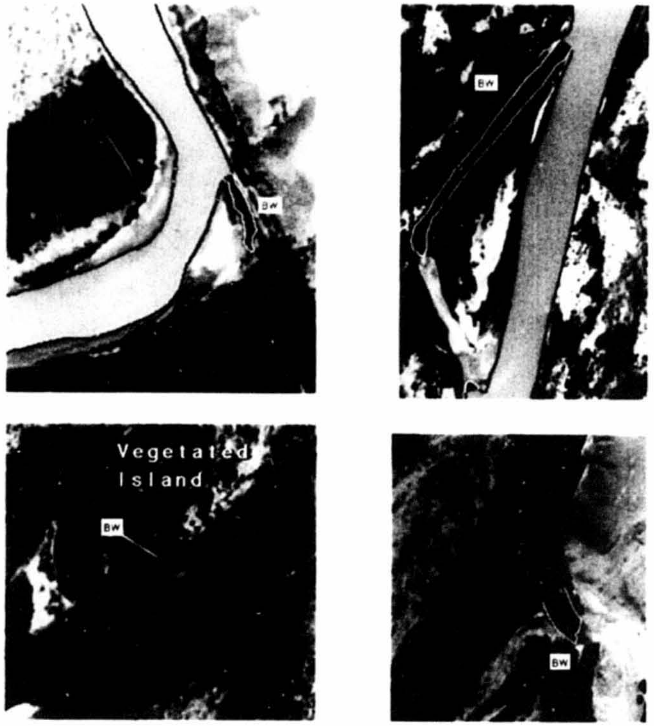


Figure 2. - Examples of backwater form and location.

Figure 3. - Examples of side channel size and location.

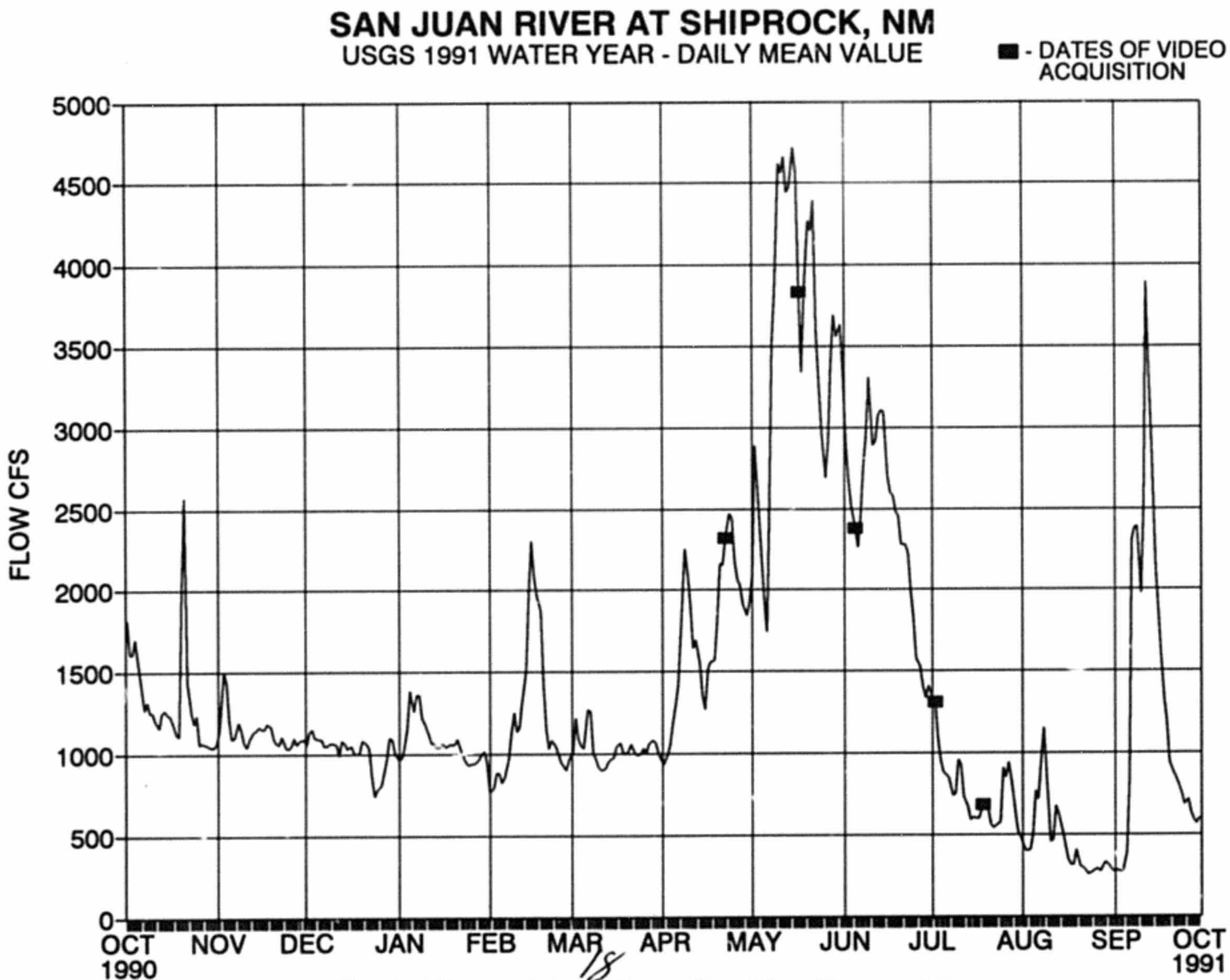


Figure 4. – 1991 water year hydrograph of San Juan River at Shiprock, NM, gauge 9368000.

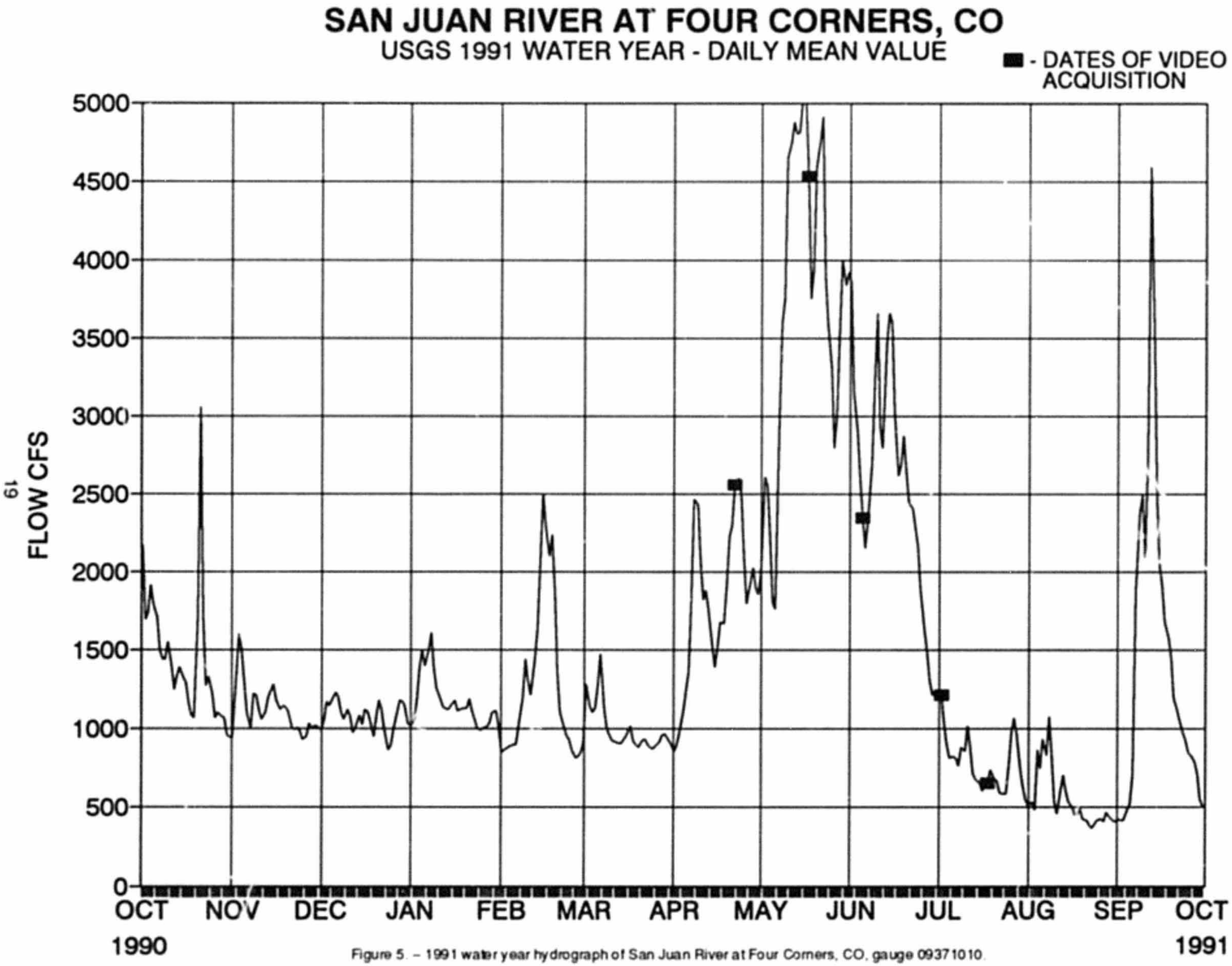


Figure 5. – 1991 water year hydrograph of San Juan River at Four Corners, CO, gauge 09371010.

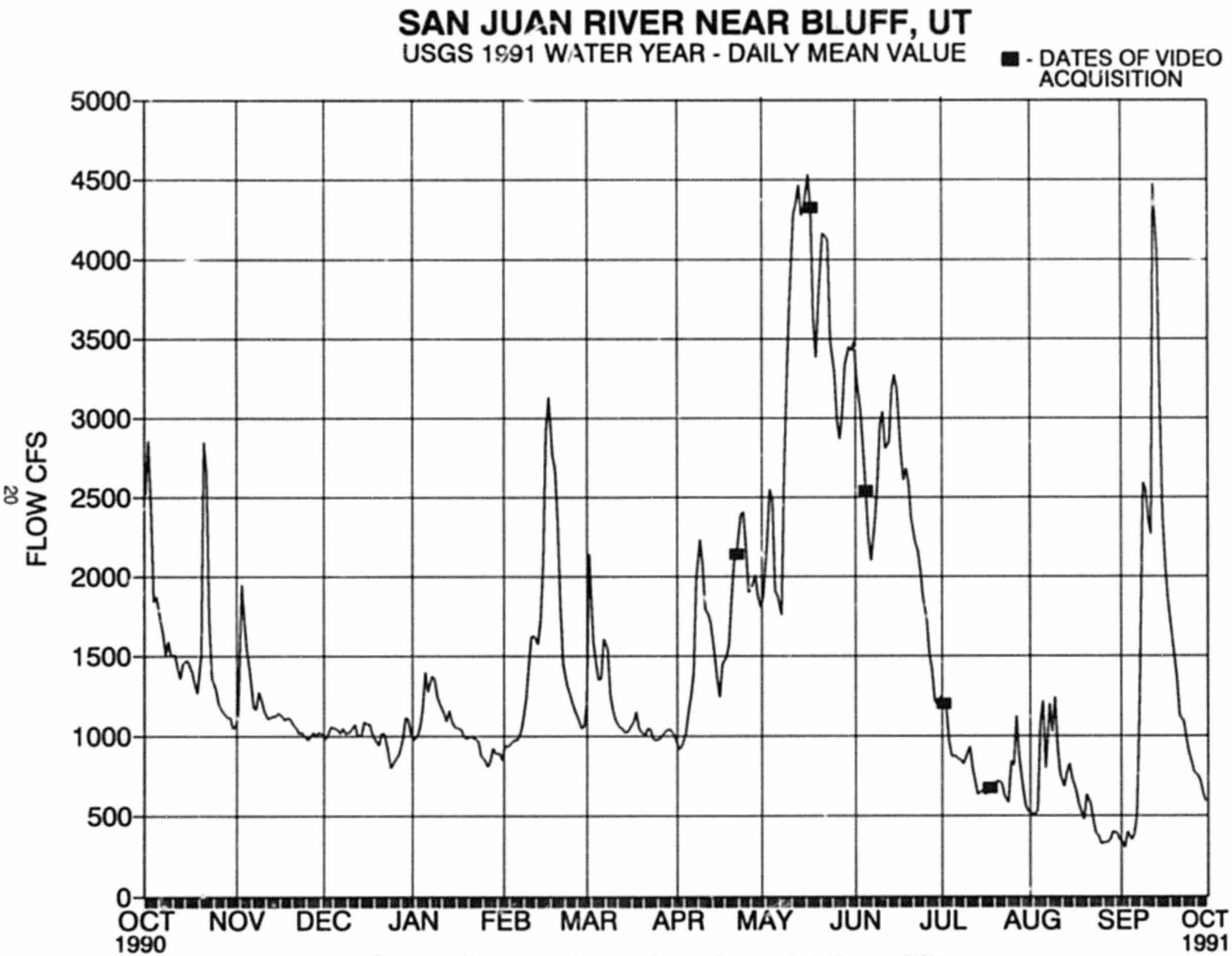
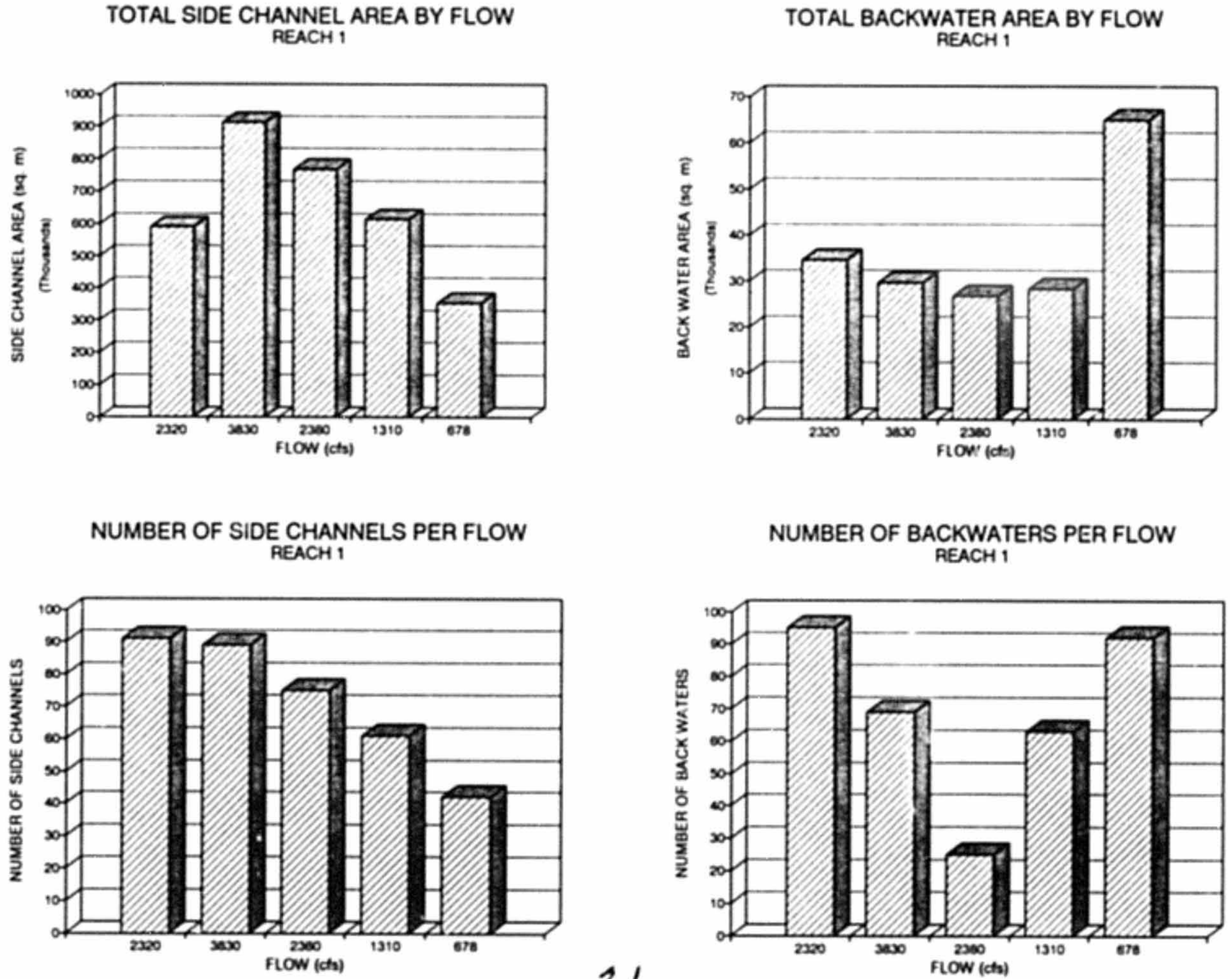


Figure 6 – 1991 water year hydrograph of San Juan River near Bluff, UT, gauge 09379500.



21

Figure 7. - Reach 1 (RM 158 - 119) habitat to flow relationships.

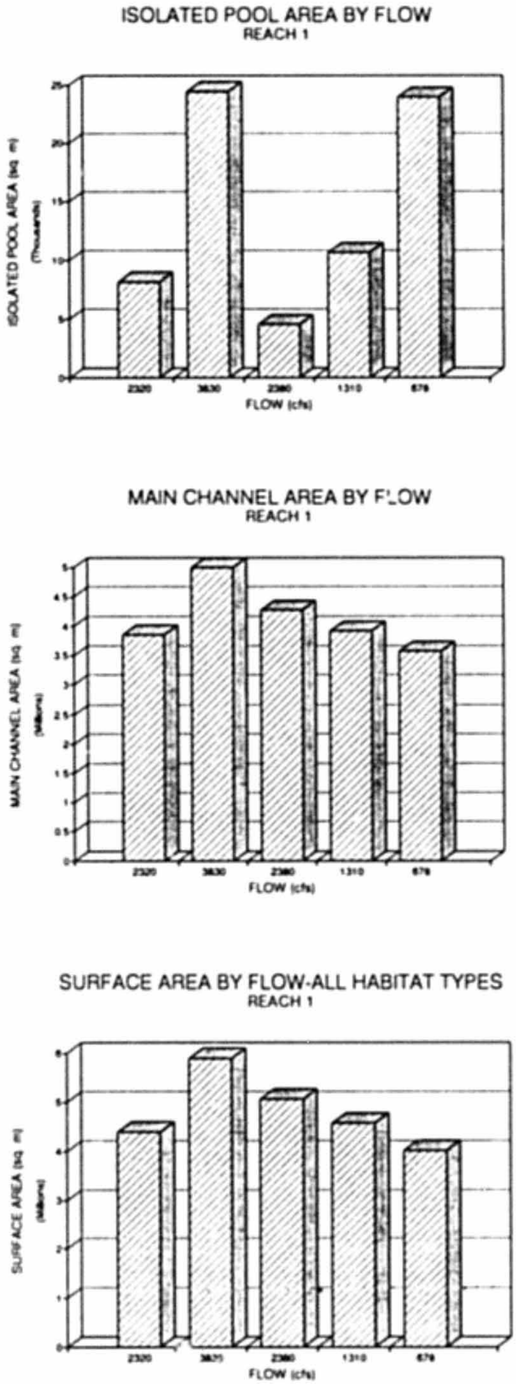


Figure 8. - Reach 1 habitat to flow relationships continued.

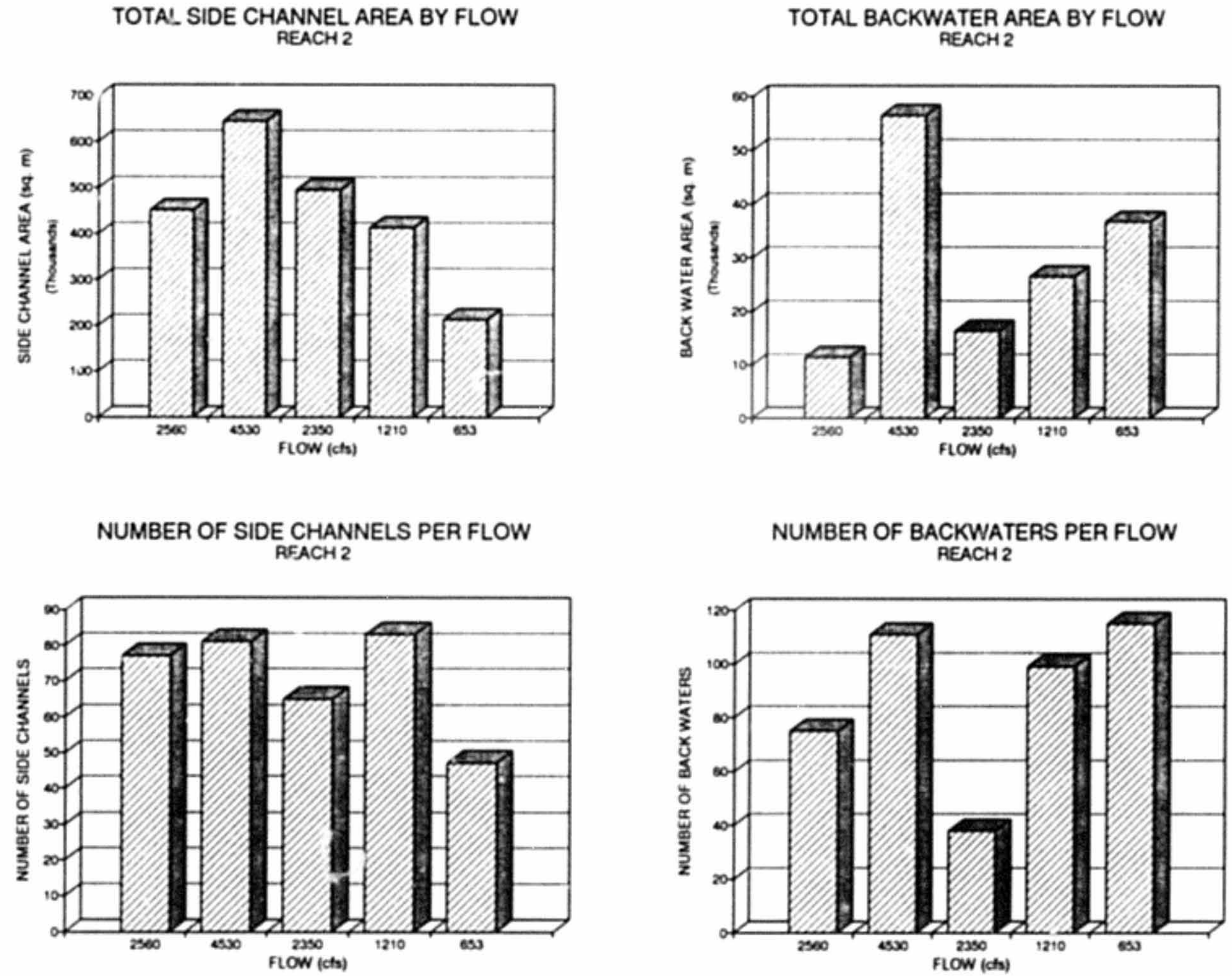
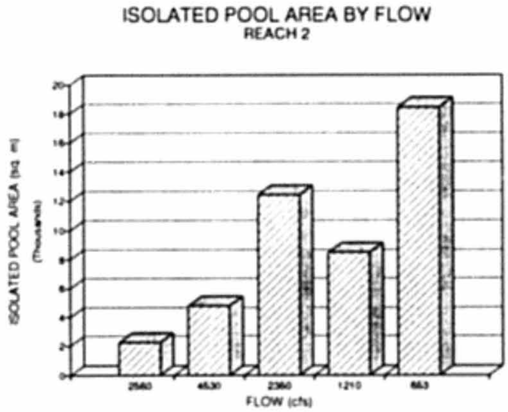
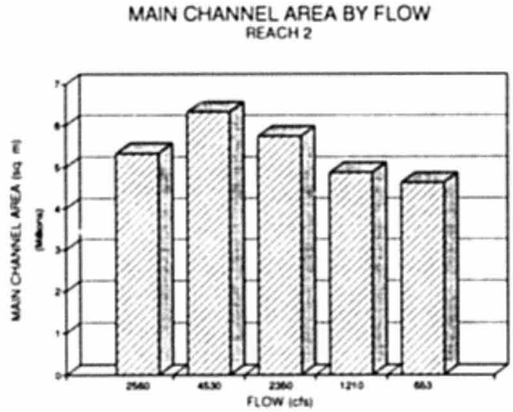


Figure 9. - Reach 2 (RM 118 - 68) habitat to flow relationships.





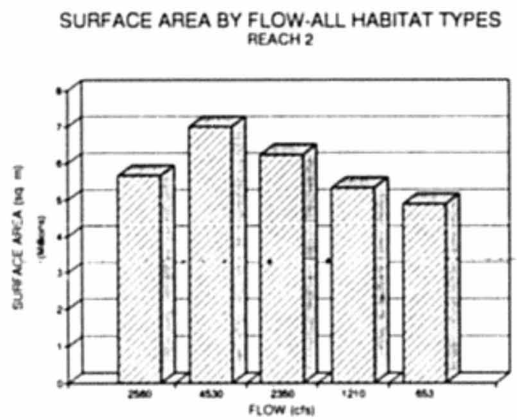


Figure 10. - Reach 2 habitat to flow relationships continued.

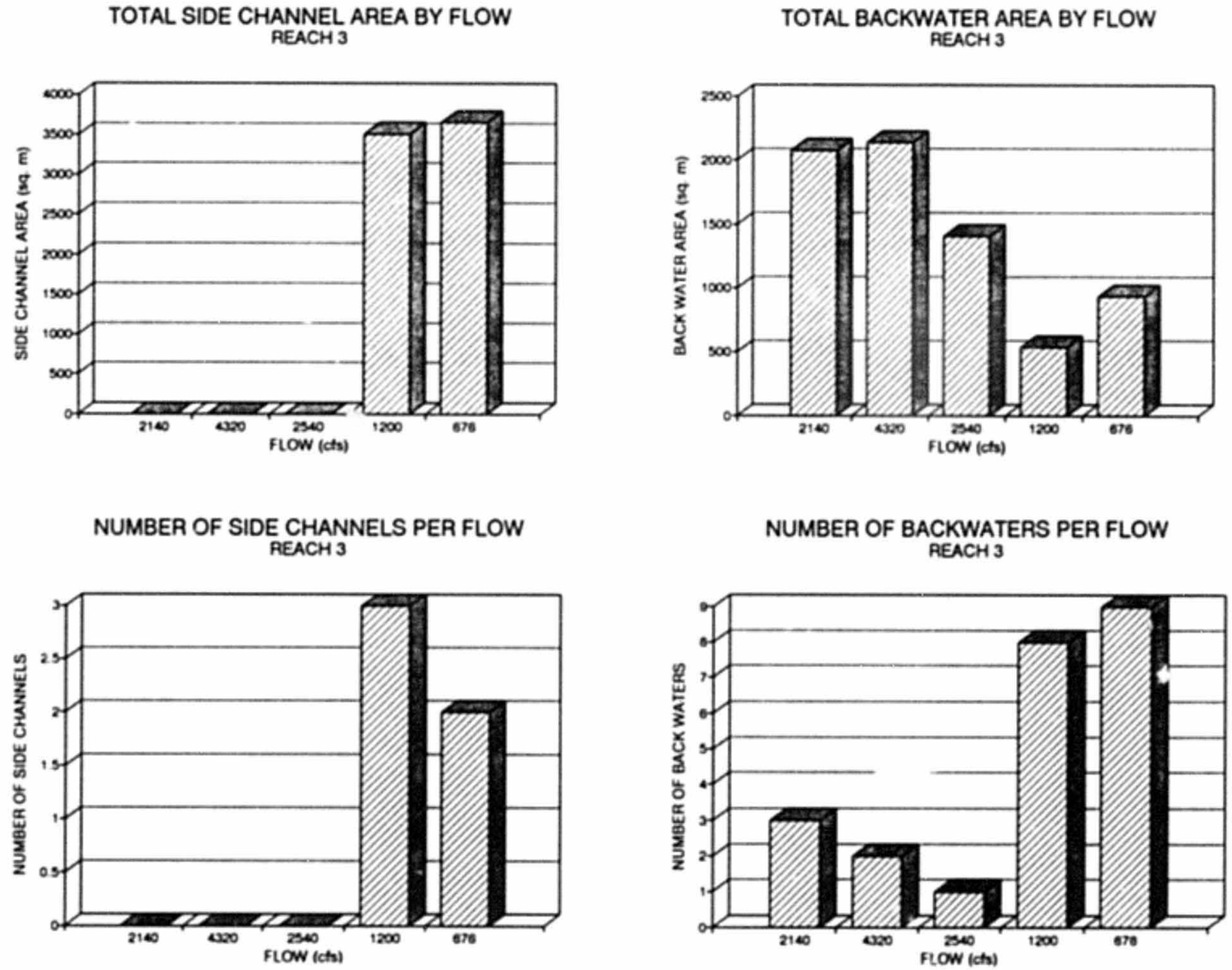


Figure 11. - Reach 3 (RM 67 - 52) habitat to flow relationships.

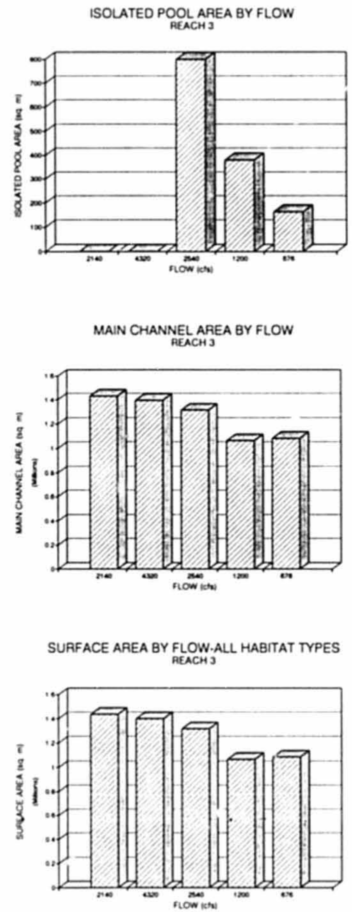


Figure 12. - Reach 3 habitat to flow relationships continued.

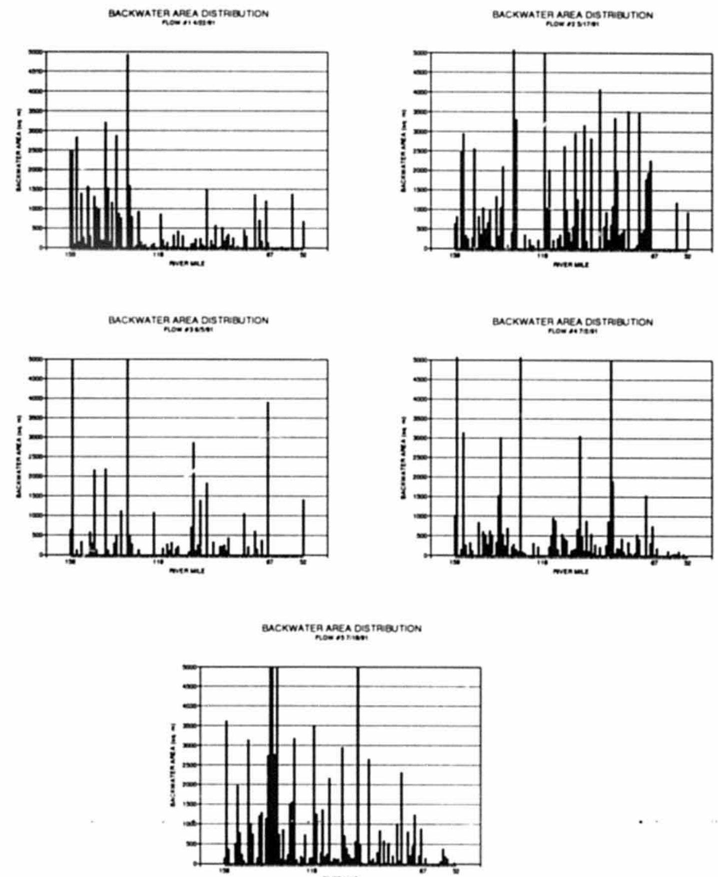


Figure 13. - Distribution of total backwater area per mile as flow changes.

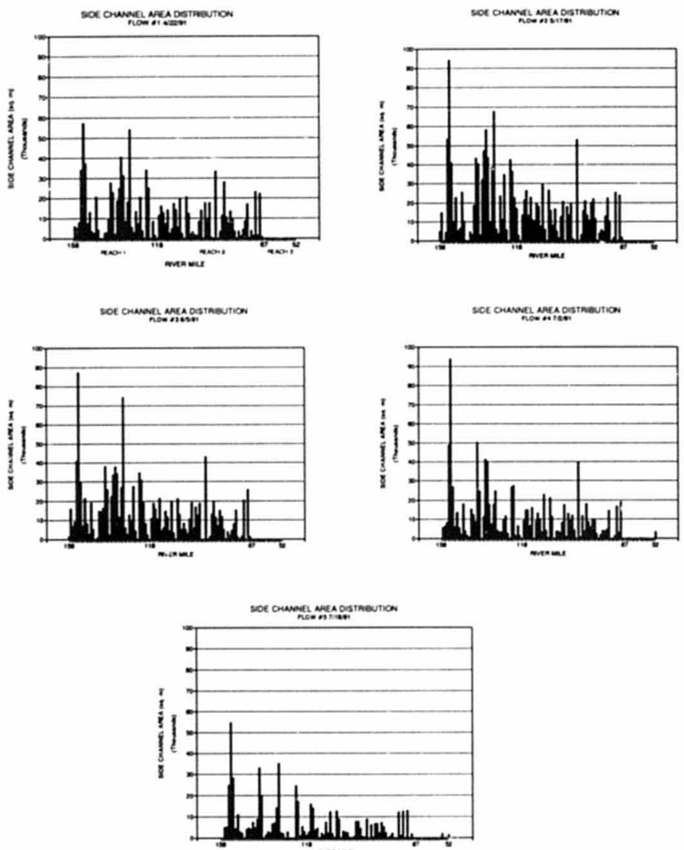


Figure 14. - Distribution of total side channel area per mile as flow changes.

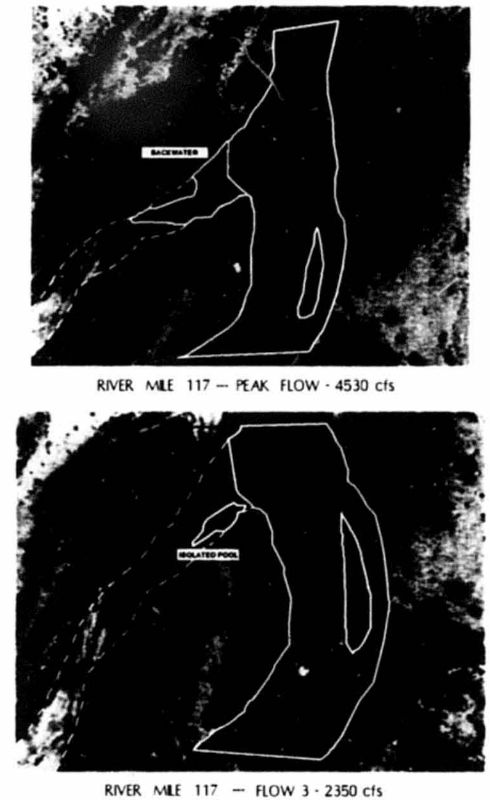
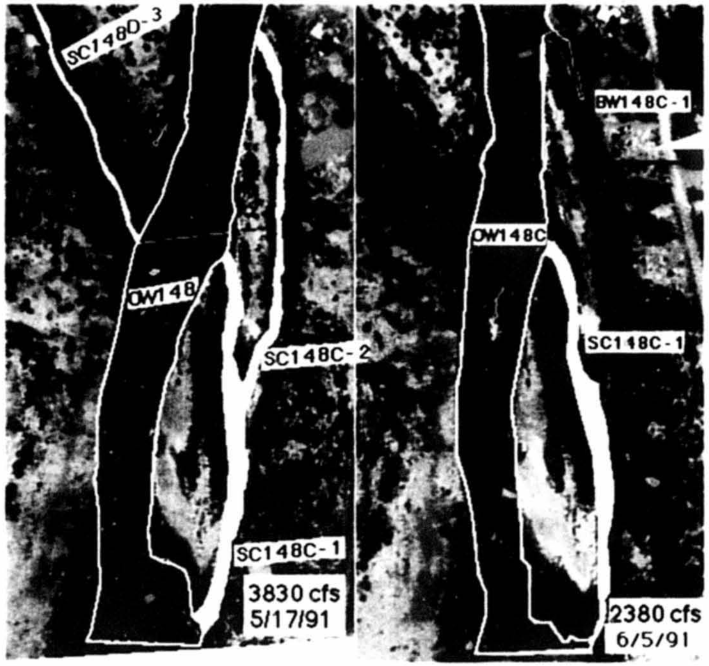


Figure 15. - Example of high flow habitat active and inactive.



Side channels 1,2,3 active

Side channel 1 still active, 2 now a backwater, 3 cut-off

Figure 16. - Example of side channel cut-off and backwater formation due to flow.

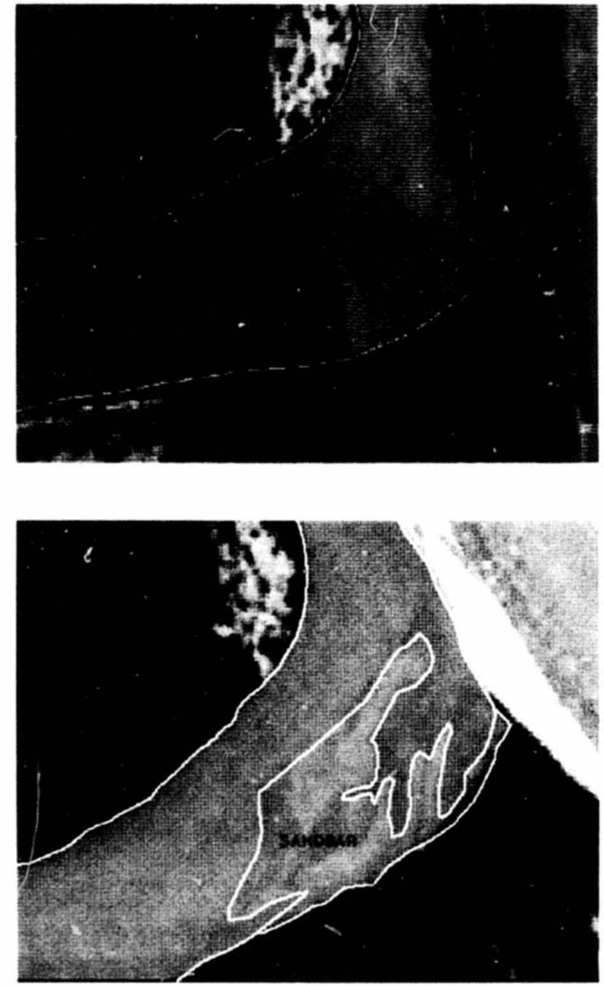


Figure 17. - Emergence of submerged habitat with decreased flow. Top - 4530 cfs, Bottom - 653 cfs.

APPENDIX

HABITAT TOTALS PER MILE BY FLOW AND REACH

HABITAT TOTALS PER MILE
4/22/1991 FLOW 1 (2320 ft^3/s) REACH 1

MILE	MAINCHANN (sq. m)	BACKWAT (sq. m)	ISOPOOL (sq. m)	SIDECHAN (sq. m)	OPEN WATER (sq. m)	TOTAL OPEN WATER (sq. m)
119	128802.75	0.00	0.00	1486.15	127776.67	127776.67
120	94513.41	112.28	0.00	8570.06	102927.37	230704.04
121	120330.38	68.47	0.00	0.00	120398.85	351102.89
122	98912.55	0.00	0.00	25050.91	123963.46	475066.35
123	108814.48	0.00	0.00	34198.97	143013.45	618079.80
124	103825.63	77.59	0.00	129.63	104032.85	722112.65
125	97388.97	47.47	0.00	3986.52	101422.96	823535.61
126	83901.26	148.80	0.00	20520.47	104099.49	927635.10
127	104578.77	922.91	210.88	7334.02	113046.58	1040681.68
128	93915.48	61.17	0.00	13665.71	107642.36	1148324.04
129	147829.77	0.00	0.00	2880.11	150709.88	1299033.92
130	119582.75	798.76	0.00	5570.36	112475.13	1411509.05
131	78362.87	1588.40	0.00	54235.63	133889.30	1545398.35
132	136201.59	4941.39	1097.27	18282.11	157299.00	1702697.35
133	98977.36	0.00	0.00	8587.39	107564.75	1810262.10
134	92091.57	0.00	0.00	31296.03	123387.60	1933649.70
135	102389.68	764.98	0.00	40672.14	143826.80	2077476.50
136	79775.07	884.57	0.00	24910.48	105570.12	2183046.62
137	111829.71	2873.73	0.00	18986.85	112185.74	2295232.36
138	75251.73	0.00	0.00	2260.27	77512.00	2372744.36
139	101732.87	1171.16	0.00	22945.47	125849.50	2498593.86
140	84900.79	153.54	0.00	27771.69	112826.02	2611419.88
141	93271.20	1525.14	0.00	9484.41	104280.75	2715700.63
142	116902.45	3204.70	188.51	3065.65	118645.12	2834345.75
143	99306.09	184.25	0.00	2790.14	100180.42	2934526.17
144	83511.25	180.84	0.00	0.00	83692.09	3018218.26
145	101744.80	991.17	0.00	52.89	100756.18	3118974.44
146	103768.95	1038.94	0.00	4365.61	109173.50	3228147.94
147	95979.43	1305.08	0.00	20669.67	117410.83	3345558.77
148	57089.01	0.00	0.00	2736.40	59825.41	3405384.18
149	82916.72	311.34	0.00	3701.13	84591.14	3489975.32
150	92797.78	1562.68	4813.43	13275.11	108937.23	3598912.55
151	88445.82	76.77	0.00	7577.97	96100.56	3695013.11
152	104120.38	271.25	0.00	37467.65	129298.98	3824312.09
153	77252.85	1397.20	699.46	57302.27	135165.03	3959477.12
154	81490.53	152.69	0.00	34257.83	113864.11	4073341.23
155	96644.77	2838.76	0.00	8142.66	93456.29	4166797.52
156	62457.73	88.71	0.00	5326.94	67108.25	4233905.77
157	71013.24	2471.96	256.75	6092.91	79834.86	4313740.63
158	77988.14	2469.41	895.64	0.00	80947.17	4394687.80
TOTALS						
SQM	3850610.58	34686.11	8161.94	589650.21		4394687.80
ACRES	951.50	8.57	2.02	145.71		1085.95

HABITAT TOTALS PER MILE
4/22/1991 FLOW 1 (2560 ft^3/s) REACH 2

MILE	MAINCHANN (sq. m)	BACKWAT (sq. m)	ISOPOOL (sq. m)	SIDECHAN (sq. m)	OPEN WATER (sq. m)	TOTAL OPEN WATER (sq. m)
68	133813.29	139.24	0.00	830.00	133334.07	133334.07
69	95176.52	1198.02	0.00	22309.97	115782.90	249116.97
70	126162.55	0.00	0.00	1495.19	125656.06	374773.03
71	90288.18	160.73	0.00	23186.10	113635.01	488408.04
72	124154.33	700.87	0.00	1274.65	107036.22	595444.26
73	132553.57	0.00	0.00	3861.33	128535.23	723979.49
74	112062.87	1369.97	0.00	253.25	113686.09	837665.58
75	113701.06	0.00	0.00	17128.38	130829.44	968495.02
76	120308.88	0.00	0.00	8831.92	128387.59	1096882.61
77	96910.96	0.00	0.00	4313.63	101224.59	1198107.20
78	105931.66	297.1[illegible]	0.00	1117.66	107346.49	1305453.69
79	103502.89	445.76	0.00	3514.63	106234.42	1411688.11
80	90629.29	0.00	0.00	0.00	90629.29	1502317.40
81	92270.21	0.00	0.00	3605.29	95875.50	1598192.90
82	102806.69	46.72	0.00	9915.01	112768.42	1710961.32
83	82732.78	0.00	0.00	13595.05	96327.83	1807289.15
84	106729.72	245.7[illegible]	0.00	7577.82	112244.18	1919533.33
85	107977.25	56.07	153.26	10671.94	118858.52	2038391.85
86	85007.35	346.69	[illegible].00	28179.73	113533.77	2151925.62
87	109431.34	291.57	205.59	11414.86	118397.82	2270323.44
88	99603.82	163.54	0.00	3515.56	103110.05	2373433.49
89	93971.62	514.90	0.00	0.00	[illegible]4486.52	2467920.01
90	98645.10	28.03	0.00	33537.96	130805.62	2598725.63
91	127058.26	0.00	0.00	0.00	1259[illegible]96	2724675.59
92	144048.26	569.11	0.00	613.96	1382[illegible].25	2862960.84
93	81868.08	66.35	0.00	17798.35	97352.63	2960[illegible].47
94	97447.96	185.03	0.00	10097.20	107244.25	3067557.[illegible]
95	152901.30	0.00	0.00	17846.06	145962.66	3213520.38
96	124564.77	1485.25	0.00	0.00	125044.04	3338564.42
97	113908.31	29.21	0.00	14083.82	108600.88	3447165.30
98	100716.39	78.51	1083.58	8690.55	107628.68	3554793.98
99	114696.12	231.88	115.02	1586.57	115738.62	3670532.60
100	87169.34	0.00	0.00	1860.44	89029.78	3759562.38
101	98297.27	218.18	0.00	3297.30	94422.13	3853984.51
102	84237.21	111.37	0.00	2135.21	86483.79	3940468.30
103	105780.09	100.41	0.00	12510.02	116769.26	4057237.56
104	90311.44	0.00	0.00	20637.32	110948.76	4168186.32
105	107138.45	0.00	0.00	0.00	107138.45	4275324.77
106	80692.51	0.00	0.00	2568.83	83261.34	4358586.11
107	95199.90	310.38	0.00	19907.95	115418.23	4474004.34
108	133546.05	0.00	0.00	5549.36	125734.60	4599738.94
109	100071.89	418.09	0.00	14402.39	114892.37	4714631.31
110	75551.22	14.61	103.15	17414.87	93083.85	4807715.16
111	89557.44	328.64	0.00	4971.51	94857.59	4902572.75
112	88186.29	20.08	0.00	2574.30	86236.38	4988809.13
113	87906.04	0.00	0.00	14287.38	97740.42	5086549.55
114	89823.08	136.93	0.00	7425.32	97166.24	5183715.79
115	107056.16	37.43	0.00	13079.65	120137.64	5303853.43
116	96623.99	192.62	0.00	16177.93	112994.54	5416847.97
117	128007.64	862.67	599.76	11593.50	140764.15	5557612.12
118	103790.04	0.00	0.00	0.00	103790.04	5661402.16
TOTALS						
SQM	5330527.43	11401.80	2260.36	451239.72		5661402.16
ACRES	1317.20	2.82	0.56	111.50		1398.96

HABITAT TOTALS PER MILE
4/22/1991 FLOW 1 (2140 ft^3/s) REACH 3

MILE	MAINCHANN (sq. m)	BACKWAT (sq. m)	ISOPOOL (sq. m)	SIDECHAN (sq. m)	OPEN WATER (sq. m)	TOTAL OPEN WATER (sq. m)
52	86581.98	674.71	0.00	0.00	87256.69	87256.69
53	115132.12	0.00	0.00	0.00	115132.12	202388.81
54	79245.26	0.00	0.00	0.00	79245.26	281634.07
55	113024.47	0.00	0.00	0.00	113024.47	394658.54
56	88838.79	0.00	0.00	0.00	88838.79	483497.33
57	95595.20	1375.58	0.00	0.00	96970.78	580468.11
58	95436.33	0.00	0.00	0.00	95436.33	675904.44
59	99995.72	0.00	0.00	0.00	99995.72	775900.16
60	85868.03	0.00	0.00	0.00	85868.03	861768.19
61	92273.07	0.00	0.00	0.00	92273.07	954041.26
62	70200.26	25.23	0.00	0.00	70225.49	1024266.75
63	72972.00	0.00	0.00	0.00	72972.00	1097238.75
64	75759.59	0.00	0.00	0.00	75759.59	1172998.34
65	83630.83	0.00	0.00	0.00	83630.83	1256629.17
66	72187.94	0.00	0.00	0.00	72187.94	1328817.11
67	107215.64	0.00	0.00	0.00	107215.64	1436032.75
TOTALS						
SQM	1433957.23	2075.52	0.00	0.00		1436032.75
ACRES	354.34	0.51	0.00	0.00		354.85

HABITAT TOTALS PER MILE

5/17/1991 FLOW 2 (3830 ft^3/s) REACH 1

MILE	MAINCHANN (sq. m)	BACKWAT (sq. m)	ISOPOOL (sq. m)	SIDECHAN (sq. m)	OPEN WATER (sq. m)	TOTAL OPEN WATER (sq. m)
158	89153.36	637.31	0.00	4969.59	94560.28	94560.28
157	91256.11	821.18	0.00	14911.82	106989.11	201549.39
156	144600.20	0.00	0.00	0.00	137531.93	339081.32
155	232474.67	2467.62	3553.00	4641.45	232568.51	571649.83
154	130474.86	2948.09	4168.13	53427.73	189638.61	761288.44
153	100327.85	338.67	0.00	94180.71	189006.13	950294.57
152	98182.60	248.90	0.00	40915.18	132648.70	1082943.27
151	122572.16	0.00	0.00	10233.65	132805.81	1215749.08
150	159943.53	279.51	5421.83	22758.43	188403.30	1404152.38
149	125043.85	2555.35	0.00	5385.11	132984.31	1537136.69
148	117676.70	0.00	0.00	6591.89	124268.59	1661405.28
147	125966.02	831.38	760.99	25599.41	144473.68	1805878.96
146	134929.65	363.16	0.00	10366.26	145659.07	1951538.03
145	116279.16	1043.56	0.00	100.99	116331.18	2067869.21
144	109257.81	497.81	363.16	0.00	110118.78	2177987.99
143	124440.98	665.11	0.00	4844.46	129950.55	2307938.54
142	156146.70	967.05	0.00	3216.38	160330.13	2468268.67
141	144400.25	61.21	0.00	18726.99	162197.93	2630466.60
140	126705.60	24.48	296.85	43312.44	169740.57	2800207.17
139	144103.40	1339.40	0.00	40363.32	176451.80	2976658.97
138	95566.03	316.23	0.00	3135.79	99018.05	3075677.02
137	137778.79	1054.78	297.87	32262.71	153341.44	3229018.46
136	111753.99	2108.55	0.00	47266.32	161128.86	3390147.32
135	106862.62	0.00	9564.45	58338.50	170326.09	3560473.41
134	90880.71	97.93	0.00	43702.11	134680.75	3695154.16
133	100324.80	0.00	0.00	10234.66	110559.46	3805713.62
132	114320.56	421.31	0.00	38906.60	151646.02	3957359.64
131	104197.09	5309.63	0.00	67630.58	176884.32	4134243.96
130	137467.65	3312.25	0.00	6207.31	146531.23	4280775.19
129	143298.55	0.00	0.00	3570.35	146868.90	4427644.09
128	94599.98	0.00	0.00	23416.40	118016.38	4545660.47
127	158321.56	0.00	0.00	11073.20	169394.76	4715055.23
126	118868.17	354.99	0.00	34694.62	153917.78	4868973.01
125	125817.10	0.00	0.00	5891.08	131708.18	5000681.19
124	145868.18	234.62	0.00	0.00	146102.80	5146783.99
123	112598.64	78.55	0.00	42648.35	155325.54	5302109.53
122	115832.35	71.41	0.00	36477.77	152381.53	5454491.06
121	121361.29	0.00	0.00	22623.78	143664.76	5598155.82
120	132516.09	214.22	0.00	17180.52	149910.83	5748066.65
119	135494.78	0.00	0.00	2903.20	138397.98	5886464.63
TOTALS						
SQM	4997664.39	29664.26	24426.28	912709.66		5886464.63
ACRES	1234.94	7.33	6.04	225.53		1454.57

HABITAT TOTALS PER MILE

5/17/1991 FLOW 2 (4530 ft^3/s) REACH 2

MILE	MAINCHANN (sq. m)	BACKWAT (sq. m)	ISOPOOL (sq. m)	SIDECHAN (sq. m)	OPEN WATER (sq. m)	TOTAL OPEN WATER (sq. m)
118	94441.89	0.00	0.00	0.00	94441.89	94441.89
117	115561.01	8202.63	0.00	13591.82	137355.46	231797.35
116	125233.61	1032.34	0.00	21503.71	147769.66	379567.01
115	131289.93	2020.82	0.00	26315.52	159626.27	539193.28
114	103727.85	0.00	0.00	13472.45	117200.30	656393.58
113	103737.02	210.14	0.00	22707.42	126654.58	783048.16
112	135832.43	0.00	0.00	11222.11	147054.54	930102.70
111	116454.61	248.90	0.00	10488.67	127192.18	1057294.88
110	101843.72	359.08	0.00	19632.86	121835.66	1179130.54
109	143265.90	39.78	0.00	18256.73	161562.41	1340692.95
108	121876.75	2629.82	918.09	7498.75	132923.41	1473616.36
107	132575.25	971.13	0.00	29423.77	162970.15	1636586.51
106	104024.69	419.27	234.62	6069.60	110748.18	1747334.69
105	128533.61	167.29	0.00	0.00	128700.90	1876035.59
104	128339.80	560.03	0.00	26434.87	155334.70	2031370.29
103	124538.91	2955.22	291.75	16076.78	143862.66	2175232.95
102	148279.69	1260.85	0.00	8137.34	157677.88	2332910.83
101	124690.91	0.00	0.00	16741.88	141432.79	2474343.62
100	128669.29	1011.94	0.00	5150.49	134831.72	2609175.34
99	145286.72	3171.49	66.31	1367.95	149892.47	2759067.81
98	116212.84	196.89	1255.74	12715.55	130381.02	2889448.83
97	102510.87	0.00	132.61	20689.67	123333.15	3012781.98
96	122469.12	2826.69	0.00	0.00	125295.81	3138077.79
95	137210.59	0.00	0.00	18129.20	155339.79	3293417.58
94	119248.67	0.00	0.00	13617.32	132865.99	3426283.57
93	84730.52	0.00	0.00	19401.28	104131.80	3530415.37
92	147049.46	4075.30	0.00	974.20	152098.96	3682514.33
91	155086.82	0.00	0.00	0.00	155086.82	3837601.15
90	133223.03	572.28	0.00	53182.92	186978.23	4024579.38
89	102715.92	932.37	0.00	0.00	103648.29	4128227.67
88	118875.32	219.32	0.00	3350.01	108740.62	4236968.29
87	113556.51	617.16	0.00	15883.99	130057.66	4367025.95
86	127393.14	1095.59	0.00	20919.17	149407.90	4516433.85
85	132739.49	3353.06	111.19	13657.10	149860.84	4666294.69
84	138412.28	2010.62	0.00	10844.68	151267.58	4817562.27
83	97557.27	350.91	0.00	20086.78	117994.96	4935557.23
82	108237.71	407.02	0.00	22081.09	126887.18	5062444.41
81	102276.24	487.61	923.19	11785.22	115472.26	5177916.67
80	112181.41	0.00	0.00	0.00	108683.49	5286600.16
79	127118.74	3520.36	0.00	4096.72	134735.82	5421335.98
78	151857.18	0.00	0.00	5713.58	157570.76	5578906.74
77	94734.65	0.00	853.83	4688.38	100276.86	5679183.60
76	134713.39	15.30	0.00	13090.95	144158.51	5823342.11
75	130154.55	100.99	0.00	22414.65	152670.19	5976012.30
74	158098.15	3496.90	0.00	10445.83	172040.88	6148053.18
73	181756.32	414.16	0.00	0.00	182170.48	6330223.66
72	104455.18	477.41	0.00	1503.63	106436.22	6436659.88
71	111910.07	1783.13	0.00	25447.43	139140.63	6575800.51
70	154641.03	1941.25	0.00	0.00	156582.28	6732382.79
69	122041.69	2265.64	0.00	23915.22	148222.55	6880605.34
68	127781.80	0.00	0.00	1814.76	129596.56	7010201.90
TOTALS						
SQM	6329153.55	56420.69	4787.33	644542.05		7010201.90
ACRES	1563.96	13.94	1.18	159.27		1732.25

HABITAT TOTALS PER MILE
5/17/1991 FLOW 2 (4320 ft^3/s) REACH 3

MILE	MAINCHANN (sq. m)	BACKWAT (sq. m)	ISOPOOL (sq. m)	SIDECHAN (sq. m)	OPEN WATER (sq. m)	TOTAL OPEN WATER (sq. m)
67	93121.87	0.00	0.00	0.00	93121.87	93121.87
66	94207.24	0.00	0.00	0.00	94207.24	187329.11
65	82579.15	0.00	0.00	0.00	82579.15	269908.26
64	83407.45	0.00	0.00	0.00	83407.45	353315.71
53	87121.63	0.00	0.00	0.00	87121.63	440437.34
62	64614.16	0.00	0.00	0.00	64614.16	505051.50
61	85012.07	0.00	0.00	0.00	85012.07	590063.57
60	71297.85	0.00	0.00	0.00	71297.85	661361.42
59	86999.23	0.00	0.00	0.00	86999.23	748360.65
58	85386.45	0.00	0.00	0.00	85386.45	833747.10
57	94417.40	1189.44	0.00	0.00	95606.84	929353.94
56	87286.90	0.00	0.00	0.00	87286.90	1016640.84
55	99805.56	0.00	0.00	0.00	99805.56	1116446.40
54	90165.62	0.00	0.00	0.00	90165.62	1206612.02
53	108465.19	0.00	0.00	0.00	108465.19	1315077.21
52	83467.63	944.61	0.00	0.00	84412.24	1399489.45
TOTALS						
SQM	1397355.40	2134.05	0.00	0.00		1399489.45
ACRES	345.29	0.53	0.00	0.00		345.82

HABITAT TOTALS PER MILE
6/05/1991 FLOW 3 (2380 ft^3/s) REACH 1

MILE	MAINCHANN (sq. m)	BACKWAT (sq. m)	ISOPOOL (sq. m)	SIDECHAN (sq. m)	OPEN WATER (sq. m)	TOTAL OPEN WATER (sq. m)
158	72624.78	625.92	706.56	1346.88	75304.14	75304.14
157	77740.42	8470.46	0.00	16027.59	102238.47	177542.61
156	92365.05	0.00	0.00	6765.27	99130.32	276672.93
155	107224.94	123.37	0.00	9291.97	116640.28	393313.21
154	88794.95	0.00	0.00	41000.01	129794.96	523108.17
153	95358.45	335.69	0.00	87414.00	183108.14	706216.31
152	79090.80	0.00	0.00	29909.14	108999.94	815216.25
151	105987.41	0.00	0.00	7037.84	113025.25	928241.50
150	129339.78	0.00	0.00	21199.59	145555.79	1073797.29
149	95605.20	585.29	0.00	8372.91	104563.40	1178360.69
148	86922.43	295.51	0.00	2665.37	89883.31	1268244.00
147	91418.26	2163.28	0.00	19000.91	108905.25	1377149.25
146	101120.52	130.06	0.00	5303.01	106553.59	1483702.84
145	106692.24	0.00	876.02	0.00	107568.26	1591271.10
144	97601.11	0.00	0.00	840.64	98441.75	1689712.85
143	118137.93	0.00	0.00	14872.32	133010.25	1822723.10
142	149977.00	2191.97	150.15	14582.56	166901.68	1989624.78
141	116061.69	113.81	0.00	16337.46	132512.96	2122137.74
140	132812.30	0.00	0.00	38125.21	170937.51	2293075.25
139	117548.82	0.00	0.00	25913.47	143462.29	2436537.54
138	87971.54	298.38	0.00	2267.53	90537.45	2527074.99
137	101146.34	503.04	1660.23	22309.93	125619.54	2652694.53
136	103193.90	0.00	963.05	33544.26	137701.21	2790395.74
135	105429.85	1110.33	0.00	37842.12	144382.30	2934778.04
134	98880.73	0.00	0.00	34362.90	133243.63	3068021.67
133	92452.08	0.00	0.00	11713.47	104165.55	3172187.22
132	124667.00	7903.34	0.00	26979.81	159550.15	3331737.37
131	111432.91	483.91	0.00	74521.33	184088.38	3515825.75
130	134732.67	278.30	207.53	6047.06	141265.56	3657091.31
129	142860.75	0.00	0.00	2477.92	145338.67	3802429.98
128	86338.08	0.00	0.00	12743.46	99081.54	3901511.52
127	105618.25	124.33	0.00	9373.26	115115.84	4016627.36
126	99036.60	0.00	0.00	27614.84	126651.44	4143278.80
125	115586.37	0.00	0.00	4559.91	120146.28	4263425.08
124	118887.72	0.00	0.00	0.00	118887.72	4382312.80
123	93199.95	0.00	0.00	34706.23	127906.18	4510218.98
122	110773.02	0.00	0.00	31061.56	141834.58	4652053.56
121	116361.03	0.00	0.00	19231.40	135592.43	4787645.99
120	116282.60	1078.77	0.00	8390.13	125751.50	4913397.49
119	142779.45	0.00	0.00	2322.04	145101.49	5058498.98
TOTALS						
SQM	4270054.92	26815.76	4563.54	768075.31		5058498.98
ACRES	1055.15	6.63	1.13	189.79		1249.98

HABITAT TOTALS PER MILE
6/05/1991 FLOW 3 (2350 ft^3/s) REACH 2

MILE	MAINCHANN (sq. m)	BACKWAT (sq. m)	ISOPOOL (sq. m)	SIDECHAN (sq. m)	OPEN WATER (sq. m)	TOTAL OPEN WATER (sq. m)
118	75460.14	0.00	0.00	0.00	75460.14	75460.14
117	125684.80	0.00	718.34	10927.76	137330.90	212791.04
116	121800.79	161.62	0.00	18838.33	140800.74	353591.78
115	105009.06	0.00	0.00	16082.12	121091.18	474682.96
114	96539.55	270.65	0.00	10560.10	107370.30	582053.26
113	120831.99	106.16	0.00	21227.32	142165.47	724218.73
112	118662.98	316.55	0.00	4663.20	123642.73	847861.46
111	104407.50	0.00	0.00	6354.05	110761.55	958623.01
110	97826.81	159.71	460.01	14755.64	113202.17	1071825.18
109	114027.50	217.09	0.00	11741.20	125985.79	1197810.97
108	106493.32	0.00	0.00	4354.30	110847.62	1308658.59
107	103109.73	0.00	0.00	19908.50	117036.21	1425694.80
106	94755.94	0.00	0.00	3506.96	98262.90	1523957.70
105	124167.78	0.00	0.00	0.00	124167.78	1648125.48
104	98957.23	81.29	722.05	21067.62	120828.19	1768953.67
103	97640.32	700.06	315.60	12941.44	111597.42	1880551.09
102	85108.20	2863.33	0.00	5071.57	93043.10	1973594.19
101	97189.88	110.94	0.00	8367.18	102156.25	2075750.44
100	106676.95	246.74	0.00	5101.21	112024.90	2187775.34
99	125498.08	1385.76	1012.78	2902.55	130290.38	2318065.72
98	114488.47	0.00	0.00	10513.24	125001.71	2443067.43
97	104255.44	0.00	0.00	18939.71	123195.15	2566262.58
96	124957.72	1828.56	0.00	5809.87	132596.15	2698858.73
95	112211.40	0.00	0.00	17022.21	129233.61	2828092.34
94	101485.83	0.00	0.00	12688.01	114173.84	2942266.18
93	99148.19	329.99	0.00	18733.69	116715.93	3058982.11
92	148376.48	0.00	4104.27	0.00	152480.75	3211462.86
91	138220.54	0.00	0.00	0.00	138220.54	3349683.40
90	122285.51	217.12	117.65	43182.39	165802.67	3515486.07
89	118187.94	210.43	985.18	0.00	119383.55	3634869.62
88	101003.75	249.64	0.00	1382.12	102635.51	3737505.13
87	94741.66	109.99	621.72	13194.69	108668.06	3846173.19
86	120943.57	425.63	0.00	19886.26	141255.46	3987428.65
85	101995.64	0.00	972.74	11446.25	114414.63	4101843.28
84	93268.68	0.00	0.00	6960.33	100229.01	4202072.29
83	84107.45	0.00	0.00	15090.45	99197.90	4301270.19
82	113812.98	0.00	0.00	11823.10	125636.08	4426906.27
81	112910.06	0.00	700.15	5049.27	118659.48	4545565.75
80	127482.08	0.00	0.00	0.00	127482.08	4673047.83
79	147376.01	1052.13	0.00	3891.93	152320.07	4825367.90
78	136517.05	0.00	0.00	1909.14	138426.19	4963794.09
77	91600.56	205.64	0.00	4533.74	96339.94	5060134.03
76	106052.06	0.00	0.00	7957.95	114010.01	5174144.04
75	97981.26	0.00	0.00	15211.92	113193.18	5287337.22
74	115977.51	606.41	0.00	1278.82	116946.43	5404283.65
73	178385.22	143.47	0.00	0.00	178528.69	5582812.34
72	124048.33	0.00	0.00	1578.20	125626.53	5708438.87
71	103778.51	373.03	0.00	20598.85	124750.39	5833189.26
70	125454.36	0.00	0.00	0.00	125454.36	5958643.62
69	125252.53	0.00	1678.63	25756.20	152687.36	6111330.98
68	128109.55	3909.15	0.00	1186.04	133204.74	6244535.72
TOTALS						
SQM	5734264.89	16281.09	12409.12	493995.43		6244535.72
ACRES	1416.96	4.02	3.07	122.07		1543.05

HABITAT TOTALS PER MILE
6/05/1991 FLOW 3 (2540 ft^3/s) REACH 3

MILE	MAINCHANN (sq. m)	BACKWAT (sq. m)	ISOPOOL (sq. m)	SIDECHAN (sq. m)	OPEN WATER (sq. m)	TOTAL OPEN WATER (sq. m)
67	83263.83	0.00	0.00	0.00	83263.83	83263.83
66	79080.19	0.00	0.00	0.00	79080.19	162344.02
65	86463.28	0.00	0.00	0.00	86463.28	248807.30
64	67488.54	0.00	0.00	0.00	67488.54	316295.84
63	62657.37	0.00	0.00	0.00	62657.37	378953.21
62	59771.63	0.00	0.00	0.00	59771.63	438724.84
61	77983.09	0.00	0.00	0.00	77983.09	516707.93
60	73158.59	0.00	0.00	0.00	73158.59	589866.52
59	73511.52	0.00	0.00	0.00	73511.52	663378.04
58	95459.96	0.00	0.00	0.00	95459.96	758838.00
57	100738.80	0.00	798.66	0.00	101537.46	860375.46
56	79929.54	0.00	0.00	0.00	79929.54	940305.00
55	91438.91	0.00	0.00	0.00	91438.91	1031743.91
54	70919.46	0.00	0.00	0.00	70919.46	1102663.37
53	125017.23	0.00	0.00	0.00	125017.23	1227680.60
52	88701.47	1406.03	0.00	0.00	90107.50	1317788.10
TOTALS						
SQM	1315583.41	1406.03	798.66	0.00		1317788.10
ACRES	325.09	0.35	0.20	0.00		325.63

HABITAT TOTALS PER MILE
7/02/1991 FLOW 4 (1310 ft^3/s) REACH 1

MILE	MAINCHANN (sq. m)	BACKWAT (sq. m)	ISOPOOL (sq. m)	SIDECHAN (sq. m)	OPEN WATER (sq. m)	TOTAL OPEN WATER (sq. m)
158	68210.47	1010.23	331.28	0.00	69551.98	69551.98
157	73176.97	6298.01	2081.43	5655.46	86765.91	156317.89
156	91294.64	0.00	0.00	6438.16	97732.80	254050.69
155	85805.73	159.27	6238.85	8403.09	100606.94	354657.63
154	116278.24	3134.44	0.00	49052.52	168465.20	523122.83
153	113491.45	263.93	0.00	93741.02	207496.40	730619.23
152	71818.15	0.00	0.00	26861.17	98679.32	829298.55
151	88835.06	319.45	0.00	6041.67	95196.18	924494.73
150	106991.41	115.58	0.00	13609.88	115075.06	1039569.79
149	76928.46	0.00	0.00	5649.09	82577.55	1122147.34
148	79238.35	0.00	0.00	2100.55	81338.90	1203486.24
147	105841.02	832.76	0.00	18049.42	124723.20	1328209.44
146	75355.78	0.00	0.00	3793.36	78703.19	1406912.63
145	80263.14	604.32	0.00	1506.24	82373.70	1489286.33
144	125701.58	513.31	0.00	596.13	126811.02	1616097.35
143	133474.88	272.12	0.00	15331.82	149078.82	1765176.17
142	160672.80	616.15	0.00	12483.15	173772.10	1938948.27
141	97790.14	514.21	281.23	8775.34	107360.92	2046309.19
140	179888.06	0.00	0.00	50330.33	229270.96	2275580.15
139	82520.21	332.19	0.00	24616.82	107469.22	2383049.37
138	74893.44	1517.16	293.06	0.00	76703.66	2459753.03
137	80345.95	3017.96	692.60	11548.46	95604.97	2555358.00
136	100363.04	535.15	0.00	41257.25	142155.44	2697513.44
135	110817.55	244.82	0.00	40422.79	151485.16	2848998.60
134	54592.40	694.41	551.53	17935.67	73774.01	2922772.61
133	88638.02	0.00	0.00	7600.39	96238.41	3019011.02
132	123734.85	208.41	0.00	17820.46	141763.72	3160774.74
131	40029.61	282.14	0.00	24673.24	64984.99	3225759.73
130	93286.90	152.90	0.00	4256.61	97369.68	3323129.41
129	122221.29	99.20	0.00	3290.98	125611.47	3448740.88
128	89604.56	5927.59	154.72	3437.51	99124.38	3547865.26
127	110330.63	91.92	0.00	9778.30	120200.85	3668066.11
126	106620.99	56.42	0.00	11614.90	118292.31	3786358.42
125	110395.24	0.00	0.00	2728.53	113123.77	3899482.19
124	113376.79	0.00	0.00	0.00	113376.79	4012858.98
123	86110.63	0.00	0.00	26602.69	112713.32	4125572.30
122	105011.91	310.35	0.00	27422.70	132744.96	4258317.26
121	95019.74	0.00	0.00	1354.25	96373.99	4354691.25
120	90378.15	212.96	0.00	6449.08	97040.19	4451731.44
119	113563.37	0.00	0.00	1371.54	114934.91	4566666.35
TOTALS						
SQM	3922911.60	28337.36	10624.70	612600.57		4566666.35
ACRES	969.37	7.00	2.63	151.38		1128.44

HABITAT TOTALS PER MILE
7/02/1991 FLOW 4 (1210 ft^3/s) REACH 2

MILE	MAINCHANN (sq. m)	BACKWAT (sq. m)	ISOPOOL (sq. m)	SIDECHAN (sq. m)	OPEN WATER (sq. m)	TOTAL OPEN WATER (sq. m)
118	80491.56	0.00	0.00	0.00	80491.56	80491.56
117	103685.88	0.00	0.00	9291.37	112977.25	193468.81
116	98389.00	0.00	0.00	14737.50	113126.50	306595.31
115	80724.56	212.06	0.00	14867.66	95804.28	402399.59
114	74834.28	509.66	53.70	6589.24	81986.88	484386.47
113	75455.89	957.44	26.39	15984.37	92424.09	576810.56
112	98196.04	885.55	1239.57	0.00	100321.16	677131.72
111	88081.03	158.36	0.00	9341.43	97580.82	774712.54
110	81831.25	0.00	0.00	13262.22	95093.47	869806.01
109	91196.36	536.05	0.00	10197.85	101930.26	971736.27
108	92597.94	435.95	0.00	3239.10	96272.99	1068009.26
107	78763.25	386.80	0.00	22738.35	101888.40	1169897.66
106	92443.21	18.20	0.00	4238.40	96699.81	1266597.47
105	102945.05	117.40	0.00	196.59	103259.04	1369856.51
104	86848.02	135.09	0.00	21134.82	108117.93	1477974.44
103	95491.11	166.14	0.00	11568.84	107226.09	1585200.53
102	72062.19	670.05	1609.40	0.00	74341.64	1659542.17
101	86696.49	3059.96	0.00	3709.92	93466.37	1753008.54
100	92277.79	466.48	0.00	3730.00	96474.27	1849482.81
99	101492.33	117.76	0.00	2916.63	104526.72	1954009.53
98	89355.67	869.96	836.19	8278.85	98668.80	2052678.33
97	77752.14	111.37	0.00	17582.87	95446.38	2148124.71
96	110854.76	545.90	107.72	837.10	112345.48	2260470.19
95	116131.16	51.12	1646.82	13070.51	130899.61	2391369.80
94	104158.83	265.64	406.22	9397.12	114227.81	2505597.61
93	91625.08	0.00	0.00	11999.72	103624.80	2609222.41
92	116187.76	199.00	0.00	4438.39	120825.15	2730047.56
91	123120.12	0.00	0.00	0.00	123120.12	2853167.68
90	104540.41	0.00	0.00	39803.09	144343.50	2997511.18
89	88857.24	251.96	1199.52	675.53	90984.25	3088495.43
88	83067.80	863.58	0.00	11946.77	95878.15	3184373.58
87	103233.20	7644.39	0.00	3759.20	114636.79	3299010.37
86	81575.26	1885.08	0.00	18047.50	101507.84	3400518.21
85	97886.48	53.86	0.00	8633.95	106574.29	3507092.50
84	94251.42	188.96	0.00	5841.48	100281.86	3607374.36
83	77284.75	166.14	857.19	9985.93	88294.01	3695668.37
82	93586.84	432.71	98.59	9344.16	103462.30	3799130.67
81	85968.01	91.29	0.00	2576.13	88635.43	3887766.10
80	89378.51	0.00	0.00	0.00	89378.51	3977144.61
79	99194.62	335.02	0.00	1913.38	101443.02	4078587.63
78	98551.97	52.95	0.00	3985.60	102590.52	4181178.15
77	87041.55	0.00	0.00	3636.89	90678.44	4271856.59
76	114765.51	60.25	220.92	4520.54	119567.22	4391423.81
75	119904.98	528.56	0.00	14530.21	134963.75	4526387.56
74	96660.49	407.14	0.00	0.00	97067.63	4623455.19
73	129533.06	0.00	0.00	0.00	129533.06	4752988.25
72	97643.65	0.00	0.00	1406.74	99050.39	4852038.64
71	98677.01	1529.06	0.00	16755.78	116961.85	4969000.49
70	121989.06	0.00	0.00	3179.54	125168.60	5094169.09
69	101774.41	313.11	158.84	19006.95	121253.31	5215422.40
68	106617.20	738.51	0.00	0.00	107355.71	5322778.11
TOTALS						
SQM	4875672.18	26418.51	8461.07	412898.22		5322778.11
ACRES	1204.80	6.53	2.09	102.03		1315.28

HABITAT TOTALS PER MILE

7/02/1991 FLOW 4 (1200 ft^3/s) REACH 3

MILE	MAINCHANN (sq. m)	BACKWAT (sq. m)	ISOPOOL (sq. m)	SIDECHAN (sq. m)	OPEN WATER (sq. m)	TOTAL OPEN WATER (sq. m)
67	79869.10	19.17	0.00	0.00	79888.27	79888.27
66	57724.63	185.31	0.00	0.00	57909.94	137798.21
65	49035.90	0.00	0.00	114.11	49150.01	186948.22
64	52356.93	0.00	0.00	0.00	52356.93	239305.15
63	43885.47	0.00	0.00	0.00	43885.47	283190.62
62	43405.31	0.00	0.00	0.00	43405.31	326595.93
61	58129.03	107.72	0.00	0.00	58236.75	384832.68
60	52223.66	0.00	0.00	0.00	52223.66	437056.34
59	59173.35	26.47	0.00	99.50	59299.32	496355.66
58	77045.59	41.99	0.00	0.00	77087.58	573443.24
57	82424.23	30.12	378.84	0.00	82833.19	656276.43
56	74851.96	95.85	0.00	0.00	74947.81	731224.24
55	86775.89	0.00	0.00	0.00	86775.89	818000.13
54	69234.14	31.95	0.00	0.00	69266.09	887266.22
53	98688.88	0.00	0.00	0.00	98688.88	985955.10
52	77933.81	0.00	0.00	3293.65	81227.46	1067182.56

TOTALS

SQM	1062757.88	538.58	378.84	3507.26		1067182.56
ACRES	262.61	0.13	0.09	0.87		263.71

HABITAT TOTALS PER MILE

7/18/1991 FLOW 5 (678 ft^3/s) REACH 1

MILE	MAINCHANN (sq. m)	BACKWAT (sq. m)	ISOPOOL (sq. m)	SIDECHAN (sq. m)	OPEN WATER (sq. m)	TOTAL OPEN WATER (sq. m)
158	67627.06	148.95	475.90	0.00	68251.91	68251.91
157	70763.11	3621.94	1049.89	0.00	74547.62	142799.53
156	78960.60	368.73	0.00	5008.77	84338.10	227137.63
155	93690.84	0.00	0.00	5175.88	98866.72	326004.35
154	86422.44	0.00	452.29	24934.89	111809.62	437813.97
153	64831.60	506.78	857.35	54656.92	120852.65	558666.62
152	67215.64	1962.64	0.00	28295.25	97473.53	656140.15
151	90610.18	777.42	0.00	4438.41	95826.01	751966.16
150	102207.12	237.95	0.00	11114.66	113559.73	865525.89
149	90463.05	78.10	0.00	2975.29	93516.44	959042.33
148	85021.99	0.00	0.00	2365.89	87387.88	1046430.21
147	84070.17	3138.78	1026.28	0.00	88235.23	1134665.44
146	85247.23	1003.57	316.97	3941.63	90509.40	1225174.84
145	87199.87	743.82	0.00	4696.35	92640.04	1317814.88
144	79965.08	0.00	0.00	4169.58	84134.66	1401949.54
143	99986.54	152.58	0.00	7465.48	107604.60	1509554.14
142	113761.36	1207.92	263.38	4909.78	120142.44	1629696.58
141	94081.37	1290.57	0.00	8934.96	104306.90	1734003.48
140	94788.88	0.00	0.00	33198.67	127987.55	1861991.03
139	93347.55	1148.89	310.61	19956.07	114763.12	1976754.15
138	73241.60	2740.97	346.93	0.00	76329.50	2053083.65
137	95369.21	14569.48	68.12	1598.45	111605.26	2164688.91
136	74395.04	14034.55	0.00	2961.67	91391.26	2256080.17
135	68833.15	2769.13	10061.15	2428.55	84091.98	2340172.15
134	81071.27	4982.43	2559.34	6657.18	95270.22	2435442.37
133	98147.41	745.63	0.00	7121.27	106014.31	2541456.68
132	96800.54	114.43	0.00	14254.34	111169.31	2652625.99
131	60910.86	858.25	654.82	35154.04	97577.97	2750203.96
130	90658.32	85.37	119.88	2416.75	93280.32	2843484.28
129	124349.25	228.87	0.00	2021.68	126599.80	2970084.08
128	76289.55	1510.35	1037.18	0.00	78837.08	3048921.16
127	105117.92	1552.12	1108.92	2817.26	110596.22	3159517.38
126	94942.36	3181.46	341.49	0.00	98465.31	3257982.69
125	110871.43	105.35	2856.32	0.00	113833.10	3371815.79
124	110136.69	0.00	0.00	0.00	110136.69	3481952.48
123	80891.45	186.19	0.00	24577.95	105655.59	3587608.07
122	94080.46	148.95	0.00	17155.16	111384.57	3698992.64
121	100259.93	722.02	0.00	874.61	101856.56	3800849.20
120	88461.37	0.00	0.00	5425.64	93887.01	3894736.21
119	111451.78	148.95	0.00	2956.21	114556.94	4009293.15

TOTALS

SQM	3566541.27	65073.14	23906.82	354659.24		4009293.15
ACRES	881.31	16.08	5.91	87.64		990.71

HABITAT TOTALS PER MILE
7/18/1991 FLOW 5 (653 ft^3/s) REACH 2

MILE	MAINCHANN (sq. m)	BACKWAT (sq. m)	ISOPOOL (sq. m)	SIDECHAN (sq. m)	OPEN WATER (sq. m)	TOTAL OPEN WATER (sq. m)
118	72048.22	155.30	0.00	1325.08	73528.60	73528.60
117	89976.27	3494.79	323.32	2901.73	96696.11	170224.71
116	91532.04	1250.60	0.00	16000.83	108783.47	279008.18
115	78341.20	0.00	0.00	14089.96	92431.16	371439.34
114	74079.89	276.09	0.00	3760.90	78116.88	449556.22
113	76382.20	1365.94	1557.58	4467.49	83773.21	533329.43
112	94636.28	174.38	35.42	0.00	94846.08	628175.51
111	88153.49	237.95	785.60	2309.58	91486.62	719662.13
110	74125.29	2166.08	1429.52	1535.78	79256.67	798918.80
109	91662.80	56.31	0.00	7522.69	99241.80	898160.60
108	96969.48	132.59	0.00	2246.00	99348.07	997508.67
107	89183.40	117.16	0.00	12360.72	101661.28	1099169.95
106	86898.34	129.88	0.00	2117.94	89146.16	1188316.11
105	102509.54	26.34	0.00	121.70	102657.58	1290973.69
104	91021.61	2945.32	66.30	12707.66	106740.89	1397714.58
103	85044.69	700.24	0.00	8935.87	94680.80	1492395.38
102	69839.45	397.79	139.86	0.00	70377.10	1562772.48
101	91745.47	229.78	666.62	3216.87	95858.74	1658631.22
100	88236.13	142.58	0.00	2692.84	91071.55	1749702.77
99	106215.04	138.04	0.00	2550.25	108903.33	1858606.10
98	96217.47	564.00	1048.07	175.28	98004.82	1956610.92
97	94186.72	8979.46	0.00	0.00	103166.18	2059777.10
96	92758.11	465.91	0.00	588.52	93812.54	2153589.64
95	93010.59	24.52	2187.88	7707.97	102930.96	2256520.60
94	93319.39	0.00	2017.13	7820.59	103157.11	2359677.71
93	83138.37	0.00	123.52	4536.51	87798.40	2447476.11
92	106018.86	2654.70	0.00	566.72	109240.28	2556716.39
91	105175.14	73.56	0.00	369.64	105618.34	2662334.73
90	93367.52	141.68	0.00	9038.50	102547.70	2764882.43
89	85923.84	23.61	969.97	0.00	86917.42	2851799.85
88	70445.24	286.09	0.00	6223.96	76955.29	2928755.14
87	80943.21	836.46	731.11	254.30	82765.08	3011520.22
86	74593.93	0.00	0.00	6738.92	81332.85	3092853.07
85	91195.09	578.53	0.00	6735.27	98508.89	3191361.96
84	95212.09	23.61	0.00	2447.62	97683.32	3289045.28
83	77766.29	513.14	303.34	7248.42	85831.19	3374876.47
82	86072.79	0.00	0.00	5253.08	91325.87	3466202.34
81	85271.74	199.81	277.91	2472.15	88221.61	3554423.95
80	89519.44	0.00	0.00	0.00	89519.44	3643943.39
79	84279.99	999.93	314.24	732.02	86326.18	3730269.57
78	88593.97	82.64	0.00	2171.53	90848.14	3821117.71
77	74737.43	2312.30	0.00	0.00	77049.73	3898167.44
76	103502.22	0.00	2825.44	0.00	106327.66	4004495.10
75	95701.61	0.00	0.00	12171.82	107873.43	4112368.53
74	88717.49	804.67	1058.06	1066.24	91646.46	4204014.99
73	110509.97	215.25	435.94	12593.22	123754.38	4327769.37
72	98864.00	445.94	309.70	0.00	99619.64	4427389.01
71	92540.14	1233.36	147.13	12859.33	106779.96	4534168.97
70	113826.74	0.00	527.67	0.00	114354.41	4648523.38
69	117344.25	199.81	155.30	1782.82	119482.18	4768005.56
68	117543.14	881.87	0.00	0.00	118425.01	4886430.57
TOTALS						
SQM	4618897.61	36678.01	18436.63	212418.32		4886430.57
ACRES	1141.35	9.06	4.56	52.49		1207.46

HABITAT TOTALS PER MILE
7/18/1991 FLOW 5 (676 ft^3/s) REACH 3

MILE	MAINCHANN (sq. m)	BACKWAT (sq. m)	ISOPOOL (sq. m)	SIDECHAN (sq. m)	OPEN WATER (sq. m)	TOTAL OPEN WATER (sq. m)
67	77330.36	0.00	0.00	0.00	77330.36	77330.36
66	61384.04	148.95	0.00	0.00	61532.99	138863.35
65	59380.53	0.00	0.00	0.00	59380.53	198243.88
64	61853.58	0.00	0.00	0.00	61853.58	260097.46
63	51480.92	0.00	0.00	0.00	51480.92	311578.38
62	51207.54	0.00	0.00	0.00	51207.54	362785.92
61	66122.15	0.00	0.00	0.00	66122.15	428908.07
60	59740.18	0.00	0.00	0.00	59740.18	488648.25
59	65338.38	59.95	0.00	0.00	65398.33	554046.58
58	80153.07	378.72	0.00	0.00	80531.79	634578.37
57	83191.02	179.83	163.48	0.00	83534.33	718112.70
56	72564.09	139.86	0.00	0.00	72703.95	790816.65
55	72884.69	0.00	0.00	2199.68	75084.37	865901.02
54	65096.79	0.00	0.00	0.00	65096.79	930997.81
53	86290.74	29.06	0.00	0.00	86319.80	1017317.61
52	67430.89	0.00	0.00	1448.59	68879.48	1086197.09
TOTALS						
SQM	1081448.97	936.37	163.48	3648.27		1086197.09
ACRES	267.23	0.23	0.04	0.90		268.40

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48