# SACRAMENTO MUNICIPAL UTILITY DISTRICT
# UPPER AMERICAN RIVER PROJECT
**(FERC Project No. 2101)**

# SHALLOW WATER ENTRAINMENT TECHNICAL REPORT


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## APRIL 2005

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# SHALLOW WATER ENTRAINMENT TECHNICAL REPORT

**SUMMARY**

This study summary provides information on shallow water fish entrainment potential in areas potentially affected by the Sacramento Municipal Utility District's (SMUD) Upper American River Project (UARP).

The four shallow water intakes that were evaluated included:

- Rubicon Reservoir to Rockbound Lake tunnel
- Buck Island Reservoir to Loon Lake tunnel
- Gerle Creek Reservoir to Robbs Peak Reservoir canal
- Robbs Peak Reservoir to Robbs Peak Powerhouse tunnel

Of these four intakes, only the Robbs Peak Reservoir to Robbs Peak Powerhouse tunnel has the potential to lethally entrain fish. Fish entering the Robbs Peak Tunnel travel down the tunnel, into Robbs Peak Penstock, and through the turbine at Robbs Peak Powerhouse.

Fish in Robbs Peak Reservoir come from two sources: Gerle Creek Reservoir via the 1.9 mile long Gerle Creek Canal; or the South Fork Rubicon River upstream of Robbs Peak Reservoir. The fish habitat in Gerle Creek Canal is inferior to Gerle Creek Reservoir, as the canal lacks significant fish cover. The South Fork Rubicon River is an intermittent stream that feeds Robbs Peak Reservoir. The South Fork Rubicon River above Robbs Peak Reservoir typically dries up or has very low flow (<2 cfs) by mid-July.

The results of an October 2004 fish salvage in Gerle Creek Canal during a maintenance drawdown of Gerle Creek Canal confirm that there are few fish in the canal: only three rainbow trout, and a very small population of brown trout (23 trout/mile). Brown trout are not a priority management species.

The results of a 2003 fish population survey conducted approximately 0.5 miles upstream of Robbs Peak Reservoir in the South Fork Rubicon River showed only a small population of rainbow trout present. Trout density was 91 trout/acre and the biomass was 6.6 pounds/acre.

Seasonal water temperature and stream flow changes are not conducive to maintaining a large trout population in the South Fork Rubicon River upstream of Robbs Peak Reservoir. Comparisons between rainbow trout habitat and spawning temperature requirements and the environmental conditions in the South Fork Rubicon River upstream of Robbs Peak Reservoir suggest that rainbow trout will not spawn until at least late May of any given year. Incubation lasting between three and 14 weeks will result in hatching anywhere from late-June to mid-July or later, with fry emerging from the gravel beginning mid-July. By mid-July, flows in the South Fork Rubicon River decrease to low levels, and water temperature continues to increase to above 20 °C. Therefore, significant rainbow trout recruitment in the upper South Fork Rubicon River is likely prevented by late spawning due to cold water temperatures late into the year, and lack of adequate summer flow shortly after emergence. Adult overwintering and oversummering is limited by frozen stream conditions in winter and intermittent flow in summer.

## 1.0 INTRODUCTION

This technical report is one in a series of reports prepared by Devine Tarbell and Associates, Inc., (DTA) and Stillwater Sciences for the Sacramento Municipal Utility District (SMUD) to support the relicensings of SMUD's Upper American River Project (UARP). SMUD intends to append this technical report to its application to the Federal Energy Regulatory Commission

(FERC) for a new license. This report addresses fish entrainment potential through shallow water intakes in UARP reservoirs. This report includes the following sections:

- **METHODS** – A description of the methods used in the study, including a listing of study sites.
- **RESULTS** – A description of the most important data results.
- **ANALYSIS** – A brief analysis of the results, where appropriate.
- **LITERATURE CITED** – A listing of all literature cited in the report.

This technical report does not include a detailed description of the UARP Alternative Licensing Process (ALP) or the UARP, which can be found in the following sections of SMUD's application for a new license: The UARP Relicensing Process, Exhibit A (Project Description), Exhibit B (Project Operations), and Exhibit C (Construction).

Also, this technical report does not include a discussion regarding the effects of the project on reservoir or stream fisheries or their habitat, nor does the report include a discussion of appropriate protection, mitigation, and enhancement measures. An impacts discussion regarding the UARP is included in the applicant-prepared preliminary draft environmental assessment (PDEA) document, which is part of SMUD's application for a new license. Development of protection, mitigation, and enhancement (PM&E) measures will occur in settlement discussions, in 2005, and will be reported on in the UARP application and in the PDEA document.

## 1.1 Water Year Types

As described in the *Water Temperature Technical Report*, the UARP Relicensing Water Balance Model Subcommittee established five water year types to be applied to all preliminary analysis with the understanding that the UARP Relicensing Plenary Group, with cause, may modify the current water year types in the future. For reference purposes, the water year types for the period of record (1975-2004) are presented below (Table 1.1-1). See the *Water Temperature Technical Report* for a detailed discussion of water year type designations.

# 2.0 METHODS

This study provides information on shallow water fish entrainment potential in areas potentially affected by the SMUD UARP. The study methods included analysis of information from the following sources:

- Descriptions of the four shallow water diversions in the UARP area
- Results of the stream fish sampling above Robbs Peak Reservoir
- Results of a fish salvage conducted in Gerle Canal while the canal was drained
- Historical fish survey information from above Robbs Peak Reservoir
- Habitat requirements of rainbow trout for spawning, egg development, and fry emergence

| Table 1.1-1. Water year types applied to individual months for Water Years 1975-2004.* | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **June** | **July** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
| 1974 | --- | --- | --- | --- | --- | --- | --- | --- | --- | W | W | W |
| 1975 | W | D | BN | BN | AN | AN | AN | AN | AN | AN | AN | AN |
| 1976 | AN | D | D | CD | CD | CD | CD | CD | CD | CD | CD | CD |
| 1977 | CD | CD | CD | CD | CD | CD | CD | CD | CD | CD | CD | CD |
| 1978 | CD | AN | AN | AN | W | W | W | W | W | AN | AN | AN |
| 1979 | AN | D | BN | BN | BN | BN | BN | BN | BN | BN | BN | BN |
| 1980 | BN | AN | W | W | W | W | W | W | W | W | W | W |
| 1981 | W | D | D | D | D | D | D | D | D | D | D | D |
| 1982 | D | W | W | W | W | W | W | W | W | W | W | W |
| 1983 | W | W | W | W | W | W | W | W | W | W | W | W |
| 1984 | W | W | W | W | W | W | W | W | W | W | W | W |
| 1985 | W | BN | BN | BN | D | D | D | D | D | D | D | D |
| 1986 | D | BN | W | W | W | W | W | W | W | W | W | W |
| 1987 | W | D | D | D | CD | CD | CD | CD | CD | CD | CD | CD |
| 1988 | CD | BN | D | CD | CD | CD | CD | CD | CD | CD | CD | CD |
| 1989 | CD | D | D | BN | BN | BN | BN | BN | BN | BN | BN | BN |
| 1990 | BN | D | D | D | D | D | D | D | D | D | D | D |
| 1991 | D | CD | CD | D | D | D | D | D | D | D | D | D |
| 1992 | D | D | D | D | D | D | D | D | D | CD | CD | CD |
| 1993 | CD | AN | AN | AN | AN | AN | AN | AN | AN | AN | AN | AN |
| 1994 | AN | D | D | D | CD | CD | CD | CD | CD | CD | CD | CD |
| 1995 | CD | W | AN | W | W | W | W | W | W | W | W | W |
| 1996 | W | BN | AN | AN | AN | AN | AN | AN | AN | W | W | W |
| 1997 | W | W | W | W | W | W | W | W | W | W | W | W |
| 1998 | W | AN | W | W | W | W | W | W | W | W | W | W |
| 1999 | W | AN | W | AN | AN | AN | AN | AN | AN | AN | AN | AN |
| 2000 | AN | BN | AN | AN | AN | AN | AN | AN | AN | AN | AN | AN |
| 2001 | AN | D | D | D | D | D | D | D | D | D | D | D |
| 2002 | D | BN | BN | BN | BN | BN | BN | BN | BN | BN | BN | BN |
| 2003 | BN | BN | BN | D | BN | BN | BN | BN | BN | BN | BN | BN |
| 2004 | BN | BN | BN | BN | BN | BN | BN | BN | BN | D | D | D |

* CD=Critically Dry; D=Dry; BN=Below Normal; AN=Above Normal; W=Wet

# 3.0 RESULTS

## 3.1 Shallow Water Diversion Information and Entrainment Potential

There are four diversions in the UARP that have the potential for shallow water entrainment of fish. These include:

- Rubicon Reservoir (elevation 6,545 feet) to Rockbound Lake (elevation approximately 6,520 feet) — The Rubicon-Rockbound Tunnel is a 0.2 mile long, 13 foot diameter unlined horseshoe tunnel, with a slope of 2.36 percent that transports water from Rubicon Reservoir to Rockbound Lake.
- Buck Island Reservoir (elevation 6,436 feet) to Loon Lake (elevation 6,410 feet) — The Buck Island Reservoir-Loon Lake Tunnel is a 1.6 mile long, 13 foot diameter, unlined

modified horseshoe tunnel, with a slope of 0.31 percent that transports water from Buck Island Reservoir to Loon Lake.

- Gerle Creek Reservoir (elevation 5,231 feet) to Robbs Peak Reservoir (elevation 5,231 feet) — The Gerle Creek Canal is a 1.9 mile long, 22 feet wide, 19 foot deep, canal partially lined with gunite, with a negligible slope, that transports water from Gerle Creek Reservoir to Robbs Peak Reservoir.
- Robbs Peak Reservoir to Robbs Peak Powerhouse — Water is transported from Robbs Peak Reservoir to Robbs Peak Powerhouse via the Robbs Peak Tunnel and Robbs Peak Penstock.
  - Robbs Peak Tunnel is a 3.2 mile long, 13 foot diameter unlined horseshoe and 10.7 foot diameter lined diversion tunnel that connects Robbs Peak Reservoir and Robbs Peak Penstock.
  - Robbs Peak Penstock is an 8.5 to 9.75 foot diameter, 0.4 mile long steel penstock that connects Robbs Peak Tunnel and Robbs Peak Powerhouse.
  - Robbs Peak Powerhouse is located on the northeast shore of Union Valley Reservoir.

The first three of the diversions described above are non-lethal to fish moving through them. Planted or naturally reproduced fish can move between the reservoirs safely because the tunnels and the canal are passive systems for moving water between the reservoirs; there are no turbines or other generation facilities that could pose a danger to fish passage.

There is potential for fish mortality, however, associated with the Robbs Peak Development through Robbs Peak Powerhouse. Fish entering the Robbs Peak Tunnel travel down the tunnel, into Robbs Peak Penstock, and through the turbine of Robbs Peak Powerhouse.

## 3.2 Fish Colonization Potential of Robbs Peak Reservoir

Fish that may be entrained through Robbs Peak Reservoir could come from two sources: Gerle Creek Canal and the South Fork Rubicon River. As described above, Gerle Creek Canal is a 1.9 mile long canal that transports water from Gerle Creek Reservoir to Robbs Peak Reservoir. The bottom of the canal is unlined, generally comprised of compacted sand, and portions of the sides of the canal are lined with gunite. However, other portions of the canal provide natural substrate and vegetation (see Appendix A: SMUD Gerle Canal Fish Salvage Photos). Thus, the fish habitat in Gerle Creek Canal is inferior to Gerle Creek Reservoir, as the canal lacks significant fish cover. The 1,260 af Gerle Creek Reservoir supports brown trout and California roach (documented in 2003, per the *Reservoir Fisheries Technical Report*), and probably supports a few rainbow trout based historical records and the relatively rare occurrence of rainbow trout in Gerle Canal. To be entrained, fish entering the canal must travel the 1.9 miles from Gerle Creek Reservoir to reach Robbs Peak Reservoir. Despite the poor habitat quality of the canal, it does contain occasional embayments at points of tributary inflow where fish can hold outside the main body of flowing water. Anecdotal evidence from UARP operators indicate that fish can and do move freely between Gerle Creek Canal and Gerle Creek Reservoir. However, poor habitat in the canal probably precludes significant use of the canal by trout from Gerle Creek Reservoir.

Limited trout occurrence in Gerle Creek Canal is supported by the results of a recent fish salvage. During a canal maintenance drawdown in October 2004, a resident population of California roach was found, as well as a small population of brown trout (*Salmo trutta*) and a few rainbow trout (*Oncorhynchus mykiss*). A total of 97 California roach, 41 brown trout and 3 rainbow trout were captured when the 1.9 mile long canal was dewatered. This results in a trout density estimate of 23 trout/mile. Only two trout (both brown trout) equal to or greater than 152 mm were captured during the salvage, resulting in an estimate of 1.05 catchable (>152 mm) trout/mile. Brown trout are not a priority management species for the USFS or CDFG within the UARP area.

The other potential source of fish to Robbs Peak Reservoir is the South Fork Rubicon River, an intermittent stream located in the upper elevations of the UARP area upstream of Robbs Peak Reservoir. The South Fork Rubicon River typically dries up or has very low flow (<2 cfs) by mid-July. A field visit on August 10, 2004 (a dry water year), for example, revealed a dry streambed (L. Maier, pers. comm.). Seasonal water temperature and stream flow changes are not conducive to sustaining a large trout population in the South Fork Rubicon River upstream of Robbs Peak Reservoir. Additional information regarding suitability of habitat in this area is provided below.

## 3.3 Water Temperature and Stream Flow Monitoring in the South Fork Rubicon River above Robbs Peak Reservoir

A continuous water temperature logger was placed in the South Fork Rubicon River above Robbs Peak Reservoir in 2001 to monitor water temperature over several years. The unit is located at longitude N 38° 56.739' and latitude W 120° 23.212'. As noted in Table 3.3-1, average monthly water temperatures do not begin rising until May of each year, and do not remain above 4 °C until June (SMUD 2004c).

Inflows to Robbs Peak Reservoir from South Fork Rubicon River range in temperature from mean daily wintertime lows of near zero to summertime peaks of 19 °C to 21 °C. The high summertime water temperatures occur as natural flows in South Fork Rubicon River transition from approximately 10 cfs in early July to less than 1 cfs at the end of August (Table 3.3-2) (SMUD 2004c). Appendix A includes representative photos of the South Fork Rubicon River above Robbs Peak Reservoir as well as photos of Gerle Canal both when it is full and when it was dewatered for maintenance.

**Table 3.3-1. Monthly water temperature maximums, minimums, and means for the South Fork Rubicon River above Robbs Peak Reservoir, 2001 through 2003.**

| Period | Monthly Max (°C) | Monthly Min (°C) | Monthly Mean (°C) | Period | Monthly Max (°C) | Monthly Min (°C) | Monthly Mean (°C) |
|---|---|---|---|---|---|---|---|
| Jul-01 | 21.6 | 12.2 | 16.5 | Sep-02 | 18.1 | 7.8 | 12.0 |
| Aug-01 | 22.3 | 11.5 | 16.4 | Oct-02 | 10.2 | 4.5 | 6.9 |
| Sep-01 | 18.5 | 8.5 | 12.8 | Nov-02 | 5.0 | 0.6 | 2.9 |
| Oct-01 | 12.6 | 4.8 | 7.9 | Dec-02 | 2.5 | -0.6 | 0.3 |
| Nov-01 | 6.4 | -0.6 | 3.2 | Jan-03 | 2.8 | -0.6 | 0.9 |
| Dec-01 | 0.9 | -0.6 | -0.3 | Feb-03 | 2.8 | -0.6 | 0.7 |
| Jan-02 | 1.8 | -0.6 | 0.2 | Mar-03 | 6.8 | -0.4 | 2.5 |
| Feb-02 | 3.3 | -0.6 | 0.6 | Apr-03 | 5.8 | -0.6 | 1.7 |
| Mar-02 | 5.0 | -0.6 | 1.1 | May-03 | 10.2 | -0.4 | 4.3 |
| Apr-02 | 7.5 | -0.6 | 2.9 | Jun-03 | 19.7 | 4.4 | 11.6 |
| May-02 | 11.9 | 1.1 | 5.6 | Jul-03 | 24.3 | 10.9 | 18.1 |
| Jun-02 | 20.5 | 5.6 | 12.5 | Aug-03 | 21.0 | 11.9 | 16.3 |
| Jul-02 | 24.5 | 12.4 | 18.2 | Sep-03 | 18.2 | 8.7 | 12.6 |
| Aug-02 | 22.0 | 11.2 | 15.7 | Oct-03 | 13.3 | 8.1 | 10.4 |

**Table 3.3-2. South Fork Rubicon River streamflow measurements upstream of Robbs Peak Reservoir during summer and fall, 2002 and 2003.**

| 2002 | | 2003 | | 2004 | |
|---|---|---|---|---|---|
| **Date** | **Flow (cfs)** | **Date** | **Flow (cfs)** | **Date** | **Flow (cfs)** |
| June 20 | 19.8 | June 18 | 34.7 | | |
| July 10 | 2.9 | July 10 | 3.76 | July 10 | 1.4 |
| August 6 | 0.2 | July 24 | 1.4 | August 10 | .07 |
| Sept 18 | < 0.05 | August 11 | 0.4 | Sept 7 | <0.05 |
| | | August 28 | 0.2 | | |
| | | Sept 10 | 0.1 | | |
| | | Sept 30 | <0.05 | | |

## 3.4 Rainbow Trout Habitat Requirements

Since the mid-1800s, rainbow trout have been introduced throughout the western Sierra Nevada. Rainbow trout spawn in the spring, although the specific spawning time is influenced by factors such as the genetic strain of the fish, water temperature, and period of daylight (Moyle 2002). Generally, it is reported that rainbow trout spawn in water ranging from 2 to 20 °C (Bell 1986 in Bjornn and Reiser 1991; Beschta, *et al.* 1987 in Larsen 1996).

Embody (1934) conducted an extensive study of rainbow trout incubation periods in relation to temperature. He found that incubation lasted 101 days for eggs in water at 2.23 °C, down to 18 days for eggs in water of 15.5 °C, with the maximum hatch occurring at water temperatures between 8 °C (41 days) and 15.5 °C. Moyle (2002) noted that rainbow trout "eggs hatch after three to four weeks at temperatures between 10 and 15 °C."
Following hatching, the fry remain in the gravel for two to three weeks. Moyle (2002) notes that "fry emerge from the gravel two to three weeks after hatching at temperatures between 10 and

15 °C." Additionally, Barnhart (1986) also notes that "steelhead fry emerge from the gravel two to three weeks after hatching."

Crisp (1988) examined data for six species of *Salmo* and *Oncorhynchus* to determine overall relationships between temperature and median time to hatching and emergence. Median time to emergence based on temperature can be loosely estimated by using the following equation:

D3 = 1.7 x D2

Where:

D2 = Number of days to median hatch
D3 = Number of days to median emergence

Bjornn and Reiser (1991) note that steelhead and rainbow trout require about 85 days at 4 °C and 26 days at 12 °C to reach 50% hatch (median hatch). When using these numbers in the equation developed by Crisp (1988), at a water temperature of 4 °C, steelhead and rainbow trout would emerge from the gravel approximately 145 days after spawning, and at 12 °C they would emerge from the gravel approximately 44 days after spawning, if the water were kept at constant temperature.

## 3.5 Trout Populations in the South Fork Rubicon River above Robbs Peak Reservoir

The South Fork Rubicon River supports a residual rainbow trout population, from historical planting, which is sustained in isolated pools during late summer and in winter. There are no brown trout in the South Fork Rubicon River above Robbs Peak Reservoir (pg. 22, *Stream Fisheries Technical Report*).

A 2003 fish population survey conducted approximately 0.5 miles upstream of Robbs Peak Reservoir documented only a small population of rainbow trout. Population estimates were made using the Zippin method described by Platts, *et al.* (1983). Trout density was 91 trout/acre. Numbers of catchable (>152 mm TL) trout were 34 trout/mile and trout biomass was 6.6 lbs/acre. Trout biomass and density estimates are presented in the Appendix C of the *Stream Fisheries Technical Report*.

Two site visits to the South Fork Rubicon River in summer and late fall documented current conditions. A site visit on November 26, 2003 documented that most of the stream was already frozen, although observations suggested that pools greater than about 2 feet deep may not freeze solid (particularly after an insulating layer of snow falls), therefore allowing overwinter survival of trout in the stream. A second site visit on September 20, 2004 showed most of the stream to be dry, except where isolated bedrock exposures at the surface prevented percolation of the stream to subsurface flow.
Historical data from surveys conducted in the late 1960s and 1970s show a large change in the fish population between that time period and recent years. A survey conducted by Gerstung in

1968 estimated trout biomass at 48 lbs/acre, with a density estimate of 3,600 trout/mile, and 120 "adult" (>152 mm fork length) trout/mile (Appendix B).

A study conducted by Cressey, *et al.* in 1978 resulted in an estimated density of 21.43 trout/acre, and 116 catchable (>150 mm) trout/mile using a variation of a Lincoln-Petersen mark-recapture population estimation method (Appendix C). Additionally, a USFS survey in 1979 estimated 35.3 lbs/acre and 144 adult trout/mile, although the size of the sample area was not available (pers. comm., Jann Williams, USFS, and Appendix D).

These larger population estimates (compared to 2003 results) could be due to a couple of factors:

- There may have been several wet years prior to the sampling that kept a year-round flow in the stream that allowed the trout population to increase. Unfortunately, there is no hydrological data available before 1975 (pg. 35, *Hydrology Technical Report*).
- The surveyors may have sampled in an isolated stream section (e.g., an isolated pool) where the fish may have concentrated, resulting in an over-estimate of the population.
- Gerstung's data sheets state that 1,700 sq-ft of the 1,800 sq-ft sampled area was pool habitat.

## 4.0 ANALYSIS

Brown trout (the dominant trout species in Gerle Creek Reservoir) are unlikely to be entrained into Robbs Peak Powerhouse in significant numbers because of the 1.9-mile-long canal of poor quality habitat through which they must voluntarily travel to reach the intake. The conditions in the canal, while not optimal for permanent residence, do provide for holding and brief period of residence, thereby allowing brown trout to move freely between the Gerle Creek Reservoir and the canal.

Few rainbow trout from the upper South Fork Rubicon River are subject to potential entrainment because the population is naturally limited by intermittent summer flow, sub-optimal water temperatures, and unfavorable winter conditions.

Although rainbow trout have a wide temperature range at which they can spawn, this analysis suggests that rainbow trout in the South Fork Rubicon River above Robbs Peak Reservoir will not typically spawn until at least late May, when temperatures begin to be maintained above 2 °C (Table 3.3-1). Incubation periods of three (Moyle 2002) to 14 weeks (Embody 1934), depending on how rapidly the temperature increases, result in hatching taking place anywhere from late-June to mid-July or later. Fry would remain in the gravel for four to six weeks at temperatures between 10 and 15 °C (Moyle 2002), and then emerge from the gravel beginning in mid-July.

However, by mid-July flows in the South Fork Rubicon River often decrease to low levels (< 2 cfs), potentially desiccating spawning areas and requiring the fish to gather in remnant pools to survive. The flows may then quickly drop to less than 1 cfs through the rest of the summer (Table 3.3-2). Additionally, the water continues to warm to sub-optimal levels, rising to above 20 °C on some days (Table 3.3-1).

These various natural conditions limit the populations of rainbow trout residing in the South Fork Rubicon River. Productivity in this portion of the river is highly variable depending upon the hydrologic conditions of individual years, but is not likely to achieve a sustained population abundance that would lead to significant entrainment levels.

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# APPENDIX A

# REPRESENTATIVE AREA PHOTOS

- SMUD UARP Gerle Canal Entrainment Study Photos, Dave Hanson, Mike Meinz, Scott Wilcox, Jann Williams, April 11, 2003
- SMUD UARP Upper South Fork Rubicon at T-Line Crossing, Scott Wilcox, Dave Hanson, November 26, 2003
- SMUD UARP Upper South Fork Rubicon, Stone Cellar Area: Fish Reconnaissance, Joe Davis, Scott Wilcox, Jann Williams, September 20, 2004
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# APPENDIX B

# FISH POPULATION SAMPLING
# DATA SHEET
# PERSONNEL: GERSTUNG
# AUGUST 1, 1968

FISH POPULATION SAMPLING DATA SHEET

Date Aug 1, 1968

Personnel Cocotsos, _____, _____, _____

Name of Stream SF Rubicon

Tributary to: Rubicon

County: El Dorado

Study Section: above Diversion

Location: ___ ¼ ___ ¼S ___ T ___ R ___

Time: Start _____ End _____

Length of study section 132

Average width of study section _____

Total pool area 1700 } 1800

Total riffle area 100

Average pool depth ≈1'

Area of cover Sparse sq. ft.

Area of spawning gravel good sq. ft.

Area of food production good sq. ft.

Percentage of bottom covered by silt or (sand) pool 60 % riffle 0 %

Canopy alders Conifers

Overall stream gradient ___ ft. /mile

Study section gradient ___ ft./mile

Aquatic vegetation present (est. quant. & types) abundant algae

Est. standing crop in pounds per acre:

Trout 46 Roughfish _____

Total trout per mile 3600

Adult trout per mile (6" F.L.) 120

Relative Fishing pressure Heavy

Type of sampling gear _____

Est. or measured $\bar{x}$ velocity (F.P.S.) ___

Water temp. 75 °F. at 1300

Stream flow 1/3 cfs.

Color and turbidity clear JCU

Transparency (Secchi disc) Clear

Electrical conductivity _____

Total dissolved solids 30

Photos taken yes yes

Stop nets used yes

Streamside environment (Land use and vegetation) Pine & fir forest logging and grazing

Condition of watershed and sources of pollution good

Fish observed but not captured

2 yearling 30 fry

Est. recovery by mark and recapture:

Relative abundance of aquatic organisms:

Reg II (5/68)

CATCH

| | PASS I Species | Length | Wt. (18/10) | PASS I Species | Length | Wt. | ~~PASS II~~ Species | Length | Wt. | Mark | PASS II Species | Length | Wt. | Mk. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | RT | 5.2 | .08 | RT | 3.2 | .01 | RT | 3.1 | .01 | | | | | |
| 2. | " | 5.3 | .07 | | 4.1 | .02 | | 3.8 | .02 | | | | | |
| 3. | " | 5.6 | .08 | | 4.8 | .05 | | 3.2 | .01 | | | | | |
| 4. | | 5.1 | .07 | | 4.0 | .03 | | 2.9 | .005 | | | | | |
| 5. | | 6.2 | .10 | | 4.0 | .03 | | 2.8 | .005 | | | | | |
| 6. | | 6.3 | .10 | | 3.7 | .02 | | 1.7 | * | | | | | |
| 7. | | 6.1 | .07 | | 3.6 | .02 | | | | | | | | |
| 8. | | 3.9 | .05 | | 3.7 | .02 | PASS II | | | | | | | |
| 9. | | 4.8 | .06 | | 3.6 | .01 | | 4.6 | .04 | | | | | |
| 10. | | 5.3 | .06 | | 4.2 | .03 | | 5.1 | .05 | | | | | |
| 11. | | 3.2 | .01 | | 4.1 | .03 | | 6.0 | .07 | | | | | |
| 12. | | 4.2 | .02 | | 3.7 | .02 | | 3.7 | .03 | | | | | |
| 13. | | 5.1 | .07 | | 3.6 | .01 | | 3.4 | .02 | | | | | |
| 14. | | 5.0 | .05 | | 3.7 | .01 | | 3.9 | .02 | | | | | |
| 15. | | 4.2 | .04 | | 3.7 | .02 | | 1.8 | | | | | | |
| 16. | | 4.0 | .05 | | 3.9 | .03 | | 6.0 | .10 | | | | | |
| 17. | | 4.2 | .05 | | 3.7 | .02 | | 5.1 | .05 | | | | | |
| 18. | | 4.7 | .05 | | 3.2 | .01 | | 4.7 | .04 | | | | | |
| 19. | | 3.8 | .03 | | 2.9 | .005 | | 4.2 | .03 | | | | | |
| 20. | | 4.3 | .04 | | 3.6 | .01 | | 3.8 | .02 | | | | | |
| 21. | | 4.2 | .04 | | 3.6 | .01 | | 3.2 | .01 | | | | | |
| 22. | | 2.9 | .01 | | 3.6 | .01 | | 1.7 | | | | | | |
| 23. | | 3.9 | .02 | | 3.3 | .01 | | 4.2 | .03 | | | | | |
| 24. | | 3.3 | .01 | | 4.0 | .03 | | | | | | | | |

69

Reg II (5/68)

2.2 16

# APPENDIX C

# ELECTRO-SAMPLING DATA SHEET
# PERSONNEL: CRESSEY, MARTZ, HENRY, ROHRER
# OCTOBER 2, 1978

ELECTRO-SAMPLING DATA SHEET Date 10-2-78

Personnel CRESSEY, MARTZ, HENRY
ROHRER, _____, _____

Name of stream: S. FORK RUBICON/ABOVE
Tributary to: IZORR'S PK FOREBAY
County: EL DORADO CO
Location: _¼ _¼ S _ T _ R _.

Type of shocker used GENERATOR
Volts 500 AC __ DC PULSE

Est. or measured $\bar{X}$ velocity (F.P.S.) ___
Water temperature ___° F. at _____

Time: Start _____ End _____
Length of study section: 391 ft.
Average width of study sec. 16.2 ft.
Average depth of " " 1 ft.

Stop nets used: Yes __ No __.
Photos taken: _____

Total pool area _____ Total riffle area _____
Est. or meas. flow in c.f.s. 1
Low water, normal water, high water (circle one)
Color and turbidity _____
Secchi disk reading _____
Type of bottom (sand, silt, gravel, rubble, etc.)
Aquatic vegetation present (Est. quant. & types)

Salt added: Yes__ No__ No. of blocks _____

Streamside Habitat (Forested, Logged, Cultivation, Pastureland, Commercial, Housing) etc. MIXED CONIFER
Upstream Pollution Sources: (Log pond, campground) etc.
Fish observed but not captured:

FORK LENGTH IN mm CATCH

| | PASS I | | | PASS II | | | PASS III | | | PASS IV | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Species | Length | Wt. | Species | Length | Wt. | Species | Length | Wt. | Species | Length | Wt. |
| 1. | R | 118mm | 19 | R | 62 | 3 | R | 58 | 2 | | | |
| 2. | R | 134 | 29 | R | 115 | 15 | R | 158 | 40 | | | |
| 3. | R | 167 | 70 | R | 123 | 17 | R | 63 | 2 | | | |
| 4. | R | 192 | 82 | R | 124 | 16 | R | 60 | 2 | | | |
| 5. | R | 129 | 28 | R | 110 | 12 | R | 60 | 2 | | | |
| 6. | R | 153 | 44 | R | 113 | 10 | R | 60 | 2 | | | |
| 7. | R | 133 | 28 | R | 62 | 2 | R | 113 | 14 | | | |
| 8. | R | 127 | 24 | R | 97 | 11 | R | 175 | 54 | | | |
| 9. | R | 126 | 25 | R | 101 | 11 | R | 142 | 36 | | | |
| 10. | R | 118 | 22 | R | 60 | 2 | R | 136 | 26 | | | |
| 11. | R | 126 | 23 | R | 60 | 2 | R | 118 | 17 | | | |
| 12. | R | 120 | 20 | R | 55 | 2 | R | 68 | 2 | | | |
| 13. | R | 113 | 16 | R | 58 | 2 | R | 95 | 8 | | | |
| 14. | R | 98 | 10 | R | 58 | 2 | R | 67 | 2 | | | |
| 15. | R | 114 | 17 | R | 58 | 2 | | | | | | |

R = RAINBOW

S. FORK KUBICON

10-2-78

ELECTRO-SAMPLING DATA SHEET Page 2 of 2 pages

FORK LENGTH IN mm

CATCH

| ~~PASS I cont.~~ | | | PASS II cont. | | | ~~PASS III cont.~~ | | | ~~PASS IV cont.~~ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | Length | Wt. | Species | Length | Wt. | Species | Length | Wt. | Species | Length | Wt. |
| 16. R | 115 | 17 | | | | | | | | | |
| 17. R | 128 | 24 | | | | | | | | | |
| 18. R | 154 | 38 | | | | | | | | | |
| 19. R | 125 | 21 | | | | | | | | | |
| 20. R | 122 | 20 | | | | | | | | | |
| 21. R | 125 | 21 | | | | | | | | | |
| 22. R | 127 | 22 | | | | | | | | | |
| 23. R | 145 | 30 | | | | | | | | | |
| 24. R | 60 | 2 | | | | | | | | | |
| 25. R | 119 | 20 | | | | | | | | | |
| 26. R | 100 | 11 | | | | | | | | | |
| 27. R | 73 | 4 | | | | | | | | | |
| 28. R | 90 | 9 | | | | | | | | | |
| 29. R | 94 | 9 | | | | | | | | | |
| 30. R | 72 | 3 | | | | | | | | | |
| 31. R | 60 | 2 | | | | | | | | | |
| 32. R | 60 | 2 | | | | | | | | | |
| 33. R | 60 | 2 | | | | | | | | | |
| 34. | | | | | | | | | | | |
| 35. | | | | | | | | | | | |

Remarks: (Includes species abbreviations used)

M = 𝍸 𝍸 𝍸 / 16 MARKED

WIDTHS: 23.4', 22.3', 24.8', 14.4' } POOL

15.6, 20.8, 11.2, 9.5 } RIFFLE

13.6

10.5, 12.5 } POOL

LENGTHS (1) 115, 100, 54, 100, 22 = 391

AVG WIDTH = 16.24'

000205 OK

S. Fk. Kaweah (Above Rocky Pool Forebay) 10/2/78

M = 44

C = 34 N = 90.59 ± 34.0 $N = \frac{M(C+1)}{R+1}$

R = 16 at 95% C.I.

SE = 17.0

Sample area = 6348.4 ft²

| Captured Trout per 6348.4 ft² | | Avg. Wt | % Tot. No. | % Tot. Wt |
|---|---|---|---|---|
| Trout ≥ 150 mm: | 274 g ÷ 6 trout = 45.66 g | | 9.5 | 28 |
| < 150 mm: | 7.12 g ÷ 57 trout = 12.49 g. | | 90.5 | 72 |

| Trout Population per 6348.4 ft² | | No. Trout × | Avg. Wt | = Tot. Wt |
|---|---|---|---|---|
| Trout ≥ 150 mm: | 90.59 × 9.5% = | 8.6 | 45.66 g | 392.6 |
| < 150 mm: | 90.59 × 90.5% = | 82.0 | 12.49 g | 1023. |

| Trout Pop. in 16/acre | | gm/acre | lb/acre |
|---|---|---|---|
| Trout ≥ 150 mm: | 392.68 × 6.86 = | 2693.76 | 5.94 |
| < 150 mm: | 1023.98 × 6.86 = | 7024.50 | 15.49 |
| | Total 16/acre = | | 21.43 |

Trout ≥ 150 mm per mile

8.6 trout × 13.5 = 116

6 miles

4,348 ft

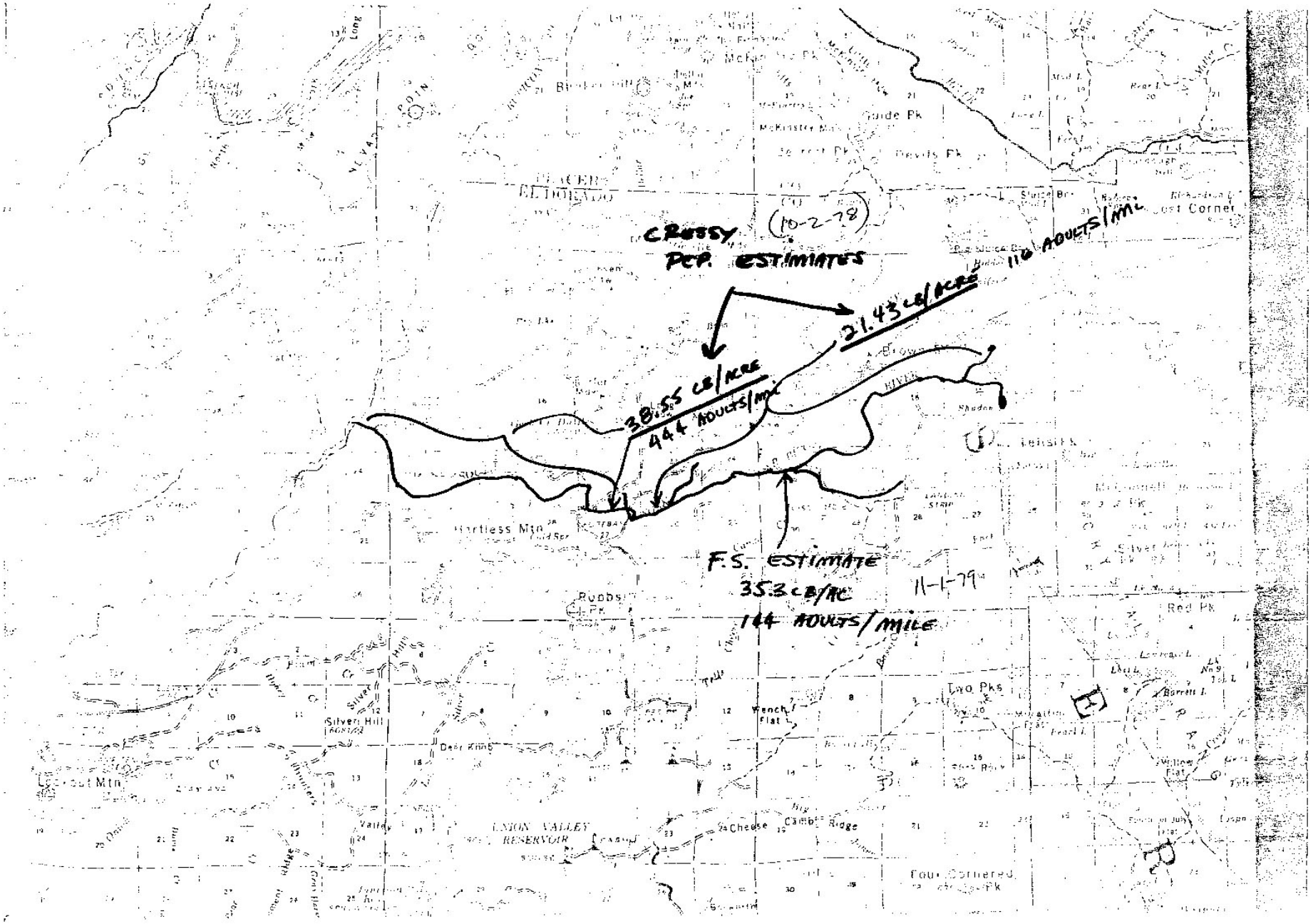
87

@ $1.50/ft = $130.50

Species Composition: 100% Rainbow Trout

# APPENDIX D

# ROBBS PEAK RESERVOIR REACH MAP SHOWING HISTORICAL U.S. FOREST SERVICE FISH POPULATION ESTIMATES


CROSSY
PCP ESTIMATES
(10-2-78)
21.43 CB/ACRE
116 ADULTS/MILE
38.55 CB/ACRE
444 ADULTS/MILE
F.S. ESTIMATE
35.3 CB/AC
11-1-79
144 ADULTS/MILE
Hartless Mtn
Silver Hill
Lyon Pks
Red Pk
Four Cornered
UNION VALLEY
RESERVOIR