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# A Survey of the Waters of the Cache National Forest, Utah

C.J. D. Brown

DEPARTMENT OF COMMERCE
U. S. BUREAU OF FISHERIES



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by

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Temporary Biologist



Washington
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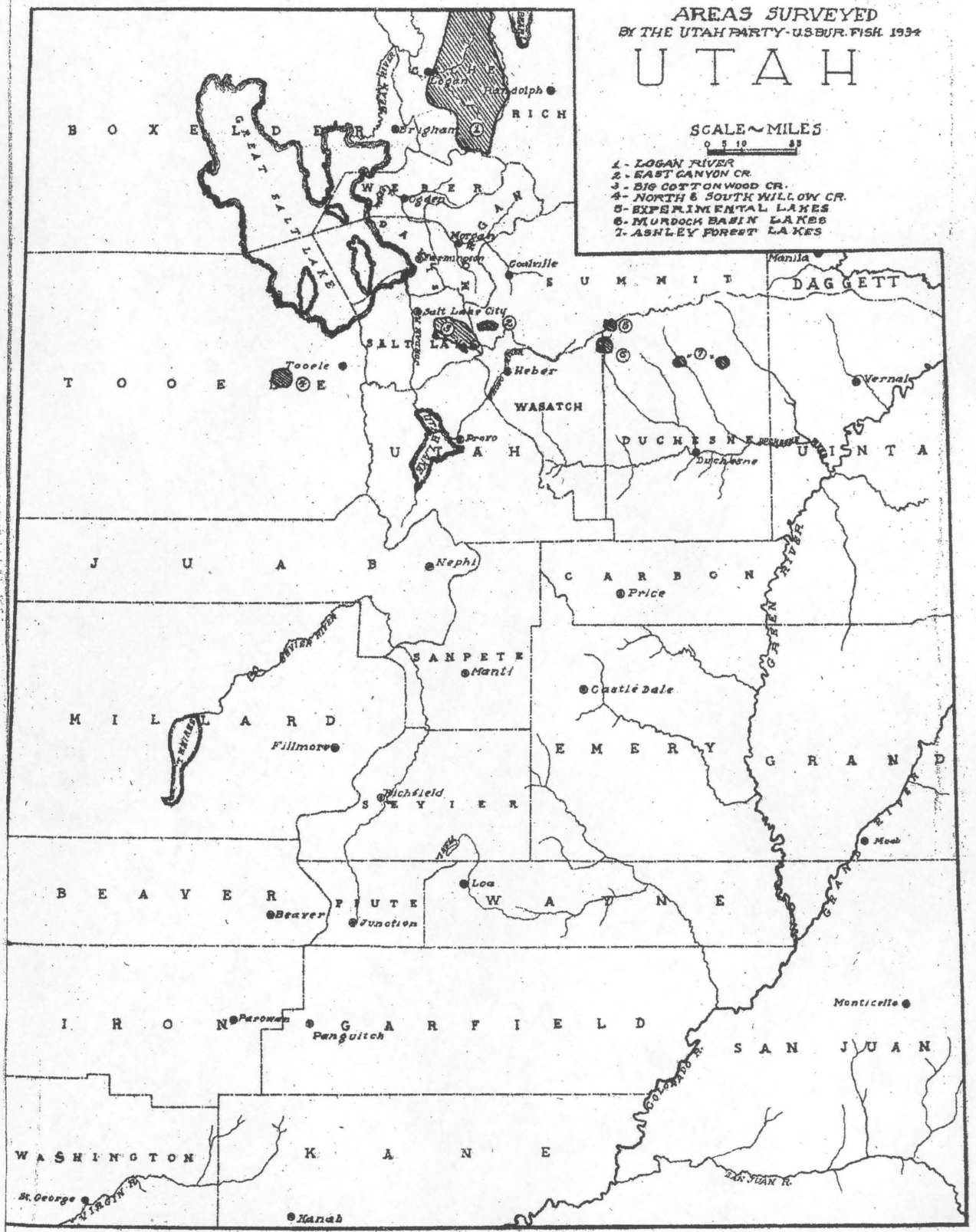
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BY THE UTAH PARTY-U.S.BUR.FISH. 1934
UTAH
SCALE~MILES
0 5 10 15
1 - LOGAN RIVER
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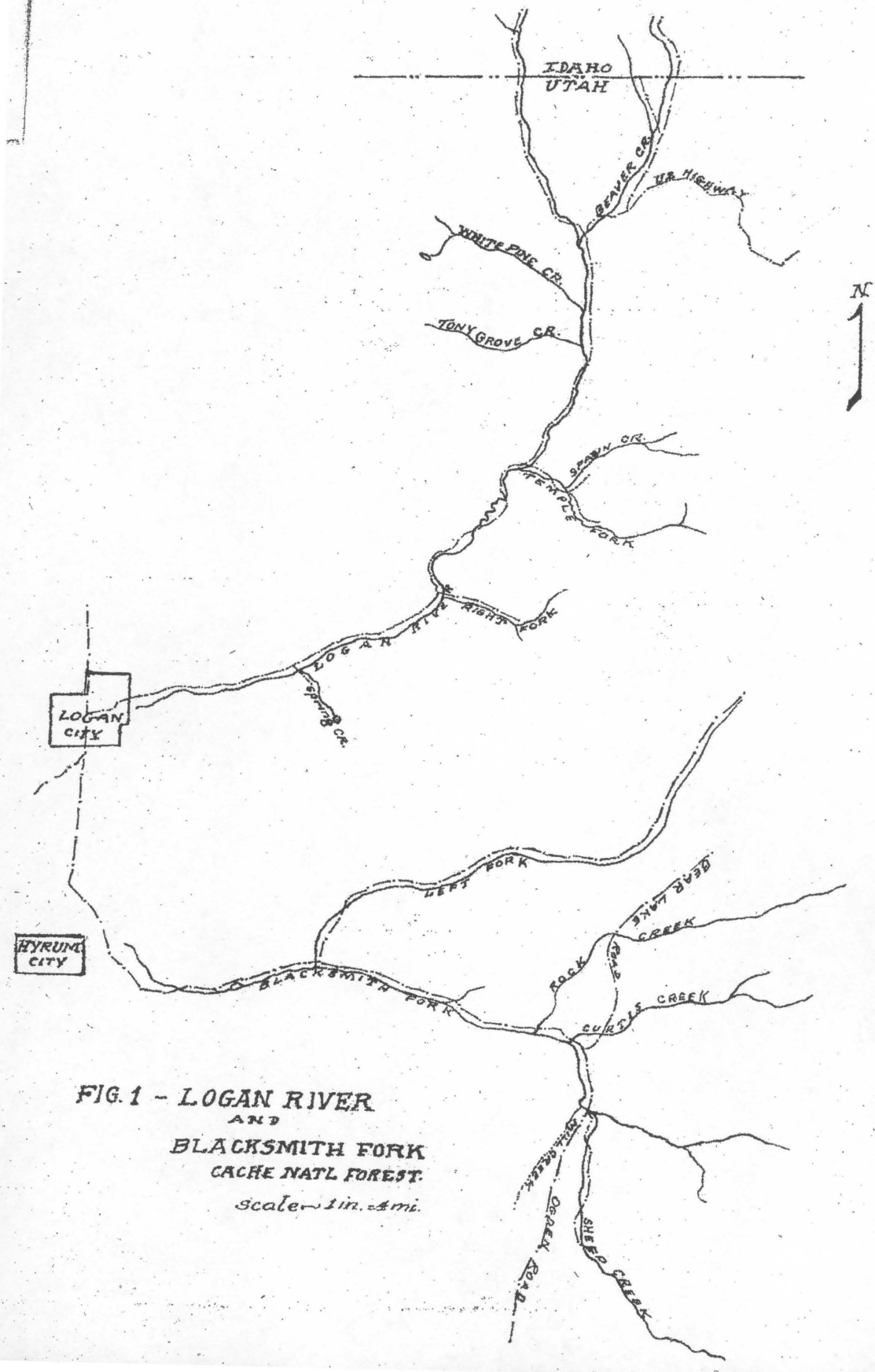


FIG. 1 - LOGAN RIVER
AND
BLACKSMITH FORK
CACHE NATL FOREST.
Scale - 1 in. = 4 mi.

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## INTRODUCTION AND ACKNOWLEDGMENTS

Between June 1 and September 7, the Utah Survey Party examined streams and lakes in the Cache, Wasatch and Ashley National Forests. Survey work in the Cache Forest and vicinity covered the main Logan River and its tributaries as well as the Blacksmith Fork, which is situated adjacent to the southern forest boundary. Certain observations were also made on 15 miles of the upper Little Bear River and the Hyrum Dam Reclamation Project. The Logan River and its tributaries, exclusive of Blacksmith Fork, embrace about 50 miles of fishable stream. There are about 60 miles in the Blacksmith Fork and its tributaries. This report will be confined to the Cache Forest and adjacent streams indicated above.

The Utah party was composed of 5 members as follows: Dr. C. J. D. Brown, leader of party; James Moffett and James Wilding, assistant biologists; Allan Randle,* improvement supervisor; and Leonard Miles, cook.

The party wishes to thank and acknowledge the assistance of others in carrying out its survey program. We thank especially Dr. A. S. Hazzard, who directed this work; C. B. Arentson, Supervisor of the Cache National Forest; Ranger Libby of the Logan District; Warden Peterson of Cache County; and Lawrence Johnson, in charge of the Logan State Hatchery. Thanks are also due Ranger Morgan Parks and Karl Bunnell of the Kamas Division for aid in transportation. We also wish to thank those fish and game associations contacted for their interest and cooperation in this work.

## METHODS

### PHYSICAL DATA

#### Streams

Widths and Depths - Velocity and Volume. Three widths were taken at each station along with three depths for each width. The averages were recorded. Velocity was measured by timing a chip allowed to float a distance of 50 feet. Several trials were made and an average taken.

* Mr. Randle, because of immediate needs in various parts of the State, did not work directly with the party.

The volume was computed from the following formula:

$$\frac{\text{Av. Width in ft. x Av. Depth in ft. x Length in ft. x 0.8 constant}}{\text{Time in seconds}} = \text{Vol in c}$$

Temperatures. Temperatures were taken with a corrected Fahrenheit thermometer always keeping the instrument shaded.

## Lakes

Measurements and Soundings. Measurements were made with rope lines calibrated in yards. Soundings were made at known distances from shore i a known direction with a calibrated line. Acreage was estimated for larg lakes and computed for small ones.

Temperatures. Temperatures were taken with a deep-sea reversible thermometer.

Turbidity. A standard Secchi disc (six inches in diameter) was used for testing the relative transparency of lake waters.

## CHEMICAL DATA

pH. All water samples below surface were taken with a Juday modification of the Kemmerer sampler. A colorimetric set of tubes with Bromthymol blue as indicator, prepared by the chemistry department of the University of Utah, was employed. This was checked against a wide-range Hellige outfit.

Carbon-dioxide. Phenolphthalein was used as an indicator and titrations were made against N/44 Sodium Hydroxide.

Oxygen. The modification of the Winkler method outlined in Standard Methods of Water Analysis was used except that the potassium permanganate step was omitted.

Alkalinity. 1. Phenolphthalein as indicator titrated against 0.02 Normal Sulfuric Acid. 2. Methyl orange as indicator titrated aginst 0.02 Normal Sulfuric acid. The number of cubic centimeters used was multiplied by ten to give parts per million.

## BIOLOGICAL DATA

Bottom Samples, Streams. A special net with a brass frame and a silk bag was used for bottom sampling. A marker of 1 sq. ft. was attache to the net. Qualitative counts were made of the organisms present and in most instances specimens were allowed to drain and placed in a centrifuge tube partially filled with water. The volume of water displacement was recorded.

Bottom Samples, Lakes. An Ekman dredge six inches square was used. The content of the dredge sample was poured into screens (30 meshes to the inch ). Qualitative counts were made and the total sample measured in a centrifuge tube as described above.

Fish Collections. Fish collections were made by angling or by the use of a gill-net. The gill nets used contained 25 feet of the following sizes (square measurement): 3/4 inch, 1 inch, 1½ inch, 2 inch, 2½ inch.

Plankton Samples. A quantitative, #20 silk bolting cloth, plankton net was used. Only surface samples were taken. A known quantity (usually 100 gals.) taken at random over the lake, by dipping with a pail, was poured through the net. Plankton samples preserved in formalin were placed in calibrated tubes and allowed to settle 24 hours. The number of cc. of sediment was recorded.

## S T O C K I N G  R E C O M M E N D A T I O N S

The purpose of stream and lake survey is many sided. Its immediate application, however, is toward physical, chemical and biological improvement. Of the biological improvements the stocking program is most vital at present. Too often in the past, plantings have been made without regard to the suitability of the species or the available food supply. Coupled with this are the poor methods used in introducing hatchery fish into streams and lakes. Often truckloads of fish have been killed by careless practices.

In the following recommendations, there has been a serious attempt to correlate the species and number of fish planted with the suitability of the water and the existing food supply. It must be remembered, however, that a single season is entirely inadequate to solve even the gross problems met with in such an investigation and that such things as quantities of fish removed annually, extent of natural propagation, and fish distribution can only be dealt with lightly until further studies increase our knowledge along these lines.

When funds are available to carry out yearly systematic studies of our streams and lakes, then and only then will stocking programs reach a high degree of efficiency.

Suitability of Species. It is common knowledge that even though enormous numbers of rainbow trout are planted in many streams and lakes, other species not stocked are of equal or greater abundance. This is true in the upper Temple Fork of the Logan River where the native cutthroat exceeds the rainbow and in the Big Cottonwood Creek where the brown trout maintains itself without stocking. Many things not understood, aside from temperature requirements of trout, make for suitability of one species and for unsuitability of another. In the following tables all of our data, including observations, have been considered in choosing a species for a given locality.

Food Present. A careful quantitative study was made of the food organisms present. A food grade was established on a basis of comparing the various food conditions and a study of the condition of the fish present. This grade does not represent any definite figure, but instead, the quanti of organisms present as compared to average numbers.

Intensity of Fishing and Natural Propagation. Information concerning these two factors was gleaned from observation and also reports of others acquainted with the general conditions from year to year.

Size and Number of Fish and Frequency of Planting. The size of fish to be planted must be considered in view of the size available, the intensity of fishing, and the accessibility of the area to be planted.

Often it is necessary to plant small fish in rather inaccessible wate due to the difficulties involved in transportation. Likewise it is often necessary to stock legal size fish at frequent intervals in waters which a fished excessively in order to maintain good fishing.

The sizes of fish listed in the tables following the discussion of each drainage are purely arbitrary except that these sizes are those usual available as the fish come from the hatchery. In most cases where rearing ponds can be utilized it would be far more economical to hold small fish until they reached a size of 6 to 8 inches.

The following table (A), copied from Embody, gives the number of fish to be planted per mile of stream. Correction factors for size follow this table.

"In order to use this table, one must first determine the average width of the stream, the number of miles suitable for stocking and values for pool (A, B, and C) and food (1, 2, and 3) conditions as already described,

Table A. Planting Table for Trout Streams: Number of 3-inch fingerlings per mile.

| Width Feet | A1 | A2 | A3 | B1 | B2 | B3 | C1 | C2 | C3 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 144 | 117 | 90 | 117 | 90 | 63 | 90 | 63 | 36 |
| 2 | 288 | 234 | 180 | 234 | 180 | 126 | 180 | 126 | 72 |
| 3 | 432 | 351 | 270 | 351 | 270 | 189 | 270 | 189 | 108 |
| 4 | 576 | 468 | 360 | 468 | 360 | 252 | 360 | 252 | 142 |
| 5 | 720 | 585 | 450 | 585 | 450 | 315 | 450 | 315 | 180 |
| 6 | 864 | 702 | 540 | 702 | 540 | 378 | 540 | 378 | 216 |
| 7 | 1008 | 819 | 630 | 819 | 630 | 441 | 630 | 441 | 252 |
| 8 | 1152 | 936 | 720 | 936 | 720 | 504 | 720 | 504 | 284 |
| 9 | 1296 | 1053 | 810 | 1053 | 810 | 567 | 810 | 567 | 324 |
| 10 | 1440 | 1170 | 900 | 1170 | 900 | 630 | 900 | 630 | 360 |

"The table refers to 3-inch fingerlings only. To find the number of

1-, 2-, 4-, 6r 6-inch fish, etc., multiply by the following factors:-

| Size in inches | 1 | 1½ | 2 | 2½ | 3 | 4 | 6 |
|---|---|---|---|---|---|---|---|
| Factor | 12 | 3.0 | 1.7 | 1.2 | 1 | 0.75 | 0.6 |

This is based upon an expected mortality as follows:

| Size: | 1 | 1½ | 2 | 2½ | 3 | 4 | 6 |
|---|---|---|---|---|---|---|---|
| Mortality | 95% | 80% | 65% | 52% | 40% | 20% | 0% |

"The table covers stream widths up to 10 feet. Values for wider streams, may be determined by multiplying that given for a stream 1 foot wide, by the width of the stream in question."

The planting table (B) for trout lakes is taken from Hazzard, "Instructions for Stream and Lake Survey Work."

Table B. Planting Table for Trout Lakes: Number of 3-inch trout per acre

| Average weight of fish in pounds | Class I Exceptionally Productive | Class II Average Productivity | Class III Below Average Productivity |
|---|---|---|---|
| 1/2 | 600 | 374 | 150 |
| 3/4 | 400 | 249 | 100 |
| 1 | 300 | 187 | 75 |

In order to use this table the total area of the lake and the approximate area over 50 feet in depth must be determined. The lake, if otherwise suitable for trout, should be placed in one of the three classes based upon the study of food.

Class I. (exceptionally productive) - Average bottom foods greater than 5 c.c. (or 5 grams) per square foot. Shore food abundant (50 or more organisms including large Amphipods), plankton averaging greater than 2c.c. per cubic meter.

Class II. (average productivity) - Average bottom sample from 2 c.c. to 5 c.c. per square foot, shore foods from 25 to 50 per square foot usually including Amphipods, plankton from 1 to 2 c.c. per C. M.

Class III. (below average in production) - Bottom samples less than 2 c.c. per square foot, shore foods less than 25 per square foot. Large amphipods not present; plankton less than 1 c.c. per C.M.

In using this classification, bottom samples taken with the Ekman dredge should be given the greatest weight inasmuch as this source of fish food is relatively constant during the summer months, is heavily used by trout, and because the samples are taken with reasonable accuracy. An abundance of

shore foods is an indicator of richness, without exception if large Amphipo are present. Plankton varies greatly during the seasons, but seasonal studies on these three types of lakes show that in general highly productiv and average lakes show a higher volume of plankton throughout the season th do poor lakes even at the height of their productivity.

The above classification is based upon samples taken from trout lakes which were classified as to the type of fishing they are known to produce. It is strictly tentative, but should be useful until more accurate information is secured.

## PRINCIPAL WATERSHEDS

### LOGAN RIVER

#### General Description

The major part of the Cache National Forest is situated in North Centra Utah and Southern Idaho, extending the width of the Wasatch Range. The Utah Division is drained mainly by the Logan River, which runs to the south and west finally emptying into the Bear River, the most substantial tributary of Great Salt Lake. This mountainous region of the Logan River Drainage has an area of approximately 225 square miles exclusive of the Blacksmith Fork Tributary which will be described in another section of this report.

The mountains of this area are chiefly limestones and shales of Paleozoic Age. These are considerably weathered and are, no doubt, in part responsible for the alkalinity of waters in this region. There are very few natural lakes in the drainage. Those present are small and isolated and of no significance to fisheries. There are, however, two small power dams which are well stocked and important.

The source of the water supply is from melting snow and springs. Ordinarily there is very heavy snowfall over the entire area and the streams are decidedly torrential during the early thaws. Irrigation and power projects divert practically all of the water during the summer, but in the canyon proper there is still sufficient for an ideal trout stream. Nearly all of the river is adjacent to good highways. Only one or two of the tributaries must be reached by rough mountain road or trail.

The Logan River was divided into eleven sections, beginning at the mouth of Logan Canyon, each containing one to three stations. The tributaries are given as supplements to the sections. In order to prevent repetition in locating talked-of points, each section is described in Table 1.

Table 1.- Description of sections and stations on Main Logan River and tributaries

| Section No. | Length | Location | Stations | | |
|---|---|---|---|---|---|
| | | | Lower | Middle | Upper |
| 1 | 1.25 mi. | From Crockett Ave. to State Dam. | 100 ft. above diversion to flour mill. | | 100 yds. below Benson Ward Canal diversion. |
| 2 | 0.25 mi. | State Dam | | | |
| 3 | 2.0 mi. | From State Dam to 1/8 mi. above diversion of Smithfield High-line Canal | 50 yds. below Utah Power & Light Co. Plant | Cache Forest Boundary | 30 yds. above Smithfield Canal Diversion. |
| 4 | 2.0 mi. | 1/8 mi. above Smithfield High-line Canal diversion to $\frac{1}{4}$ mi. above Utah Power & Light Co. Dam. | 30 yds. above Utah Power & Light Co. Intake. | 200 yds. above Logan City Power Plant | 300 yds. below Camp Lamar. |
| 5 | 0.25 mi. | Logan City Dam | | | |
| 6 | 6.0 mi. | Logan City Dam to Card Canyon | Dewitte Camp | Bierdneau Camp | 100 yds. down canyon from Card Canyon Ranger Sta. |
| 7 | 2.0 mi. | Card Canyon to Bridge above Right fork. | Chokecherry Camp | | 0.3 mi. below Right fork. |
| 8 | 6.2 mi. | Right Fork to 0.1 mi. above Temple fork. | Wood Camp Hollow | Cottonwood Canyon | 0.2 mi. below Temple Fork. |
| 9 | 4.5 mi. | Temple Fork to Tony Grove Creek | 50 yds. below Ricks Spring | 0.5 mi.below W. Hodges | 0.3 mi. below Tony Grove Camp. |
| 10 | 2.5 mi. | Tony Grove Cr. to Beaver Creek | | 100 yds.blw. White Pine Cr. | 100 yds. below Beaver Cr. |
| 11 | 3.5 mi. | Mouth of Beaver to end of stream Franklin Basin. | 1 mi. above Beaver Creek | 150 yds.below mouth of Steam Mill Creek | Petersons Hollow |

Table 1.- (Cont.) Description of tributaries and stations

| Tributary | Length | Location | Stations | | |
|---|---|---|---|---|---|
| | | | Lower | Middle | Upper |
| Spring Hollow Creek | 1.0 mi. | Supplement to Section 5. | 100 yds. up from mouth. | | |
| Right Fork | 6.25 mi. | Supplement to Section 7. | 100 yds. above mouth. | | Boy Scout Camp. |
| Temple Fork | 6.0 mi. | Supplement to Section 8. | 100 yds. above mouth. | 100 yds. below mouth of Spawn Cr. | 200 yds. below forks and old saw-mill site. |
| White Pine Creek | 6.0 mi. | Supplement to Section 10. | 1/4 mi. above mouth. | | Just below forks of stream. |
| Beaver Creek | 10.0 mi. | Supplement to Section 10. | 1 mi. above mouth. | 5.2 mi. below upper saw-mill. | 1.5 mi. below upper saw-mill. |

The data collected in this survey will be treated under the headings of physical, chemical, and biological. A section is also devoted to improvements and one to stocking programs.

## Physical Characteristics

Gradient. The average gradient for the main Logan River is approximately 70.0 feet per mile. The lowest gradient figure for any section was found to be 30.0 feet per mile and the highest 167.0 feet per mile. Among the tributaries, Right Fork has the lowest gradient of 90.0 feet per mile, while Spawn Creek has a gradient of 394.0 feet per mile, the highest for the Logan River system. A summary of gradients for the main Logan River and its tributaries is given in Table 2.

The influence of gradient upon the type of bottom, size, type, and frequency of pools and general living conditions of the fish, is of great importance. In the Logan River, the extreme gradient has reduced the size and number of pools until improvements are almost a necessity for maintenance of good fishing. To improve the physical conditions of the stream bed in such tributaries as Spring Hollow and White Pine Creeks would not only be very expensive but almost impossible. Suggestions for improvements will be treated under another section.

Widths and Depths. No measurements were taken to show the effects of 1934 drought conditions on the widths and depths of the stream. The condition this year, however, no doubt is far from normal.

The average width for the Logan River is 37.81 feet and the average depth 0.74 feet. This low depth figure can be explained on a basis of the almost complete lack of pools. Comparisons in widths and depths of the various sections on the main river and its tributaries is given in Table 2.

Table 2.- Average widths, depths, velocities, volumes, and gradient for the sections of the Logan River and its tributaries

| Section No. | Length in Miles | Average Width in ft. | Average Depth in ft. | Average Velocity Ft.per Sec. | Average Volume c.f.s. | Gradient in Feet per mile |
|---|---|---|---|---|---|---|
| 1 | 1.25 | 38.8 | 1.1 | 2.71 | 88.6 | 30 |
| 2 | | State Dam - Area 3 acres. | | | | |
| 3 | 2.0 | 40.05 | 0.73 | 3.11 | 54.5 | 35 |
| 4 | 2.0 | 26.0 | 0.45 | 1.3 | 38.8 | 40 |
| 5 | | Logan City Dam - Area 4 acres. | | | | |
| 6 | 6.0 | 48.3 | 0.90 | 3.02 | 105.0 | 35 |
| 7 | 2.0 | 52.2 | 0.79 | 2.08 | 101.7 | 55 |
| 8 | 6.2 | 41.9 | 0.79 | 3.26 | 94.1 | 83 |
| 9 | 4.5 | 40.9 | 0.65 | 2.98 | 54.06 | 100 |
| 10 | 2.5 | 31.6 | 0.66 | 2.33 | 38.6 | 80 |
| 11 | 3.5 | 20.6 | 0.63 | 2.74 | 27.9 | 167 |
| Tributaries | | | | | | |
| Spring Hollow Cr. | 1.0 | 9.0 | 0.37 | 3.0 | 5.0 | 300 |
| Right Fork | 6.25 | 10.7 | 0.37 | 3.52 | 11.37 | 90 |
| Temple Fork Cr. | 6.0 | 14.0 | 0.39 | 2.43 | 11.45 | 208 |
| Spawn Cr. | 4.0 | 8.75 | 0.22 | 2.50 | 3.9 | 394 |
| White Pine Creek | 6.0 | 10.5 | 0.30 | 2.5 | 6.1 | 333 |
| Beaver Cr. | 10.0 | 9.2 | 0.33 | 1.29 | 3.27 | app.200 |

Volume and Velocity. Under average conditions, the Logan River is a sizable mountain stream. The measurements given in Table 2 for the summer of 1934 represent the lowest water in history. The average normal flow at the mouth of the canyon, according to Dr. Clyde, Irrigation Engineer, is 1350 c.f.s. for May and June. The maximum flow for these months is recorded as 2700 c.f.s. The minimum summer flow at this same point is 90 c.f.s. No doubt, records for August and September of 1934 will show a considerable decrease over this last figure. The average volume during the period of this investigation (June - July) for the main river was 67 c.f.s. Throughout the season reports show that 60% of the flow comes in above the Temple Fork tributary. The average volumes for the tributaries during June and July are given in Table 2.

The velocity is unusually high throughout the course of the river with an average of 2.61 feet per second. The maximum was found in section with 3.26 feet per second and the minimum in section 4 was 1.3 feet per second. Average velocities for each section of the main river and the tributaries are given in Table 2.

Types of Bottom. For the greater part, the stream bottom is composed of boulders and coarse rubble. Only occasional beds of gravel and sand occur. This may be explained almost entirely by the extreme gradient and velocity of the stream. The absence of gravel in many sections is a decided detriment to spawning as the fish inhabiting those areas must either migrate or fail to spawn successfully. The types of bottom for the various sections are summarized in Table 3.

Pools. Probably the most undesirable physical condition existing in the main Logan River from the point of view of fisheries is the almost complete absence of good pools. The Logan has but one or two good pools per mile, while the Blacksmith Fork stream has 40 to 50. As already mentioned the absence is a natural result of a steep gradient and a flow of high velocity. The general pool condition is summarized in Table 3, with explanations.

Riffles. The extensive areas of riffles make feeding places abundant and of high quality. The summary of riffles given in Table 3, although rather vague, gives a picture of the general conditions for each section.

Table 3.- Showing the physical features:- types of bottom, pools, shade, color and turbidity.

| Section No. | Types of Bottom | Shade* | Riffles | Color and Turbidity | Pools** |
|---|---|---|---|---|---|
| 1 | Rubble | B | Continuous | White - Clear | S2 T2 F3 |
| 2 | State Dam | C | | | |
| 3 | Boulders and Rubble | B | Short-Deep | White - Clear | S2 T2 F1 |
| 4 | Gravel and Boulders | B | Long-Shallow | " " | S2 T3 F2 |

*Shade: Dense - A, Partially Shaded - B, Open - C

**Pools: Size - S, Type - T, Frequency - F; Good - 1, Fair - 2, Poor - 3

Table 3.- Continued

| Section No. | Types of Bottom | Shade* | Riffles | Color and Turbidity | Pools** |
|---|---|---|---|---|---|
| 5 | Logan City Dam | C | | | |
| 6 | Rubble to large gravel | A | Long-Deep | White-Clear | S2 T3 F2 |
| 7 | Rubble to gravel | B | Short-Deep | White-Clear | S3 T2 F2 |
| 8 | Boulders to rubble | B | Long-Deep | White-Clear | S3 T3 F3 |
| 9 | Rubble to boulders | B | Long - shallow | White-Clear | S3 T3 F3 |
| 10 | Rubble to boulders | A | Long - shallow | White-Clear | S3 T2 F3 |
| 11 | Rubble to boulders | B | Long-Deep | White-Clear | S2 T2 F1 |
| Tributaries | | | | | |
| Spring Hollow Creek | Rubble to gravel | A | Torrential | White-Clear | S2 T2 F2 |
| Right Fork | Sand to gravel | A | Short - shallow | White-Clear | S2 T1 F1 |
| Temple Fork | Boulders to gravel | A | Long - shallow | White-Clear | S2 T2 F1 |
| Spawn Creek | Gravel to rubble | B | Long - shallow | White-Clear | S3 T2 F2 |
| White Pine Creek | Gravel to rubble | A | Short-Deep | White-Clear | S2 T1 F2 |
| Beaver Creek | Fine gravel to boulders | A | Long - shallow | White-Clear | S2 T1 F2 |

Shade. Shade and cover in the Logan River are generally good. (see Table 3.) In many of the sections it is very dense and affords an excellent hide-out for fish. Those plants along the banks and the brush-falls in the water should be carefully guarded.

Color and Turbidity. The water of the Logan River is invariably white in color and throughout the summer, even during and after rains, it is clear and free from silt and sand. Only during the heavy run-off is there a noticeable amount of turbidity.

Temperature. The water is comparatively cold the year round. Since the major source is from springs during summer and fall and the velocity of the stream is high with an abundance of shade, water temperatures far down the canyon stay rather low. The maximum temperature during June and July for the Logan and its tributaries was 61°F. The minimum for that period was 43°F. with an average of 52°F. The maximum air temperature for this period was 80°F. and the minimum 49°F. with an average of 66°F. The temperatures at the various stations along with dates, hours, and condition of the sky are given in Table 4.

Certain knowledge concerning development and growth of fishes in relation to temperatures has been available for a long time. Likewise, the knowledge that certain species of fish are suited to live in cold water while others do well in warmer water. Outside of the tributaries and portions of the main stream where considerable water comes directly from springs (43° - 45°F.) the water in the Logan is suitable for several species of trout. The lower portion including Sections 1 - 6 is more suitable for brown trout, while above this point the native cutthroat is highly recommended.

Table 4. - Air and water temperatures at various stations on the Logan River and its tributaries.

| Section No. | Station | Date 1934 | Hour | Sky | Temperature °F. Air | Water |
|---|---|---|---|---|---|---|
| | Lower | June 3 | 9:00 AM | Partly Cloudy | 61 | 53 |
| 1 | Middle | | | | | |
| | Upper | | 10:00 AM | Partly Cloudy | 64 | 51 |
| 2 | State Dam. | | | | | |
| | Lower | June 5 | 8:30 AM | Cloudy | 62 | 49 |
| 3 | Middle | June 5 | 9:05 AM | Cloudy | 64 | 52 |
| | Upper | June 5 | 10:30 AM | Cloudy | 65 | 51 |
| | Lower | June 5 | 2:30 PM | Cloudy | 72 | 51 |
| 4 | Middle | June 5 | 3:45 PM | Cloudy | 69 | 52 |
| | Upper | June 5 | 4:30 PM | Cloudy | 67 | 60 |
| 5 | Logan City Dam. | | | | | |
| | Lower | June 7 | 9:00 AM | Cloudy-rain | 49 | 47 |
| 6 | Middle | June 7 | 1:15 PM | Cloudy-rain | 52 | 47 |
| | Upper | June 7 | 2:30 PM | Cloudy-rain | 49 | 47 |
| 7 | Lower | June 9 | 11:30 AM | Bright-clear | 61 | 51 |
| | Upper | June 9 | 9:15 AM | Bright-clear | 63 | 49 |
| | Lower | June 10 | 11:30 AM | Bright-clear | 72 | 52 |
| 8 | Middle | June 10 | 5:00 PM | Bright-clear | 66 | 61 |
| | Upper | June 10 | 3:30 PM | Bright-clear | 74 | 61 |

Table 4.- Continued

| Section No. | Station | Date 1934 | Hour | Sky | Temperature Air °F. | Water °F. |
|---|---|---|---|---|---|---|
| | Lower | June 14 | 4:00 PM | Cloudy | 66 | 55 |
| 9 | Middle | June 14 | 3:45 PM | Cloudy | 66 | 55 |
| | Upper | June 14 | 3:00 PM | Showers | 63.5 | 54 |
| 10 | Upper | July 6 | 10:00 AM | Bright-clear | 69 | 45 |
| | Lower | July 9 | 1:30 PM | Bright-clear | 69 | 55 |
| 11 | Middle | July 9 | 9:00 AM | Bright-clear | 66 | 44 |
| | Upper | July 9 | 11:25 AM | Bright-clear | 73 | 43 |
| Tributaries | | | | | | |
| Spring Hollow Creek | Lower | June 6 | 9:00 AM | Cloudy-rain | 50 | 44 |
| | Lower | June 10 | 10:00 AM | Bright-clear | 63 | 48 |
| Right Fork | Middle | June 10 | | | | |
| | Upper | June 10 | 1:00 PM | Bright-clear | 69 | 51 |
| | Lower | June 13 | 10:00 AM | Bright-clear | 68 | 48.5 |
| Temple Fork | Middle | June 13 | 1:30 PM | Bright-clear | 80 | 64 |
| | Upper | June 13 | 5:00 PM | Bright-clear | 74 | 44 |
| Spawn Creek | Middle | June 13 | 2:30 PM | Partly Cloudy | 80 | 60 |
| White Pine Creek | Lower | July 6 | 3:30 PM | Bright-clear | 72 | 56 |
| | Upper | July 6 | 7:00 PM | Bright-clear | 60 | 50 |
| | Lower | July 8 | 2:30 PM | Bright-clear | 72 | 58 |
| Beaver Creek | Middle | July 8 | 12:15 PM | Bright-clear | 75 | 60 |
| | Upper | July 8 | 10:30 PM | Bright-clear | 67 | 50 |

## Chemical Characteristics

Hydrogen Ion Concentration. As already mentioned the water in the Logan River drainage is consistently alkaline. The variation is small, being from 8.2 to 8.4 pH. The exact significance of pH on biological productivity is still much debated. It is known, however, that ordinarily plants and animal species are more abundant in waters with a high pH value. Table 5 gives a summary of the pH values for the various sections of the main river and its tributaries.

Carbon dioxide. Except for certain springs, the water of the Logan River is characterized by the complete absence of carbon dioxide.

Oxygen. Water running over stones at a high velocity will invariably contain a liberal amount of dissolved oxygen, especially if the temperature is low. In the Logan River the oxygen range was between 7.2 and 9.2 parts per million. In the tributaries it ranged from 8.4 to 9.1 p.p.m.

Phenolphthalein and Methyl Orange Alkalinity. The phenolpthalein alkalinity in parts per million of calcium carbonate ranges from 8 to 14 for the entire river system. Methyl orange representing hydroxides, normal carbonates and bicarbonates, ranges from 148 to 212 p.p.m. for the same samples.

These analyses are given in more detail in Table 5.

Table 5.- Summary of chemical conditions for Logan River and its tributaries

| Region of Stream | Date 1934 Hour | Temperature Degrees F. Air | Water | Sample Depth | pH | $CO_2$ ppm | $O_2$ ppm | phth. alk. ppm. | M O Alk ppm. |
|---|---|---|---|---|---|---|---|---|---|
| Sect. 4 | 2:30 PM June 5 Cloudy | 72 | 51 | Surface | 8.2 | 0.0 | 9.2 | 12 | 151 |
| Sect. 6 | 1:15 PM June 7 Cloudy | 52 | 47 | Surface | 8.4 | 0.0 | 9.3 | 10 | 163 |
| Sect. 8 | 3:30 PM June 10 Clear | 74 | 61 | Surface | 8.2 | 0.0 | 7.2 | 11 | 155 |
| Sect. 9 | 3:00 PM Bright June 14 | 63 | 54 | Surface | 8.2 | 0.0 | 7.8 | 14 | 151 |
| Sect. 11 | 1:30 PM Bright July 7 | 69 | 55 | Surface | 8.4 | 0.0 | 8.4 | 8 | 148 |
| Tributaries | | | | | | | | | |
| Right Fk. | 10:30 AM Bright June 9 | 63 | 48 | Surface | 8.4 | 0.0 | 8.9 | 12 | 212 |
| Temple Fork | 9:30 AM Bright June 13 | 68 | 48.5 | Surface | 8.4 | 0.0 | 9.1 | 11 | 160 |
| White Pine Cr. | 3:30 AM Bright July 7 | 72 | 58 | Surface | 8.4 | 0.0 | 8.0 | 8 | 150 |
| Beaver Creek | 2:30 PM Bright July 7 | 72 | 58 | Surface | 8.4 | 0.0 | 8.4 | 12 | 194 |

## Biological Characteristics

Plants. In only a few places on the Logan River are higher plants capable of maintaining themselves due to the vigorous physical conditions resulting from molar agents and the high velocity of the water. Watercress, one of the best harboring plants for insect foods in streams, is comparatively rare throughout the main river. The most luxuriant growths occurred in the Right Fork tributary. Moss is relatively common in the upper reaches of the main river and the tributaries.

Algae is common to abundant throughout the whole river.

It is hardly necessary to point out the importance of plants in trout streams. They are fundamental food of aquatic insects which, in turn, are of the greatest importance as food for fish.

Animals. There are only six species of fish commonly found in that part of the Logan River studied. Three of these are native to the stream and the other three introduced artificially. The first group contains the bullhead or sculpin Cottus semiscaber, whitefish, Prosopium williamsoni, and the native cutthroat trout, Salmo utah. Those of the latter are the brown trout, Salmo fario, the rainbow trout, Salmo shasta, and the eastern brook trout, Salvelinus fontinalis. Due to inadequate stocking records little can be learned about their distribution throughout the stream. The majority of brown trout are located below Card Canyon. Those in best condition are found in the dams and adjacent waters.

All specimens observed above Section 5 were in rather poor condition, i.e., thin and small. The rainbows are found throughout the entire system. Those observed in the headwaters and distant tributaries were small, indicating possible winter-killing or slow growth due to low temperatures. Brook trout were observed only in Right Fork. These were small, but in good condition. The native cutthroat was abundant in Temple Fork, lower White Pine Creek, Beaver Creek, and the upper Logan River generally. Although cutthroats have never been stocked in these waters they are the predominant species in many places.

The whitefish is most abundant in the first five sections, including the dams, but can be found in the main river up as far as Steam Mill Creek. The sculpin, although seen and collected on several occasions, is not abundant.

Fish Food Organisms. In spite of recent advances made in sampling devices, there still remains no reliable quantitative method for measuring available food organisms. Bottom samples represented in Table 6. give the total number of organisms for each species found per one, two or three square feet of bottom. This data affords a comparative measure of the various streams and stream sections. The probably correct assumption is that where large quantities are present, large quantities will be available. Even if this last assumption is correct, we still have no knowledge of relative food values of the various species.

The following table (Table 6) represents qualitatively and quantitatively the organisms found in sections of the Logan River and its tributaries. Superficial studies of fish caught from all the stream sections,

indicate an abundance of available food. According to our present knowledge this stream would be rated as unusually good in number and kind of food organisms.

Table 6.- Numbers of animals per square foot sample of bottom in the main Logan River and its tributaries

| Section No. | Sq. Ft. | Date, 1934 | Caddisflies | Mayflies | Stoneflies | Midge larvae | Other Diptera | Oligochaeta | Leeches | Snails | Pisidium | Hydrachnida | Nematoda | Coleoptera | Turbellaria |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 6/3 | 809 | 396 | 8 | - | 503 | 27 | 4 | 4 | - | - | - | - | |
| 2 | State Dam | | | | | | | | | | | | | | |
| 3 | 3 | 6/5 | 273 | 546 | - | - | 2340 | - | - | 3 | - | - | - | - | |
| 4 | 3 | 6/5 | 1035 | 413 | 6 | - | 1020 | 3422 | - | 2 | 3420 | - | - | 2 | |
| 5 | Logan City Dam | | | | | | | | | | | | | | |
| 6 | 3 | 6/7 | 257 | 523 | 23 | - | 214 | 17 | - | - | 4 | - | - | 22 | |
| 7 | 2 | 6/9 | 335 | 192 | 31 | - | 16 | - | - | 1 | - | - | - | - | |
| 8 | 3 | 6/10 | 608 | 512 | 21 | - | 75 | - | - | 3 | - | - | 1 | 2 | |
| 9 | 3 | 6/14 | 619 | 1143 | 5 | - | 62 | 5 | - | - | - | - | - | 10 | |
| 10 | 2 | 7/6 | 59 | 486 | 12 | 26 | 2 | - | - | - | - | - | - | 50 | |
| 11 | 3 | 7/9 | 50 | 335 | 1 | 65 | 8 | - | - | 1 | - | - | - | 3 | 25 |
| Tributaries | | | | | | | | | | | | | | | |
| Spring Hollow Creek | No food sample taken. | | | | | | | | | | | | | | |
| Right Fork | 2 | 6/10 | 160 | 57 | 26 | - | 16 | 1 | - | 1 | - | - | - | - | 1 |
| Temple Fork | 3 | 6/13 | 685 | 645 | 32 | - | 175 | 5 | - | 5 | - | - | - | - | 12 |
| Spawn Creek | 1 | 6/13 | 50 | 235 | 30 | - | 5 | 5 | 5 | 5 | - | - | - | - | 20 |
| White Pine Creek | 1 | 7/6 | 97 | 70 | 5 | 16 | 5 | - | - | - | - | 1 | - | 17 | 9 |
| Beaver Creek | 3 | 7/8 | 67 | 458 | 18 | - | 38 | 4 | - | - | 10 | 7 | - | 246 | 35 |

## Improvements

There is great need for physical improvements on the Logan River. Materials with the exception of large timber are present in situ thus making labor the only major expense item. Since the completion of this survey, certain improvements in the form of dams and deflectors have been made between the upper and middle stations of Section 9 by the CCC camp under the supervision of the Bureau of Fisheries. These devices, as already evident, have made great improvement in this short section.

Table 7 is a summary of the major physical improvements suggested for the Logan River.

Table 7.- General summary of improvement recommendations

| Section Number | Number of devices, (dams, deflectors, etc.) recommended | Rearing Pools | Removal of Barriers | Screening of Diversions |
|---|---|---|---|---|
| 1 | 20 - 30 distributed over 1¼ mile of section. | - | - | 1. Diversion to flour mill east of Crockett Ave. 2. Small irrigation canal ¼ mi. below State Dam. 3. Benson Ward canal. |
| 2 | State Dam. | - | - | Inlet to pipe-line. |
| 3 | 25 distributed over 2 miles. | - | - | Smithfield High-line Canal. |
| 4 | 25 distributed over 2 miles of section. | - | - | - |
| 5 | Logan City Dam. | - | - | Inlet to pipe-line. |
| 6 | 200 or more distributed over 6 miles of section. | 1. Logan City springs. 2. Old Fish Hatchery Spring | - | - |
| 7 | 25 - 50 distributed over 2 miles of section. | - | - | - |
| 8 | 200 or more distributed over 6 miles of section. | - | - | - |
| 9 | 150 or more distributed over 4 miles of section. | - | - | - |
| 10 | 50 or more distributed over 2.5 miles of section. | Rearing pool at mouth of White Pine Cr. | - | - |
| 11 | 75 or more distributed over 3½ miles of section. | - | 2 brush barriers just below Peterson Hollow. | - |

Table 7.- Continued

| Tributaries | Number of devices, (dams, deflectors, etc.) recommended | Rearing Pools | Removal of Barriers | Screening of Diversions |
|---|---|---|---|---|
| Spring Hollow Creek | Gradient too great for improvement | Rearing pool in Hollow - 500 ft. above mouth | - | - |
| Right Fork | - | Rearing pool below spring in mouth of Rick's | - | - |
| Temple Fork | 75 - 100 from mouth to forks at big spring | - | - | - |
| White Pine Creek | Building of 10 dams in section from mouth up ½ mi. and the construction of a large dam in outlet of White Pine Lake | - | Barriers in middle section of stream | - |
| Beaver Creek | 200 or more distributed over the tributary | Rearing pool 200 yds. above mouth of creek | Brush barriers between mouth of stream and point where U2 Highway leaves creek | - |

## Artificial Lakes

Fishing in the Logan River is very much enhanced by the presence of two power dams. These partially offset the damage done by the removal of all the water from the region of the lower river, potentially the most productive section of the whole stream. The lower one, State Dam, situated in the mouth of Logan canyon is 45 ft. high and produces an artificial lake of about 4 acres. It is situated directly across the Logan River and receives from 100 to 200 c.f.s. of water at the inlet. The shoreline and basin are fairly regular, the deepest point (18 ft.) being about in the center of the lake. At 8:30 A.M., June 4, 1934, the temperature at the inlet was 51°F. The bottom is covered with a rich layer of silt and mud and around the shallower areas there is an abundance of Algae. Higher plants are not abundant although common in a few places. There was no measurable amount of gross plankton, but a bottom sample of one square foot produced 168 midges and 12,500 Tubificidae. The fish from this lake were in excellent condition. A 15-hour gill-net haul produced four rainbow, five browns and five whitefish.

The upper dam (Logan City) is quite similar to the State Dam. It is 25 feet high and produces a lake of about three acres. The main river was carrying about 150 c.f.s. and Spring Hollow Creek contributed 5 c.f.s. at 44°F. During the heavy run-off a considerable quantity of silt and sand is carried in and deposited. The maximum depth is 17 feet, and is situated in the center of the lake 500 feet above the dam. The basin is regular but the shoal areas are concentrated at the upper end. These were covered with buttercup and water cress as well as quantities of Spirogyra. The temperature on June 6, 1934 at 8:00 A.M. was 48.2°F. from top to bottom and the Secchi disc could be seen at 13 feet. There was no visible plankton, but a square foot of bottom produced 18 midges, 7 Pisidium, and 21,920 Tubificidae.

From observation of fishermen's catches, rainbows and brown trout seemed to be most abundant, with a considerable number of whitefish and a few native cutthroat.

## Stocking Recommendations

According to Mr. Lawrence Johnson of the Logan Hatchery, over 1,000,000 rainbow and approximately 200,000 brown trout have been planted in the main Logan River and its tributaries during the past three years. Unfortunately no detailed stocking records were kept and as a result no fish census study could be made for the various sections.

All sizes recommended in the following table are purely on the basis of those most available when distributed from the hatcheries. Where rearing pools are available or can be constructed along the stream, as in the case of the Logan, it is highly advisable to hold fish until they are at least 6 inches long. For sizes other than those listed, the conversion table should be used.

Brown trout are recommended for the lower Logan River including the dams, as far up as Card Canyon (Table 8). Fish of this species taken above Bierdneau Hollow were not in good condition. On the other hand, those caught from the dams and the adjacent stream were in especially good condition.

Rainbow trout are recommended between Card Canyon and Right Fork. These might be extended as far up as Temple Fork although it is our opinion that cutthroat would be a better fish for the section due to their greater adaptability to colder temperatures and water with high velocity. Under no condition should rainbow and cutthroat be planted together unless they are of legal size for immediate catching. Cutthroat trout are recommended for all the tributaries and the main river above Right Fork. For a detailed treatment of this program see Table 8 and for conversion of sizes see Table A.

Table 8.- Tentative stocking recommendations for the Logan River and its tributaries

| Stream Section | Aver. Width in ft. | Length to be Stocked | Exact Location | Food Grade | Pool Grade | Species Recommended | Size in in. | Number of Trout | Frequency |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 39 | 1.2 mi. | Between dam east of Crocket Ave. and State Dam. | 1 | C | Brown | 3 | 4,400 | Yearly |
| 3 | 40 | 0.5 " | Between Smithfield Highline Canal diversion and Utah P & L Dam. | 1 | B | Brown | 3 | 2,350 | " |
| 4 | 50 | 0.25 " | Between Utah Power & Light Dam and Logan City power plant. | 1 | B | Brown | 3 | 1,400 | " |
| 6 | 48 | 6.0 " | Between Logan City Dam and Card Canyon | 2 | B- | Brown or Rainbow | 3 | 26,000 | " |
| 7 | 52 | 2.0 " | Between Card Canyon and Right Fork | 2- | B- | Rainbow | 2 | 13,600 | " |
| 8 | 42 | 6.2 " | Between Right Fork and Temple Fork | 2 | C | Cut-throat | 1½ | 49,500 | " |
| 9 | 40 | 4.5 " | Between Temple Fork and Tony Grove Creek | 1 | C | Cut-throat | 1½ | 47,500 | " |
| 10 | 31 | 2.5 " | Between Tony Grove Cr. and mouth of Beaver | 2- | C | Cut-throat | 1½ | 14,600 | " |
| 11 | 20 | 3.5 " | Between mouth of Beaver Cr. and Peterson Hollow | 3 | B | Cut-throat | 1½ | 13,200 | " |
| Tributaries: | | | | | | | | | |
| Spring Hollow Cr. | 9 | 0.5 " | Between mouth and Lodge. | 2 | B | Cut-throat | 1½ | 1,200 | " |
| Right Fork | 10 | 6.0 " | Between mouth and Rick's canyon | 3 | A | Cut-throat | 1½ | 16,200 | " |
| Temple Fork | 14 | 6.0 " | Between mouth and Saw Mill Site at Fk. | 2 | B | Cut-throat | 1½ | 22,350 | " |
| Spawn Creek | 8 | 2.0 " | Upstream from mouth two miles | 2 | C | Cut-throat | 1½ | 3,000 | " |

Table 8.- Continued

| Tributaries | Aver. Width in ft. | Length to be Stocked | Exact Location | Food Grade | Pool Grade | Species Recommended | Size in inches | Number of Trout | Frequency |
|---|---|---|---|---|---|---|---|---|---|
| White Pine Creek | 10 | 0.5 mi.<br>1.0 | From mouth upstream 0.5 mi.<br>Down from Forks 1 mi. | 2 | B | Cut-throat | 1½ | 4,050 | Yearly |
| Beaver Creek | 9 | 10.0 " | Between mouth and upper saw-mill div. | 3 | B | Cut-throat | 1½ | 17,000 | " |

| Dam | Acres | Food Grade | Estimated length of growing season in months | Species Recommended. | Number of 3-inch trout | Frequency |
|---|---|---|---|---|---|---|
| State Dam | 3.0 | 1 | 7 | Brown | 1,500 | Yearly |
| Logan City Dam | 4.0 | 1 | 7 | Brown | 1,500 | Yearly |

The total number of fish recommended for the annual stocking of the main Logan River and its tributaries are as follows:

| | | |
|---|---|---|
| Brown trout | - 3 inch - | 37,150 |
| Rainbow Trout | - 2 inch | 13,600 |
| Cutthroat trout | - 1½ " | 188,600 |
| Grand Total | | 239,350 |

These totals do not allow for any fish arising by natural propagation. We are of the belief, however, that the intensity of fishing on this drainage compensates for any natural propagation. As already stated, the stocking recommendation above includes fish of the smaller sizes. Were it possible to plant larger sized fish these numbers would be very much reduced. For example, if six-inch fish were planted in place of those given above, the totals would be as follows:

| | | |
|---|---|---|
| Brown trout | - 6 inch | 22,290 |
| Rainbow trout | - 6 inch | 4,800 |
| Cutthroat trout | - 6 inch | 39,125 |
| Grand Total | | 66,215 |

This last total represents the number of fish which actually survive and shows the economy of planting larger sized fish in preference to those found in the foregoing table. However, where rearing pools are not available, the smaller size must be resorted to.

## BLACKSMITH FORK RIVER (Fig. 1)

### General Description

The Blacksmith Fork is the largest tributary of the Logan River drainage. Its main course is a little north of west and it drains about 250 square miles. Only a small part of this is on the Cache National Forest, the remainder being private property. The surrounding country is essentially the same as that already described except for the much reduced altitude and gradient. Like the Logan, the source of water is from melting snow and springs. Not a single lake persists in this drainage.

Practically all of the water is utilized for power and irrigation purposes and the lower part of the river is often dry in early Summer. With the exception of the tributaries this stream can be reached by fair mountain roads and offers unusual opportunity to fishermen.

The Blacksmith Fork was divided into five sections beginning at the Utah Power and Light Company dam and each of these contains three stations. Below this point all the water was diverted from the river for power and irrigation. The five tributaries were treated as supplements to these sections. Table 9 gives a brief description of the sections and stations in the main Blacksmith Fork and its tributaries.

Table 9.- Description of sections and stations on Blacksmith Fork and its tributaries

| Section Number | Length | Location | Stations Lower | Middle | Upper |
|---|---|---|---|---|---|
| 1 | Utah Power and Light Company Dam. | | | | |
| 2 | 4 mi. | Between U.P.& L.Co. Dam lake and Hyrum City Dam | 0.5 mi.above U.P.&L. Dam | 0.5 mi. below mouth of left fork | 0.5 mi. below Hyrum City Dam |
| 3 | Hyrum City Dam | | | | |
| 4 | 6.7 mi. | Between Hyrum City Dam-lake and mouth of Curtis Creek | 1.1 mi. above Hyrum City Dam-lake | 3.6 mi. below mouth of Curtis Creek | 0.3 mi. below mouth of Curtis Creek |
| 5 | 6.0 mi. | Curtis Creek to end of main river | 0.5 mi. south of Hardware ranch | 200 yds. below mouth of Sheep Creek | 200 yds. below big spring in Mollen's Hollow |
| Tributaries: | | | | | |
| Left Fk. | 10.0 mi. | Supplement to Section 2 | 0.5 mi. above mouth | 5.5 mi. above mouth | 9.1 mi. above mouth |
| Rock Creek | 6.0 mi. | Supplement to Section 4 | 100 yds. above mouth | 1.5 mi. above mouth | 1.2 mi. above Bear Lake Road |
| Curtis Creek | 6.5 mi. | Supplement to Section 4 | 100 yds. east of Bear Lake Road | 3 mi. east of Bear Lake Road | Store Hollow |
| Mill Creek | 0.7 mi. | Supplement to Section 5 | 300 yds. above mouth | - | - |
| Sheep Creek | 7.5 mi. | Supplement to Section 5 | 0.5 mi.above mouth | Mouth of Hay's Canyon | 1 mi. below source |

## Physical Characteristics

Gradient. In the main Blacksmith Fork the average gradient is about 86 feet per mile. This, however, does not give a true picture of the gradient conditions of the lower river. From the mouth of the canyon to the Mill Creek tributary the gradient varies between 35 and 45 feet per mile. This part of the river is an ideal trout stream. The upper section,however, is very much terraced and steep. Enormous quantities of travertine form shelves varying from three to forty feet in height. Many of these create falls which are barriers to fish. There are apparently no fish in the stream above the falls in Mollen's Hollow. The gradient over this four miles increases the average to a point beyond that of the Logan while actually it is very much less over the major part of the river.

The average gradient for the tributaries is less than for those of the Logan. Almost all of these offer unusual spawning areas and carry large numbers of trout. Table 10 gives a summary of the gradients for the sections of the main river and its tributaries.

As contrasted with the Logan River, the Blacksmith Fork has almost perfect physical conditions with respect to gradient and pools.

Widths and Depths. The Blacksmith Fork is relatively narrow and deep throughout its course. Its average width is 23.7 feet and depth 0.72 feet, while the average width and depth on the Logan River are 37.8 feet and 0.74 feet respectively. In a comparison of the depths it is necessary to take into consideration the places chosen for stations. In almost every instance typical riffles were selected. Had pools been included in these average measurements the Blacksmith Fork would have shown a much greater average depth than the Logan River.

Table 10.- Average widths, depths, volumes and velocities for sections of the Blacksmith Fork and its tributaries

| Section Number | Length in Miles | Aver. Width in ft. | Aver. Depth in ft. | Ave. Velocity in ft./sec. | Ave. Volume in c.f.s. | Gradient in feet per mile |
|---|---|---|---|---|---|---|
| 1 | Utah Power and Light Co. Dam | | | | | |
| 2 | 4.0 | 28.5 | 0.73 | 1.89 | 27.7 | 37.5 |
| 3 | Hyrum City Dam | | | | | |
| 4 | 6.7 | 21.8 | 0.81 | 2.70 | 45.2 | 41 |
| 5 | 6.0 | 21.0 | 0.62 | 2.99 | 30.9 | 180 |
| Tributaries: | | | | | | |
| Left Fork | 10.0 | 13.1 | 0.73 | 1.89 | 7.56 | 100 |
| Rock Creek | 6.0 | 9.2 | 0.24 | 0.92 | 1.68 | 200 |
| Curtis Creek | 6.5 | 9.64 | 0.29 | 1.70 | 3.98 | 175 |
| Mill Creek | 0.7 | 9.0 | 0.26 | 1.10 | 2.0 | 50 |
| Sheep Creek | 7.5 | 7.5 | 0.25 | 1.70 | 2.7 | 207 |

Volume and Velocity. The average volume throughout the Blacksmith Fork was 34.6 cubic feet per second. This, however, represents a very low water year. According to Dr. Clyde, the normal average in the lower canyon for the same period is 880 cubic feet per second, the maximum is 1800 cubic feet per second, and the minimum, not including this year, is 40 cubic feet per second. The major part of this volume comes from the headwaters of the main stream. The tributaries were contributing less than one-fourth the total volume. Average volumes for the sections and tributaries are given in Table 10.

The average velocity of 2.52 feet per second is not much less than the average velocity for the Logan River. This, however, must again be considered in connection with the selection of stations. On the Logan, the stream is almost a continuous riffle, while on the Blacksmith Fork there are many deep pools. Had the pooled areas been included in this average, it would have been much lower than the present figure. Average velocities for the Blacksmith Fork drainage are given in Table 10.

Types of Bottom. Bottom conditions of the Blacksmith Fork are very favorable for spawning as well as for good feeding grounds. They vary from rubble to sand with the majority of rubble and gravel (Table 11). A certain amount of silting occurs after heavy rains. This is primarily due to extreme overgrazing throughout the major part of the drainage. As yet this silting has showed no very serious effects but if continued will not only ruin many of the spawning areas and feeding grounds but be a constant hazard to the fish themselves.

Pools. There are an unusually large number of good pools in the main river. Counts showed an average of 40 - 50 per mile in sections 2 and 4. Even the tributaries have better than average pools. A summary is given in Table 11.

Riffles. In the main river the riffles are comparatively short and deep. They are, however, well situated and frequent enough to make good feeding grounds. The tributaries have long, shallow riffles. This last condition is partly due to the unusual low-water conditions.

Table 11.- Summary of types of bottom, pools, riffles, shade, and turbidity for the Blacksmith Fork Drainage.

| Section No. | Types of Bottom | Pools | Riffles | Shade | Color and Turbidity |
|---|---|---|---|---|---|
| 1 | Utah Power and Light Company Dam | | | | |
| 2 | Rubble to sand | S1 T1 F1 | Short-deep | A | White - clear |
| 3 | Hyrum City Dam | | | | |
| 4 | Rubble to gravel | S1 T1 F1 | Long-deep | B | White-clear |
| 5 | Gravel to sand | S1 T1 F1 | Long-deep | B | White-clear Slightly turbid |
| Tributaries: | | | | | |
| Left Fork | Rubble to fine gravel | S2 T1 F2 | Long-shallow | A | White-clear |
| Rock Creek | Rubble - gravel sand | S2 T1 F1 | Long-shallow | A | White-clear |
| Curtis Creek | Rubble to gravel | S2 T2 F1 | Long-shallow | A | White-clear |
| Mill Creek | Rubble to sand and silt | S2 T1 F1 | Long-shallow | A | White-clear |
| Sheep Creek | Gravel to silt | S2 T2 F1 | Long-shallow | A | White-clear Turbid after rain |

Shade. The river proper is fairly well shaded, Recent observations, however, show that private land owners are removing the trees and brush and burning the debris in order to produce more grazing land. Other areas show overgrazing to the extent of serious danger. The tributaries on the other hand are densely shaded.

Color and Turbidity. Like all the Logan Drainage, the water of the Blacksmith Fork is white in color. It is very turbid after heavy rains. Following a continuous rain of four hours, the main river remained very turbid for four days and slightly turbid for ten days. Even the water in the dams was roily. The causes of turbidity have already been mentioned above.

Temperature. Temperature studies made between July 14 and July 21 show an average water temperature of 51.1°F. for the main river, with a maximum of 63°F. and a minimum of 46°F. The air temperature averaged 78.4°F. with a maximum of 89°F. and a minimum of 61°F. for the same period.

The average temperatures for each section as well as those for the tributaries are given in Table 12.

Table 12.- Air and water temperatures taken on the Blacksmith Fork and its tributaries

| Section Number | Station | Date 1934 | Time of Day | Sky | Air Temp. °F. | Water Temp. °F. |
|---|---|---|---|---|---|---|
| 1 | Utah Power and Light Company Dam | | | | | |
| 2 | Lower | 7/14 | 9:00 AM | Partly cloudy | 72 | 58 |
| | Middle | 7/14 | 11:00 AM | Bright-clear | 86 | 63 |
| | Upper | 7/12 | 12:00 noon | Bright-clear | 88 | 59 |
| 3 | Hyrum City Dam | | | | | |
| | Lower | 7/17 | 9:00 AM | Bright-clear | 69 | 50 |
| 4 | Middle | 7/17 | 10:30 AM | Bright-clear | 82 | 52 |
| | Upper | 7/17 | 3:00 PM | Bright-clear | 89 | 62 |
| | Lower | 7/19 | 5:30 PM | Rain | 61 | 59 |
| 5 | Middle | 7/19 | 3:30 PM | Cloudy | 83 | 56 |
| | Upper | 7/19 | 10:30 AM | Bright-clear | 76 | 46 |
| Tributaries: | | | | | | |
| Left Fork | Lower | 7/13 | 7:00 PM | Bright-clear | 73 | 64 |
| | Middle | 7/13 | 6:00 PM | Bright-clear | 85 | 63 |
| | Upper | 7/13 | 5:00 PM | Bright-clear | 81 | 58 |
| Rock Creek | Lower | 7/18 | 8:00 AM | Cloudy | 64 | 55 |
| | Middle | 7/18 | 10:15 AM | Cloudy | 70 | 59 |
| | Upper | 7/18 | 6:00 PM | Bright-clear | 82 | 53 |
| Curtis Creek | Lower | 7/18 | 2:15 PM | Cloudy | 88 | 60 |
| | Middle | 7/18 | 3:30 PM | Bright-clear | 86 | 55 |
| | Upper | 7/18 | 7:00 PM | Bright-clear | 69 | 49 |
| Mill Creek | Lower | 7/20 | 9:30 AM | Partly cloudy | 76 | 52 |
| Sheep Creek | Lower | 7/21 | 9:00 AM | Rain | 68 | 59 |
| | Middle | 7/22 | 11:30 AM | Cloudy | 77 | 54 |
| | Upper | 7/21 | 2:00 PM | Rain | 63 | 43.5 |

## Chemical Characteristics

pH - Carbon-dioxide - Oxygen - Alkalinity. The amount of variation in pH in the Blacksmith Fork is exactly the same as that for the Logan River (8.2 - 8.4 ).

Carbon-dioxide was found to be present in Mill Creek and nowhere else in this river. Its abundance was not great, however, being 3.86 p.p.m.

Oxygen was found in abundance, with a minimum of 6.4 p.p.m. and a maximum of 9.6 p.p.m.

Phenolphthalein alkalinity varied from 8 to 18 p.p.m. while the methyl orange alkalinity ranged from 173 to 215 p.p.m. with an average of 190 p.p.m. This last figure is unusually high. Huge deposits of travertine are found in various places on the system, especially in Section 5 and the Sheep Creek tributary. Analyses are given in more detail in Table 13.

Table 13.- Summary of chemical characteristics for Blacksmith Fork Drainage

| Region of Stream | Hour | Date 1934 | Temperature in °F. Air | Water | Depth | pH | $CO_2$ ppm* | $O_2$ ppm* | Phth. Alk. ppm* | MO Alk. ppm* |
|---|---|---|---|---|---|---|---|---|---|---|
| 50 yds. above mouth of Sheep Creek, Sect.5 | 4:15 PM | 7/19 | 83 | 54 | Surf. | 8.2 | 0.0 | 8.1 | 8.0 | 205 |
| Tributaries: | | | | | | | | | | |
| Left Fork | 7:00 PM | 7/13 | 73 | 64.5 | Surf. | 8.2 | 0.0 | 6.8 | 12.0 | 178 |
| Rock Creek | 9:00 AM | 7/18 | 64 | 55 | Surf. | 8.4 | 0.0 | 8.2 | 12.0 | 178 |
| Curtis Creek | 10:30 AM | 7/19 | 78 | 54 | Surf. | 8.4 | 0.0 | 9.6 | 18.0 | 186 |
| Mill Creek | 9:00 AM | 7/20 | 76 | 52 | Surf. | 8.2 | 3.8 | 8.4 | 0.0 | 215 |
| Sheep Creek | 4:00 PM | 7/20 | 83 | 70 | Surf. | 8.4 | 0.0 | 6.4 | 10.0 | 173 |

* Parts per million.

## Biological Characteristics

Plants. The higher plants are comparatively abundant throughout this river system. Water-cress and buttercups predominate, occurring to a greater or less degree in all sections and tributaries. Mill Creek is especially productive in the higher plants. Mosses and liverworts are common and algae are abundant.

Animals. The species of fish occurring in the Blacksmith Fork Drainage are the same as those described for the Logan River. Generally speaking, all species are more abundant in the Blacksmith Fork. The whitefish is extremely common. Various pool counts showed as many as 25 and no pool investigated below Anderson's Ranch was barren of this species. Both brown and rainbow trout were in excellent condition. There are only a few native cutthroat trout in the main stream below the Hardware Ranch but this species is the most abundant in all the tributaries and headwaters of the main stream.

About 50 per cent of the specimens taken from the lower river and dams were the rainbow-cutthroat cross.

Fish-food organisms. Trout streams supporting an abundance of vegetation and having considerable riffle area of rubble and gravel, are invariably rich in food organisms. Blacksmith fork is of very high quality in this respect.

The average volume of food organisms per square foot is approximately 3.0 cc. (water displacement). Table 14 gives a qualitative and quantitative summary of the samples taken on the Blacksmith Fork and its tributaries.

Table 14.- Qualitative and Quantitative summary of fish-food samples from the Blacksmith Fork and its tributaries

| Section No. | Date, 1934 | Square foot | Caddisflies | Mayflies | Stoneflies | Midge larvae | Other Diptera | Oligochaeta | Snails | Pisidium | Hydrachnida | Nematoda | Coleoptera | Turbellaria | Hemiptera | Volume cc. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7/14 | Utah Power and Light Company Dam | | | | | | | | | | | | | | |
| 2 | 7/14 | 3 | 194 | 358 | 61 | 177 | 405 | 4 | 30 | - | 33 | - | 139 | 4 | 4 | |
| 3 | Hyrum City Dam | | | | | | | | | | | | | | | |
| 4 | 7/17 | 3 | 110 | 271 | 13 | 126 | 77 | 4 | 2 | 13 | 5 | 3 | 5 | 8 | - | 4.35 |
| 5 | 7/19 | 3 | 546 | 213 | 6 | 166 | 41 | 19 | - | 10 | 3 | - | 10 | 8 | - | 12.5 |
| Tributaries: | | | | | | | | | | | | | | | | |
| Left Fork | 7/13 | 3 | 2071 | 133 | 200 | 167 | 211 | 14 | 15 | - | 4 | - | 10 | 4 | - | - |
| Rock Creek | 7/18 | 3 | 47 | 232 | 32 | 88 | 57 | 10 | 39 | - | 2 | - | 313 | 3 | - | 7.3 |
| Curtis Creek | 7/18 | 3 | 462 | 391 | 44 | 96 | 31 | 5 | - | 1 | 4 | 9 | - | 97 | - | 9.2 |
| Mill Creek | 7/20 | 1 | 63 | 227 | 2 | 78 | 170 | 50 | 10 | - | 13 | 6 | 26 | 99 | - | 7.0 |
| Sheep Creek | 7/21 | 2 | 37 | 70 | 28 | 39 | 22 | 18 | 15 | - | 7 | - | 86 | 57 | - | 4.0 |

## Improvements

No improvements are recommended for the Blacksmith Fork and its tributaries at the present time.

## Artificial Lakes

The artificial lakes produced by the two power dams in the Blacksmith Fork Canyon, are very productive. The lower one (Utah Power and Light Company) is a dam about 25 feet high and retains approximately 2½ acres of water. The inlet contributes about 35 c.f.s. The basin is regular,

reaching a maximum depth of 18 feet at a point 25 yards above the dam. The shoal areas are situated on the northeast and east end. These are covered with a rich layer of silt and an abundance of vegetation both higher plants and algae. At 8:30 AM July 14, 1934 the temperature at the inlet was 63°F. and at the outlet 63°F. The temperatures from top to bottom were as follows: Surface - 63°F.; 2 yards - 62.8°F.; 3 yards - 59°F.; 6 yards - 58°F. Chemical analyses of the water taken at the surface and at four yards show a uniform condition from top to bottom. (pH - 8.2; $CO_2$ - 0.0 p.p.m.; $O_2$ - 7.4 p.p.m. at surface and 8.3 p.p.m. at 4 yards; phenolphthalein alkalinity 10.0 p.p.m.; methyl orange alkalinity 178 p.p.m.) One square foot of bottom produced 630 midges, 114 Pisidium and 11,495 tubificid worms. The Tubificidae alone had a volume of 22 cc. There are no good spawning areas in the lake proper but the fish have free run up the main river where spawning areas are ideal. Of the fish present, the brown trout seemed to be most abundant. There were also large numbers of whitefish and rainbow trout.

The upper dam (Hyrum City) is only 12 feet high and forms a lake of about 3 - 4 acres. It is fed by the main river (30 c.f.s.) and during the whole summer all of this water went into the power main at the opposite end. The lake has a maximum depth of 8 feet. The shoals are extensive and covered deeply with silt. Many weed beds occur especially along the north side and east end. Almost the whole bottom is a veritable mass of filamentous algae. Measurements showed 278 cc. of this algae per square foot of bottom. Temperatures taken July 16, 1934, were as follows: Inlet - 63°F.; Outlet - 59.5°F.; Surface - 59.5°F. There was no chemical stratification. Samples taken were as follows: pH - 8.4; $CO_2$ - 0.0 p.p.m.; $O_2$ - 6.4 p.p.m.; phenolphthalein alkalinity - 8 p.p.m.; methyl orange alkalinity - 179 p.p.m. In a bottom sample (0.5 square feet) there were 58 cc. of Tubificidae and 2.8 cc. of other organisms. Food conditions in these lakes are excellent. Brown trout is the predominant species with large numbers of whitefish and rainbow trout. Only rarely is a native cutthroat taken. A gill-net haul of one hour took the following fish: 23 brown trout, 5 rainbow trout, 5 whitefish, and 1 native cutthroat trout.

## Stocking Recommendations.

Since 1930, 663,170 rainbow (3-10 inches) and 225,000 brown trout ($2\frac{1}{2}$ - 3 inches) have been stocked in the Blacksmith Fork and its tributaries. (Figures are from Lawrence Johnson). No detailed stocking records are available.

Brown trout are recommended for the dams and the main river up as far as the Hardware Ranch, although some rainbow might be substituted for brown trout if more available. From careful observations and a study of the physical features of the river above this point including all tributaries, we are convinced that cutthroat trout is the best species for these waters. The native cutthroat maintain themselves in considerable numbers by natural propagation.

A complete stocking program for each section is given in Table 15.

Table 15.- Tentative stocking recommendations for the Blacksmith Fork and its tributaries, including dams.

| Section No. | Aver. Width Ft. | Length to be Stocked | Exact Location | Grade Food | Grade Pool | Species Recommended | Size In. | No. of Trout | Frequency |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 29 | 3.5 | Between Utah Power and Light Dam and Hyrum City Power plt. | 2 | A | Brown | 3 | 2,775 | Annual |
| 4 | 22 | 6.7 | Between Hyrum City Dam and mouth of Curtis Creek | 3 | A | Brown or Rainbow | 3 | 9,975 | Annual |
| 5 | 21 | 6.0 | Between mouth of Curtis Creek and source of main river. | 2 | A | Cutthroat | 1½ | 33,200 | Annual |
| Tributaries: | | | | | | | | | |
| Left Fork | 13 | 10.0 | From mouth to source at springs | 1 | B | Cutthroat | 1½ | 22,650 | Annual |
| Rock Creek | 9 | 6.0 | From mouth to 1 mile above Beaver dams at source. | 3 | B | Cutthroat | 1½ | 7,650 | Annual |
| Curtis Creek | 9 | 6.5 | From mouth to Store Hollow | 2 | B | Cutthroat | 1½ | 11,850 | Annual |
| Mill Creek | 9 | 1.0 | From mouth upstream 1 mile | 1 | A | Cutthroat | 1½ | 2,900 | Annual |
| Sheep Creek | 7 | 7.5 | From mouth to source - 7.5 miles. | 3 | B | Cutthroat | 1½ | 7,450 | Annual |

Dams:

| Lake | Acres | Food Grade | Estimated length of growing season in months | Species Recommended | Size Inches | Number of Trout | Frequency |
|---|---|---|---|---|---|---|---|
| Utah Power and Light Dam | 3.0 | 1 | 7 | Brown | 3 | 825 | Annually |
| Hyrum City Dam | 4.0 | 1 | 7 | Brown | 3 | 1,050 | Annually |

The total number of each species to be stocked in the Blacksmith Fork and its tributaries are as follows:

Brown trout - 3 inches ..... 14,625
Cutthroat - 1½ " ..... 85,700

As already mentioned, the sizes listed are not those most desirable. Fish held in rearing ponds until 6 inches are far more economical for planting. In Table 15 there has been a 25 per cent reduction in the numbers recommended due to the known favorable conditions for natural propagation. Whether or not this allowance is enough to cover the number actually produced by natural reproduction can only be determined by a more careful investigation of this point.

## LITTLE BEAR RIVER

At the request of the Hyrum Fish and Game Association, certain observations were made on the headwaters of the Little Bear River and the new Hyrum Dam reclamation project. The area drained by this river is immediately south of the Blacksmith Fork and is similar in all respects to that stream. Three stations were established. The lower one was situated ¼ mile above the new dam site, the middle one just below the Lofthouse Bridge in Avon and the upper, 300 yards below big spring in East Canyon. The average gradient over this section is about 55 feet per mile. At the upper station, it is almost twice as great as at either of the other two. The bottom generally is composed of rubble to fine gravel with smaller amounts of sand in the lower portion. The riffles are long and shallow and the pools are rather infrequent, being only of fair quality. The main stream has an average width of 24 feet, while East Canyon tributary averages 14 feet. The average depth is 0.3 feet and the velocity in the riffles ranges between 1.75 feet per second and 2.6 feet per second. East Canyon was carrying 9 cubic feet per second and the river proper, just as it entered the reservoir site, had 16 cubic feet per second. The stream is partly shaded except at the lower end where all the brush has been removed in preparation for the new reservoir.

Temperatures taken July 26, 1934 are as follows: Lower station - hour - 3:45 PM; Sky - clear; Air temperature - 90°F.; Water temperature - 76°F. Middle station - hour - 10:30 AM; Sky - clear; Air temperature - 76°F.; Water temperature - 63°F. Upper station - hour - 1:00 PM; Sky - clear; Air temperature - 88°F.; Water temperature - 63°F.

Water-cress and buttercup were common at the lower station. Only small amounts of algae were present at the middle and upper stations. The results of square foot samples taken from the bottom were as follows: Lower - 5.2 cc. volume consisting mainly of caddis, snails, amphipods and midges. Middle - 3.6 cc. volume containing an abundance of mayflies, Mollusca and Coleoptera. Upper - 4.5 cc., consisting almost entirely of caddis, mayflies and stoneflies. Generally speaking, food conditions in this stream are excellent.

A chemical analysis at Station 2 shows an abundance of oxygen and the complete lack of carbon-dioxide. The pH was 8.3 and the total alkalinity 206 parts per million.

Brown and rainbow trout are reported for the upper stations. At the lower one, suckers, chub, minnows and trout fingerlings were observed.

When the Hyrum project is complete the artificial lake created by the dam will range between 250 and 450 acres. This will no doubt develop into a very fine fish pond after it becomes stocked with plants and food organisms. It must be remembered, however, that natural stocking with the fundamental plants and animals takes time and although no reliable information is available with regard to the rate or succession of stocking, the maximum abundance of food organisms will probably not be reached for a few years. In view of these facts, great care should be exercised in a trout stocking program. There is a great danger of stocking beyond the available food supply.

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DEPARTMENT OF COMMERCE
BUREAU OF FISHERIES

Lake and Pond Survey

State | River System | Name of lake

Forest or Park | Map | Number

County | Tributary to

Notes--Sketches

Name of lake: | Date:
Altitude: | Area:
Natural or artificial:
Height of dam: | Fishway:
Character of shore line:

Character of watershed: Mountainous, hilly, rolling, flat, swampy, wooded, open, cultivated, uncultivated.

Principal tributary streams (names and size):

Fluctuations in water level (causes and feet variation):

Approximate depth 100' from shore_____, 200' from shore_____, Maximum_____.

Shoal areas (extent, type of bottom):

Deep areas: Bottom--Mud, silt, sand, clay, peat, marl, detritus, hardpan, gravel, bedrock.

Temperatures: Inlet_____, Outlet_____, Surface_____, Hour_____, Weather_____, At various depths_____.

Color and turbidity:

Higher plants:
Emergent:

Submerged:

Algae (kinds and abundance):

Note: For actual field use this form was printed on a sheet of the same size and general layout as the accompanying stream survey form.

(Over)

DEPARTMENT OF COMMERCE
BUREAU OF FISHERIES
STREAM SURVEY

State River system Name of stream

Forest or park Map Number

County Tributary to

Stream section:

Length of section:

Note—Sketches:

Vertebrates:
Kinds of fish and abundance

Others

Invertebrates (indicate abundance by count or estimate):

| | |
|---|---|
| Caddisflies | Hemiptera |
| Mayflies | Stoneflies |
| Midges | Decapods |
| Other Diptera | Amphipods |
| Dragonflies | Entomostraca |
| Damselflies | Mollusks |
| Neuroptera | Worms |

Plankton (length of haul):
Quantity in ccs:
Dominant organisms:

Spawning areas:

Young fish seen:

Accessibility:
Boats available:
Pollution: Source:
Type:

Degree fished (heavy, medium, light):
Rearing pool sites:

Fish recommended:

Remarks:

Improvements:

_____
Investigator

STOCKING PROGRAM

Species:

Size:

Numbers:

Frequency:

_____
Authority

Name of stream _____ Date _____

| REGION | UPPER | MIDDLE | LOWER |
|---|---|---|---|
| Station | | | |
| Altitude | | | |
| Average width and depth | | | |
| Volume | | | |
| Velocity | | | |
| Color and turbidity | | | |
| pH | | | |
| Air temperature | | | |
| Water temperature | | | |
| Hour and sky | | | |
| Pools and shelter: | | | |
| Size, type, frequency | | | |
| | | | |
| | | | |
| Riffles: | | | |
| Character and extent | | | |
| | | | |
| | | | |
| Shade | | | |
| Bottom: Mud, silt, sand, clay detritus, hardpan, gravel, rubble, bedrock | | | |
| Aquatic vegetation: | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| Fish food: | | | |
| Caddisflies | | | |
| Mayflies | | | |
| Diptera | | | |
| Stoneflies | | | |
| Crustacea | | | |
| Miscellaneous | | | |
| | | | |
| | | | |

Character of watershed: Canyons, mountainous, hilly, rolling, flat, swampy, wooded, open, cultivated, uncultivated.

Fluctuation in volume:

Gradient:

Character of watershed: Canyons, mountainous, hilly, rolling, flat, swampy, wooded, open, cultivated, uncultivated.
Fluctuation in volume:

Gradient:
Source:
Barriers (location and height):

Diversions (location, screened):

Springs (location, size, temperature):

Tributaries:

Fish (kinds, abundance):

Enemies:

Degree fished (heavy, medium, light):
Spawning areas:

Fry, fingerlings seen:

Accessibility of stream:

Previous stocking:

Pollution (source, type):
Rearing pool sites:

Fish recommended:

Vertebrates:

Kinds of fish and abundance

Others

Invertebrates (indicate abundance by count or estimate):

| | |
|---|---|
| Caddisflies | Hemiptera |
| Mayflies | Stoneflies |
| Midges | Decapods |
| | Amphipods |

Remarks:

Improvements:

*Investigator.* ----------

Pool grade: Food grade:

Average width:

STOCKING PROGRAM

Section to be stocked:

Species:

Size:

Number.

Frequency:

STOCKING PROGRAM

Species:

Size:

Numbers:

Frequency:

Authority

*Authority.* ----------

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