HABITAT EVALUATION FOR THE MOHAVE TUI CHUB (Gila bicolor mohavensis)

A Project Presented to the faculty of

California State University Fullerton

In Partial Fufillment of the Requirements for

Master of Science in Environmental Studies

By

Christopher A. Archbold

Approved by:

Professor Joel Weintraub

Date

TABLE OF CONTENTS

PAGE

I. INTRODUCTION TO THE STUDY

The Mohave tui chub (Gila bicolor mohavensis) is listed by both state and federal agencies as an endangered species (U.S. Fish and Wildlife Service 1984). Mohave tui chub (MTC) are known to exist at only four locations: Soda Springs, Camp Cady wildlife Area, China Lake Naval Weapons Base and the California Desert Information Center in Barstow (BLM 1994). The purpose of this study is to evaluate and compare the habitat areas for MTC at Soda Springs, Camp Cady, and the California Desert Information Center on the basis of past and present data on aquifer tests, water quality data, contaminant plumes and the ecology of the habitat areas. A grading system as developed evaluates MTC habitat at these locations and other potential relocation sites. Trends in water quality and changes in habitat areas as examined for the three sites were considered in developing the evaluation system.

The three habitat areas studied at Soda Springs were Mohave Chub Spring (M.C. Spring), Lake Tuende and West Pond. M.C. Spring has been a good habitat for MTC based on its water quality and history of stability over the past 77 years (U.S. Fish and Wildlife Service 1984). Lake Tuende has been acceptable; its water quality has been within the tolerance levels of the species since they were introduced to the lake but the water level must be artificially maintained. West Pond is now an unsuitable habitat area following the fish kill of 1985 (BLM 1994). Its water quality is too poor to sustain a population of MTC.

Data gaps exist in the understanding of the relationship between the leach field contamination plume from the restroom facilities and its effects on: Three Bats Pond, the pump well, and Lake Tuende via the pump well. See figure one for leach field location. Chemical analysis of these locations and comparisons with chemical analysis from aquifer test data will shed light on the leach field contamination effects on Lake Tuende and Three Bats Pond.

The other habitat areas evaluated were the two large ponds at Camp Cady and a small pond at the California Desert Information Center in Barstow. Figure 2 is a regional map which shows the location of all three sites being evaluated in reference to the Mojave River. All three sites being evaluated are located within San Bernardino County and the historic range of the MTC. Evaluation of these habitat areas contributed to an evaluation model for habitat suitability for the MTC.

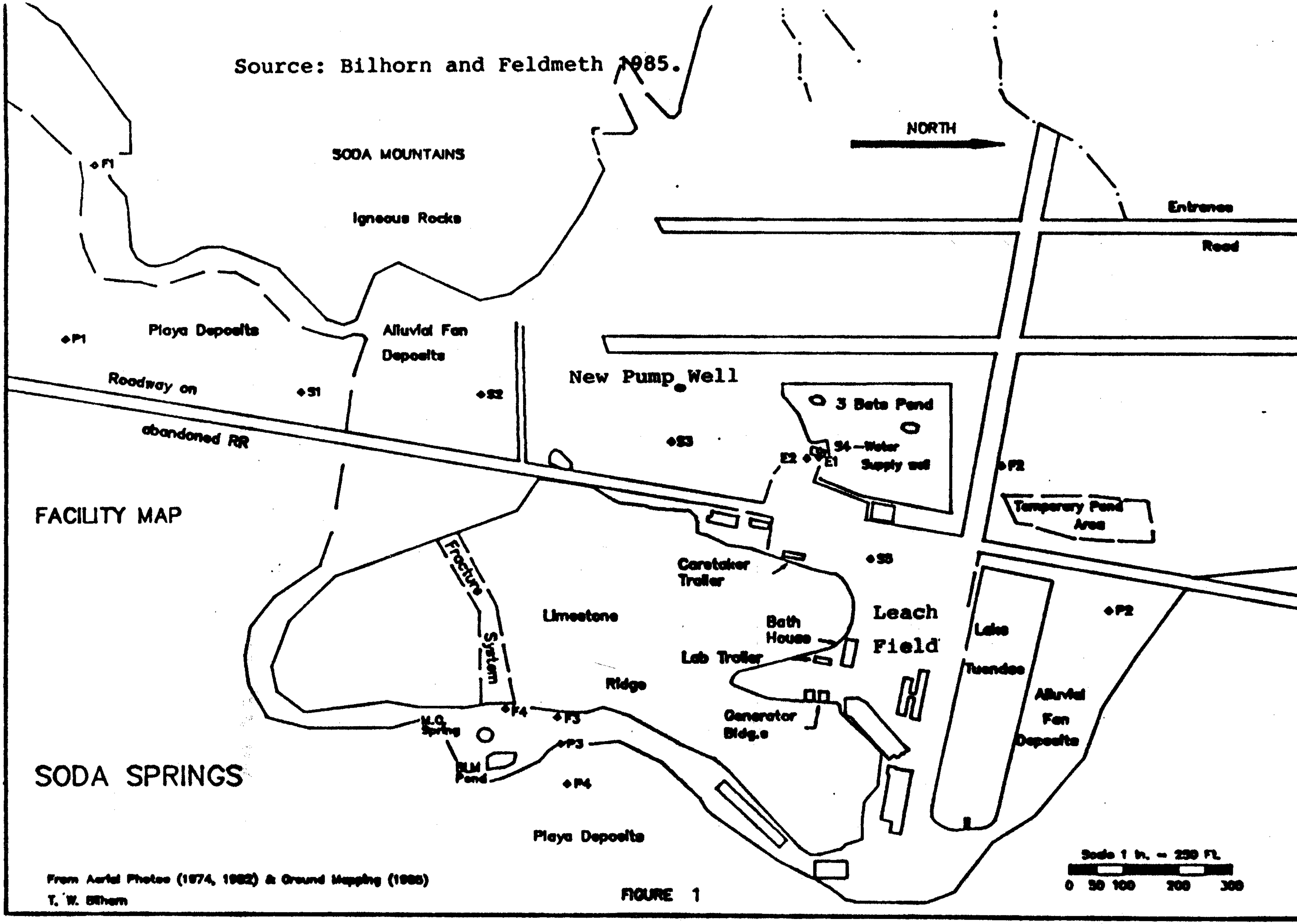

Source: Bilhorn and Feldmeth 1985.
SODA MOUNTAINS
Igneous Rocks
NORTH
Entrance
Road
F1
P1
Playa Deposits
Alluvial Fan
Deposits
Roadway on
abandoned RR
S1
S2
New Pump Well
S3
3 Bete Pond
S4—Water
Supply well
E2
E1
F2
Temporary Pond
Area
S6
Caretaker
Trailer
Fracture
System
Limestone
Ridge
Bath
House
Lab Trailer
Leach
Field
Lake
Tuendae
Alluvial
Fan
Deposits
P2
Generator
Bldg.
F4
F3
P3
P4
M.C.
Spring
BLM
Pond
Playa Deposits
FACILITY MAP
SODA SPRINGS
From Aerial Photos (1974, 1982) & Ground Mapping (1985)
T. W. Bilhorn
Scale 1 in. = 250 Ft.
0 50 100 200 300

FIGURE 1

Source: U.S. Fish and Wildlife Service 1984.

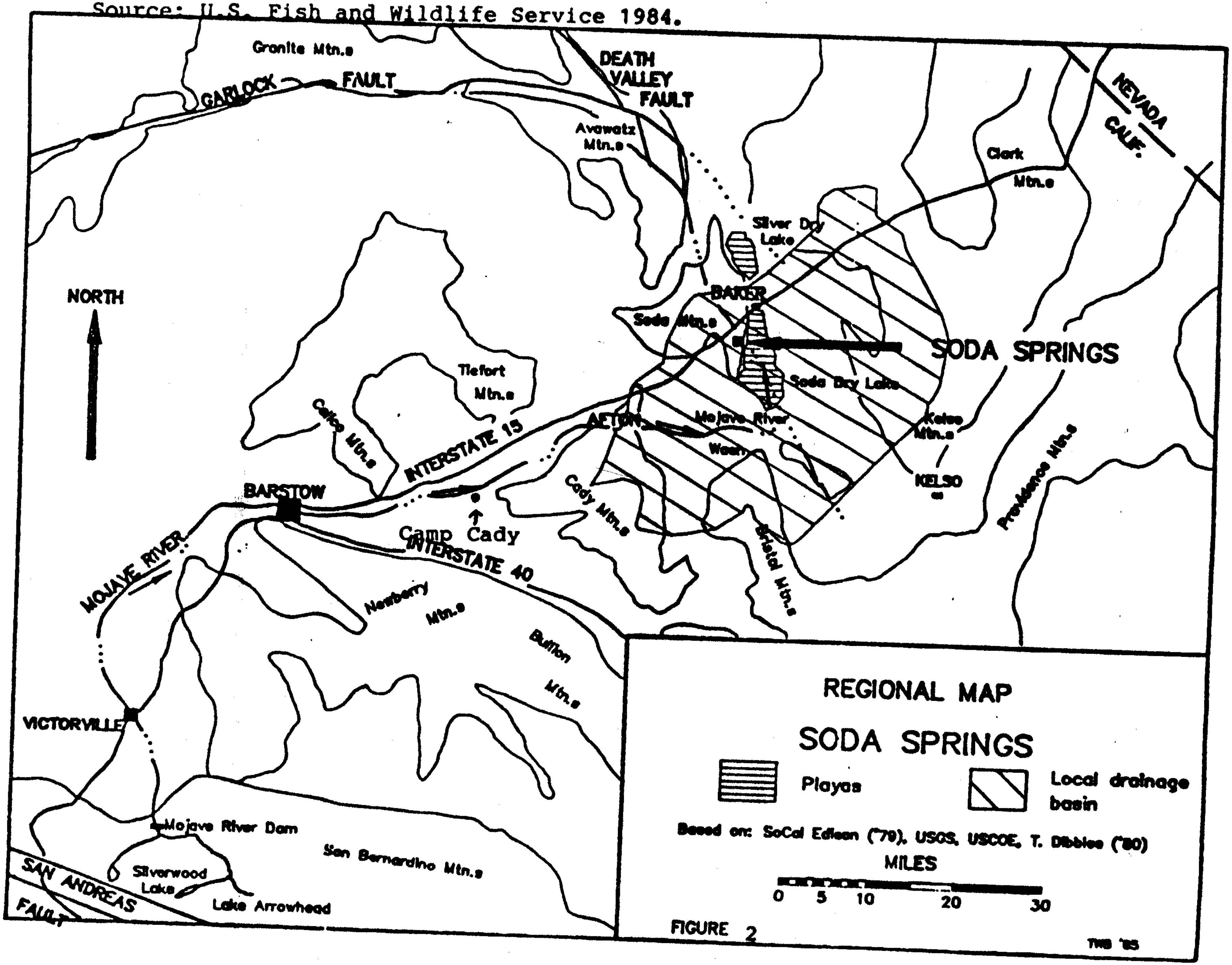


FIGURE 2

II. INTRODUCTION TO MOHAVE TUI CHUB ECOLOGY

II. A. History of the Mohave Tui Chub

During the Pleistocene the drainage area of the Mojave River included three large lakes that have since dried up: Mojave, Little Mojave and Manix (U.S. Fish and Wildlife Service 1984). This provided lacusturine habitat for the MTC (see figure 3). As the drainage volume of the Mojave River decreased so too has the natural habitat for this indigenous species of fish.

From the time that the lakes dried up until the middle of the 20th century MTC were restricted to the largely riverine habitat of the Mojave River. MTC are not well adapted to this habitat but they did persist there. Snyder reported that MTC were found predominantly in the deep pools and slow moving areas of the Mojave River (Snyder 1918).

By the 1930's a nonnative subspecies the arroyo chub, Gila orcutti, (a riverine adapted fish of the Los Angeles Basin) was introduced into the headwaters of the Mojave River by fishermen who used the fish as live bait (U.S. Fish and Wildlife Service 1984). The proliferation of this species is credited as being the primary cause for the decline of the MTC.

After the introduction of the arroyo chub the population of MTC declined dramatically due to hybridization and competitive exclusion (Miller 1961). The hybrid of the two species has a very low fertility rate. During periods of extreme conditions such as high temperature or floods the population of MTC would greatly decline whereas the population of arroyo chub would not. This left an ever increasing ratio of arroyo chubs to MTC. By 1968 the population of purebred MTC had essentially been eliminated from the Mojave River System (Miller 1968). Genetically isolated MTC remained at Soda Springs. All of the known stock of MTC is existence today emanates from Soda Springs (U.S. Fish and Wildlife Service 1984).

As of 1994 populations of MTC are known to exist at four sites: Soda Springs, lagoons fed by Lark Seep at the Naval Weapons Center in Ridgecrest and artificial pools at the California Desert Information Center and at the Camp Cady Wildlife Area (BLM 1994). Table 1 shows the numerous recent attempts that have been made to establish MTC populations.

The MTC was listed as an endangered species by the U.S. Department of the Interior in 1970 and by the State of California in 1971 (U.S. Fish and Wildlife Service 1984). When six self sustaining populations of at least 500 fish have been established the MTC will be considered for reclassification as a threatened species. If the MTC was reestablished in the historic habitat of the Mojave River it would be considered for delisting.

Figure 4. Pluvial hydrology of the Mohave River area.

Figure 4 adapted from the U.S. Fish and Wildlife Service. 1984.

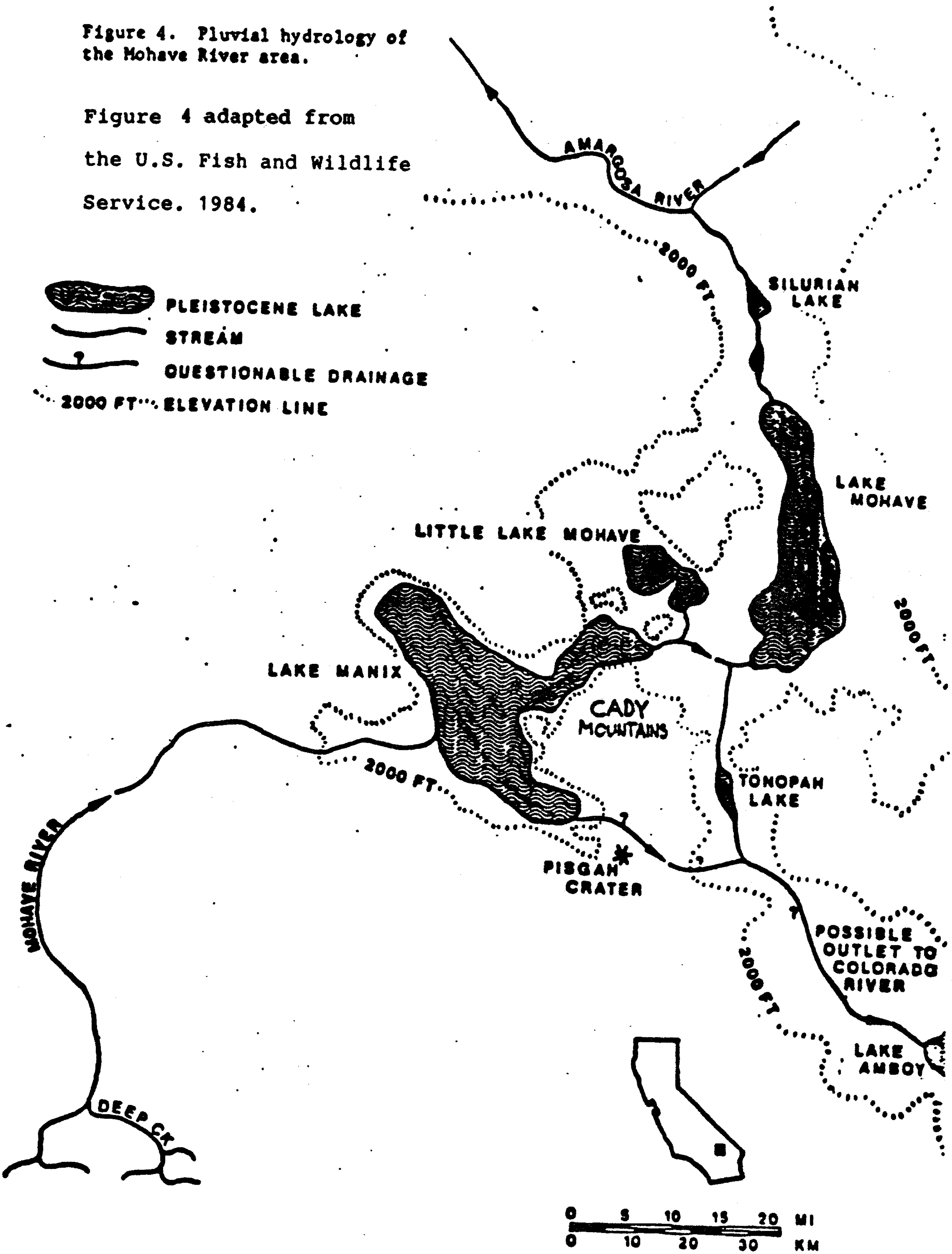


TABLE 1. Results of Mohave Chub Relocations in California and Nevada.

Site	County	Date(s) planted	No. of fish planted	Date(s) surveyed	Population established	Cause of failure of introduction	Date of reintroduction	No. of fish planted	Date(s) surveyed	Current population	Cause of plant failure
Paradise Spa [1]	—	June 1967	50	April 1981	No	Unknown	—	—	—	No	—
Piute Creek	San Bernardino	18 and 19 December 1969	150	9 November 1976	Yes	—	—	—	1978 and 1980	No	Flood
South Coast Botanic Garden Pond	Los Angeles	27 January 1970	147	—	Yes	Pond drained [2]	20 July 1972; 28 March 1975	55; 105	1976	No	Unknown
Two Hole Springs	San Bernardino	20 August 1970	41	June 1971	No	Unknown	9 July 1971	150	27 July 1971	No	Unknown
Lark Seep Lagoon	San Bernardino	12 July 1971	400	1979 and 1980	Yes	—	5 November 1976	75	1979 and 1980	Yes	—
Dos Palmas Spring Area.											
Dos Palmas Spring	Riverside	25 May 1972	100	8 January 1980	No	Unknown	—	—	—	No	—
Shrimp Pond	Riverside	25 May 1972	100	8 January 1980	No	Unknown	—	—	—	No	—
Lion Country Safari Ponds	Orange	1 June 1972 and 28 March 1975	822	January 1974	Yes	—	—	—	8 November 1977	No	Unknown
Eaton Canyon Nature Center	Los Angeles	5 June 1972	20	—	No	Unknown	—	—	—	No	—
Busch Gardens	Los Angeles	27 July 1972	49	—	No	Unknown	—	—	—	No	—
Barstow Way Station	San Bernardino	22 July 1975	60	16 September 1976; 1979	Yes	Flood	1 July 1981	30	—	Unknown	—
Lake Norconian	Riverside	1978	—	6 February and 3 July 1980	No	Unknown	—	—	—	No	—
Desert Research Station	San Bernardino	12 December 1978	16	Continuous	Yes	—	—	—	—	Yes	—

[1] Located in Clark County, Nevada. All other locations listed are in California.
[2] Fish salvaged and stocked elsewhere.

Table 1 taken from Hoover 1983.

II. B. Review of Tolerance Level Studies

a. Extreme Temperature

Air temperature variations in the Mojave Desert range from $-6.7^{\circ}C$ to $40.6^{\circ}C$ (Victorville Data, NOAA 1983). The water temperature along the course of the Mojave River ranges from $0^{\circ}C$ to $36^{\circ}C$ (U.S. Geological Survey 1981). The water temperature along the course of the Mojave River ranges from $0^{\circ}C$ to $36^{\circ}C$ (U.S. Geological Survey 1981). The mean critical maximum water temperature for MTC acclimated at $30^{0}C$ is $36.2^{\circ}C$. The mean critical minimum water temperature for MTC acclimated at $18^{\circ}C$ is $2.8^{\circ}C$ (McClanahan et al. 1986).

In lacusterine environments low temperature hypoxic conditions are more prevalent than in riverine environments. The lacusterine adapted MTC have greater low temperature hypoxia tolerance than the riverine adapted arroyo chub. Conversely the arroyo chub is better able to tolerate the higher temperatures that are present in a desert river system (Castleberry and Cech 1986).

b. Low Oxygen

The metabolic rate of the MTC (a cold blooded animal) is closely linked to the water temperature in which it lives. As the water temperature rises so too does the fish's metabolic rate and need for oxygen. The oxygen level in water decreases as the temperature rises if all other factors are held constant. So as the demand for oxygen increases the supply of oxygen decreases.

Factors that cause the oxygen level in water to become depleted include: plant respiration without compensating oxygen producing photosynthesis as occurs during night time, decomposition of plant material or algae by aerobic bacteria, and lack of mixing which occurs at the bottom of deep frozen over lakes.

The oxygen consumption rate of MTC went from 40mg/Kg hr at 10°C to 110 mg/Kg hr at 20°C to 175 mg/Kg hr at 30°C under normoxic, normal oxygen level, conditions (20 KPaPPO$_2$). Under hypoxic, low oxygen level, conditions (5 KPaPPO$_2$) the metabolic rate of MTC decreased by more than double at 10°C, by 15% at 20°C and by 25% at 30°C. MTC held under hypoxic conditions died after an overnight increase of 5°C (Castleberry and Cech 1986).

The temperature dependence of the metabolic rate ranged from 0.03cc O_2/g hr at 18°C to 0.07cc O_2/g hr at 30°C. The maximum metabolic activity is 0.01cc O_2/g hr at approximately 35°C (McClanahan et al. 1986). At this temperature all energy would be spent on metabolic requirements.

An oxygen content of water of less than 1 ppm was observed in which the fish survived after the power to an aerator had stopped over the weekend (McClanahan et al. 1986).

c. <u>Salinity</u>

MTC can survive indefinitely at up to 323mOsm/L (McClanahan et al. 1986). Salinities of greater than 10ppt can not be tolerated. Osmoregulatory problems are suspected to occur at 8ppt (Feldmdth 1984).

d. <u>High pH</u>

All of the habitat areas studied have alkaline water. The toxic action of hydroxyl ions is the destruction of gill and skin epithelium (Day and Garside 1976). A compounding factor is that high pH readings are associated with increased ammonia toxicity (Morgan and Turner 1976). A pH value of 10.4 was recorded at Soda Springs in Lake Tuende in which no fish died (BLM memorandum 1989). It is important to note that pH varies with depth and location in a large pond such as Lake Tuende. Table 2.1 lists the effects of extreme pH to fish. Note that a pH greater than 11 is rapidly lethal to all species of fish (Alabaster and Lloyd 1982).

Table 2.1 SUMMARY OF THE EFFECTS OF pH VALUES ON FISH

Range	*Effect*
3.0-3.5	Unlikely that any fish can survive for more than a few hours in this range although some plants and invertebrates can be found at pH values lower than this.
3.5-4.0	This range is lethal to salmonids. There is evidence that roach, tench, perch and pike can survive in this range, presumably after a period of acclimation to slightly higher, non-lethal levels, but the lower end of this range may still be lethal for roach.
4.0-4.5	Likely to be harmful to salmonids, tench, bream, roach, goldfish and common carp which have not previously been acclimated to low pH values, although the resistance to this pH range increases with the size and age of the fish. Fish can become acclimated to these levels, but of perch, bream, roach and pike, only the last named may be able to breed.
4.5-5.0	Likely to be harmful to the eggs and fry of salmonids, and to adults particularly in soft water containing low concentrations of calcium, sodium and chloride. Can be harmful to common carp.
5.0-6.0	Unlikely to be harmful to any species unless either the concentration of free carbon dioxide is greater than 20 mg/ℓ, or the water contains iron salts which are freshly precipitated as ferric hydroxide, the precise toxicity of which is not known. The lower end of this range may be harmful to non-acclimated salmonids if the calcium, sodium and chloride concentrations, or the temperature of the water are low, and may be detrimental to roach reproduction.
6.0-6.5	Unlikely to be harmful to fish unless free carbon dioxide is present in excess of 100 mg/ℓ.
6.5-9.0	Harmless to fish, although the toxicity of other poisons may be affected by changes within this range.
9.0-9.5	Likely to be harmful to salmonids and perch if present for a considerable length of time.
9.5-10.0	Lethal to salmonids over a prolonged period of time, but can be withstood for short periods. May be harmful to developmental stages of some species.
10.0-10.5	Can be withstood by roach and salmonids for short periods but lethal over a prolonged period.
10.5-11.0	Rapidly lethal to salmonids. Prolonged exposure to the upper limit of this range is lethal to carp, tench, goldfish and pike.
11.0-11.5	Rapidly lethal to all species of fish.

Reference is made to different species on the basis of information known to us; the absence of a reference indicates only that insufficient data exist.

Source: Alabaster and Lloyd 1982.

II. C. Habitat Requirements

Habitat requirements for the MTC fall into three categories: configuration; ecology; and water quality. To provide a stable habitat all three categories must continuously satisfy the requirements for the survivability of the species in a particular habitat.

a. Configuration

To stabilize physical and chemical conditions a surface to volume ratio of 1:5 is recommended (Bilhorn and Feldmeth 1985). The depth over a majority of the habitat should be at least 1.2m (4') to prevent invasions of cattails and to stabilize dissolved oxygen and temperature fluctuations (Bilhorn and Feldmeth 1985). M.C. Spring in which the fish has been documented to inhabit since 1917 has a current maximum depth of between 1.5m (5') and 1.8m(6'). Habitats for MTC should have a maximum depth of at least this much.

Water flow is an important part of the habitat configuration. The water in this desert region has a comparatively large quantity of salts. Evaporation ponds in which there is little percolation are not suitable habitats because increases in salinity can exceed the tolerance level of the fish. In studies done on the Mojave River the fish were found in the slower moving troughs of the river (Snyder 1918). West Pond (Three Bats Pond) could be made more suitable if water was allowed to flow through the pond to discharge salts.

b. Ecology

MTC habitat should be capable of providing aquatic invertebrates as food for the MTC. Aquatic ditch grass, Rupia maritima, provides a substrate in which aquatic invertebrates are found in abundance. Aquatic ditch grass also provides a structure for fish egg attachment. Cattails and lillies provide shade from intense sunlight and high temperatures. However, if the aquatic vegetation becomes too prolific as happens when nutrient levels are elevated the aerobic digestion of detritus and the night time respiration of plants can lead to anoxic conditions.

The habitat should be free from excessive predation and competitive inbreeders such as the arroyo chub.

c. Water Quality

The water should be free from toxic substances or the threat of toxic spills year round. The water quality should always fall well within the limits that can be tolerated by the species.

III. DESCRIPTION OF WATERBODIES AND GROUNDWATER CONDITIONS

III. A. Hydrologic Setting

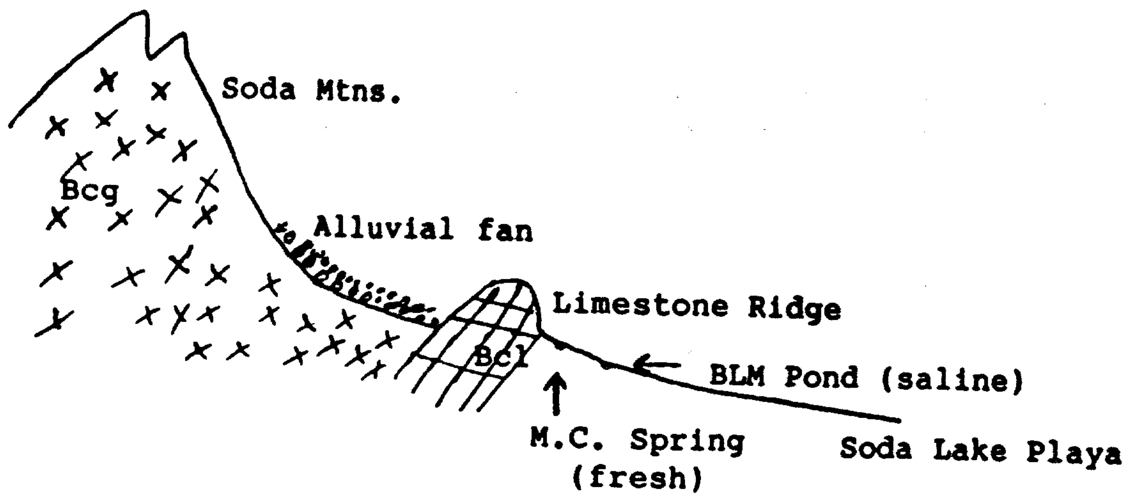
There are two aquifer systems at Soda Springs. One aquifer system is below Soda Lake and is part of the Mojave River Sink. The other aquifer system is in the alluvial fan material at the base of the Soda Mountains and within the Soda Moutains themselves.

The Soda Lake Basin encompasses 414 Km^2 (160 square miles). Water enters the Soda Lake Basin from three sources (Foster 1984): 1) Deep percolation of storm runoff from outside the Soda Lake Basin at Afton Canyon and the Kelso Wash; 2) Subterranean inflow from the Kelso Valley moving toward Baker; 3) Deep percolation of precipitation falling within the Soda Lake Basin.

The water entering the lake sediments is held between clay aquitards which create artesian conditions of up to 0.6m (2') at some locations. Water is extracted from the basin by evapotranspiration from plants and extraction from pumping wells for irrigation and domestic use at a rate of between 10,500 and 21,500 feet per year (Foster 1984).

A line of several springs exist along the base of the Soda Mountains. These springs may result from faulting of Precambrian limestone. The springs might also arise due to the intersection of the fractured bedrock of the Soda Mountains with the clay layers of the playa, or they may arise due to artesian pressure (Foster 1984).

Figure 4



The alluvial fan deposits which slope downwards from the Soda Mountains to Soda Lake provide a reservoir of aquifer material through which groundwater flows downward toward the playa material of Soda Lake. It is believed that a fracture system through limestone hill provides a conduit for water flow towards M.C. Spring. BLM Pond at a lower elevation and with a higher total dissolved solid reading is believed to be part of the ground water table.

III. B. Historical Evolution of the Waterbodies

a. Soda Springs

The springs at Soda Springs served as a water stop along the Wagon-Mohave Road. This road stretched from the Los Angeles Basin to Ft. Mohave on the Colorado River. Soda Springs later served as the site of an army fort. Afterwards the Tonopah and Tidewater Railroad utilized Soda Springs as a watering stop (U.S. Fish and Wildlife Service 1984). Railroad ties can be seen to this day in the vicinity of M.C. Spring.

Springer operated a health retreat known as Zzyzx Mineral Springs from the 1940's until he was removed from the BLM land in 1974 (U.S. Fish and Wildlife Service 1984). He had occupied the land on the grounds of mining claims. Lake Tuende and West Pond were excavated circa 1945 for use as swimming pools by Springer (U.S. Fish and Wildlife Service 1984). Springer operated a commune in which he brought homeless people out to the site. Just as the springs at Soda Springs provided an oasis for travelers along the Wagon Supply Road, Zzyzx provided an oasis of hope and encouragement to the homeless people who came out to live at Soda Springs with "Doc" Springer.

Lake Tuende and West Pond (Three Bats Pond) have undergone excavations to improve their habitat suitability for Mohave tui chub. Lake Tuende wunderwent excavations in 1979, 1982, and 1992 (BLM 1994). West Pond was deepened in 1979, 1982 and 1992 (BLM 1994). The excavations of 1979 and 1992 to West Pond included enlargements as well as deepening (BLM 1994).

b. California Desert Information Center

In 1976, 1979, and 1981 a total of 90 MTC were introduced to a small artificial cement pond at the California Desert Information Center in Barstow (BLM 1994). There have been some losses in population. The establishment of vegetation has increased population size (BLM 1994). Aquatic ditch grass, Ruppia maritima, is removed periodically under the direction of Tom Egan Ph.D., BLM Biologist. This is done to avoid a die off which might result in anoxic conditions and high nutrient levels.

c. Camp Cady

Camp Cady was established along the banks of the Mojave River by the U.S. Army in 1860 in order to suppress hostility from the Piute Indians (California Dept. of Fish and Game 1990). The property was later developed for use as an Arabian Horse Ranch. In 1979 the property which includes 1,546 acres was purchased by the California Department of Fish and Game for the sum of $983,000 (CDFG 1990).

Camp Cady is a designated State Wildlife Area. It provides habitat for the State and federally listed least bells vireo, Vireo bellii pusillus, as well as the MTC and several other species of special concern (CDFG 1990).

Two ponds at Camp Cady were excavated circa 1986 by the California Dept. of Fish and Game to serve as habitat for the MTC (BLM 1994). These ponds were dug to a maximum depth of

2.75m (9') (Frank Hoover, pers. comm.). Both ponds were lined with clay but the east pond suffered water loss problems. In 1991 MTC were transferred cut of the east pond so that the pond could be drained and a plastic liner installed (CDFG 1990). Subsequent to the transfer of fish to the west pond an outbreak of ick occurred which was treated with methylene blue by Frank Hoover. At the present time both of these ponds support populations of MTC.

III. C. Habitat Geometry

The water depth of the habitat is important not only for providing a larger habitat for more fish but also and more importantly for providing refuge from extremes in temperature. Based on average surface and bottom measurements the rate of temperature drop was 1.4°C/m (.44°C/ft) in Lake Tuende (5/03/94, 1000-1200 hours) and 4.7°C/m (1.4°C/ft) in West Pond (5/03/94, 1500-1700 hours). Temperature depth profiles are dependent on the fluctuations of day and night temperatures, time of day, mixing caused by wind, and light penetration which varies with turbidity and shading.

a. Methods

Lake Tuende was transected by centering a rowboat along transecting lines of palm trees. A grid was made by measuring the distance between the palm trees surrounding Lake Tuende. West Pond was transected visually by staking out the borders of West Pond every 6.1m (20') with wooden stakes. See figures 5 through 10 for habitat geometry.

b. Results

Lake Tuende had the shallowest average depth .94m (3.08') of the three habitat areas at Soda Springs. However, it gets as deep as 1.65m (5.4') in the west end. The east end is predominantly at the 0.9m (3') to 1.2m (4') depth as measured by Taylor (Taylor 1982). Taylor's measurements agree with the measurements made by the author in that the shallowest parts of the lake are around the fountain. Here depths range from

0.27m (0.9') to 0.61m (2.0'). Note that the water level measurements on 2/25/94 were taken with a water level 0.625m (2.05') below the top middle center of the dock. The water level of Lake Tuende drops and rises in accordance with the amount of water that is pumped into Lake Tuende from the new pump well.

The name Three Bats Pond for West Pond at Soda Springs now seems more appropriate since the recent dredging operations. Before there was only one island but now there are three. The maximum depth measurement in 1981 was 1.3m (4.3'). Now the maximum depth is 1.86m (6.1'). Approximately 22% of Three Bats Pond is now at the four to six to feet range. The west side adjacent to the old leach field is the deepest part of Three Bats Pond.

c. Discussion

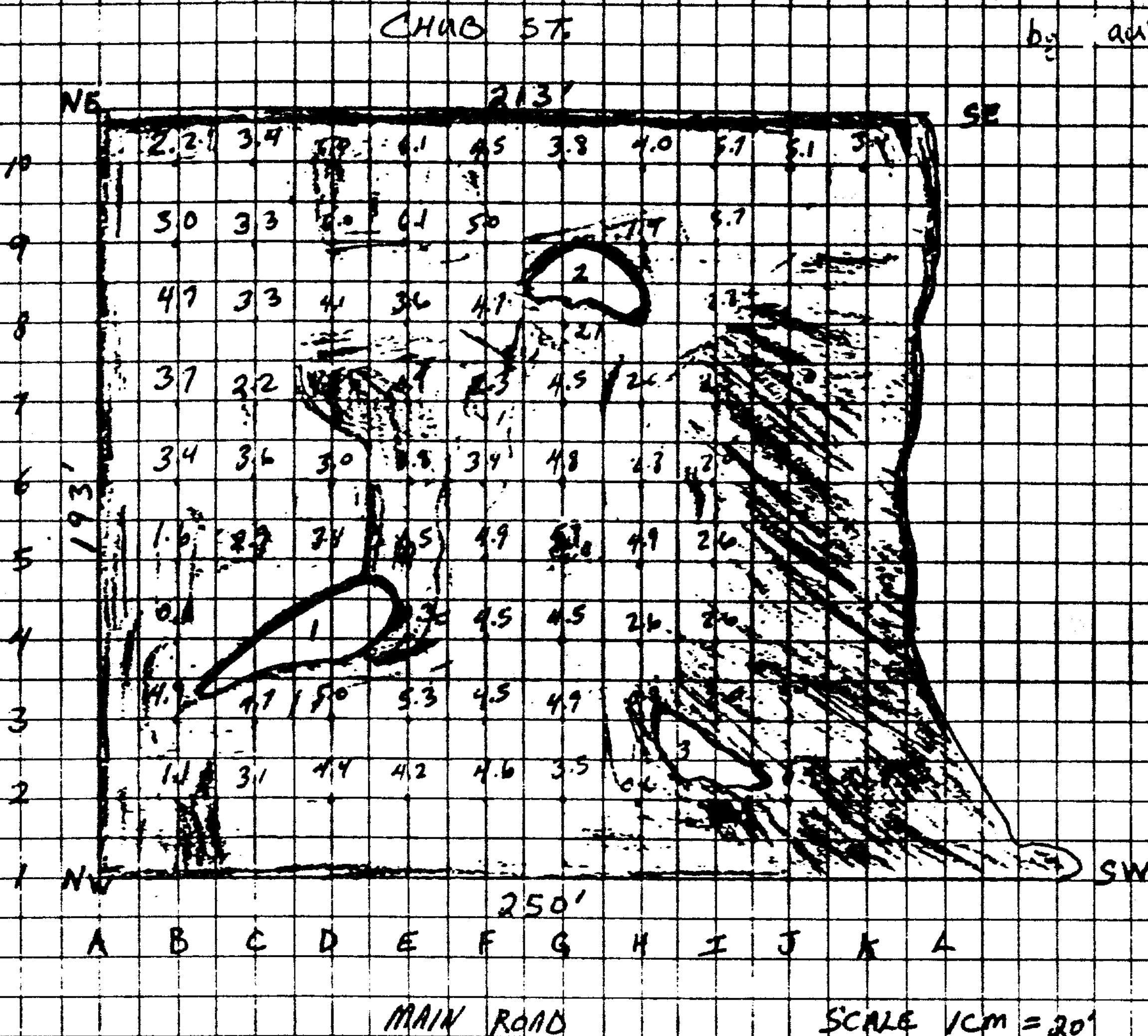
The measurements made by Taylor (Taylor 1982) show an average depth around the center of M.C. Spring 0.18m (0.59') greater than the average measurements made by the author. This difference may be attributable to the filling in of M.C. Spring. A permanent measuring stick placed in M.C. Spring would allow a better understanding of how the water levels change.

Of the three habitat areas at Soda Springs, West Pond had the greatest measured maximum depth, 1.86m (6.1'). Robert Fulton(Manager of the Desert Studies Center) reported a depth of approximately 6' in the center of M.C. Spring in 1993. This measurement comes from his standing in the center of M.C Spring to remove cattails and sedges. The average measured depth around the periphery of the center of M.C. Spring was 1.24m (4.08'). Lake Tuende had the shallowest average depth, 0.94m (3.08'), followed by West Pond with an average depth of 1.02m(3.35').

SODA SPRINGS

[illegible] 5 - WEST POND DEPTH PROFILE 5/03/94

by author



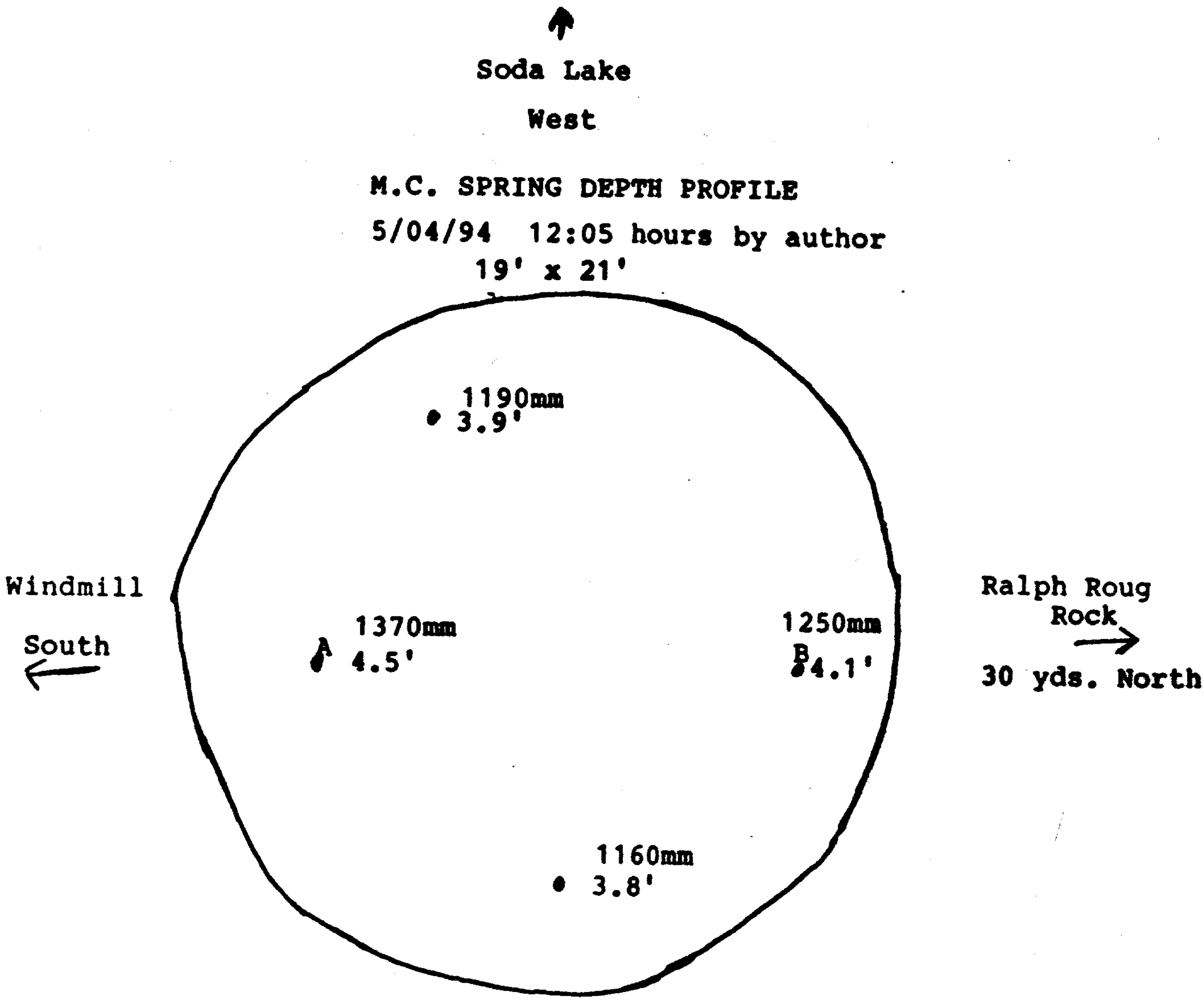
- 0 - 2.0'
- 2.0 - 3.0'
- 3.0 - 4.0'
- 4.0 - 5.0'
- 5.0 - 6.0'
- 6.0 - 7.0'

ISLANDS

1) FOREMAN ISLAND ~20' X 65'
2) FULTON ISLAND 18' X 28'
3) EGAN ISLAND 25' X 40'

AVG DEPTH = 3.35'

figure 7

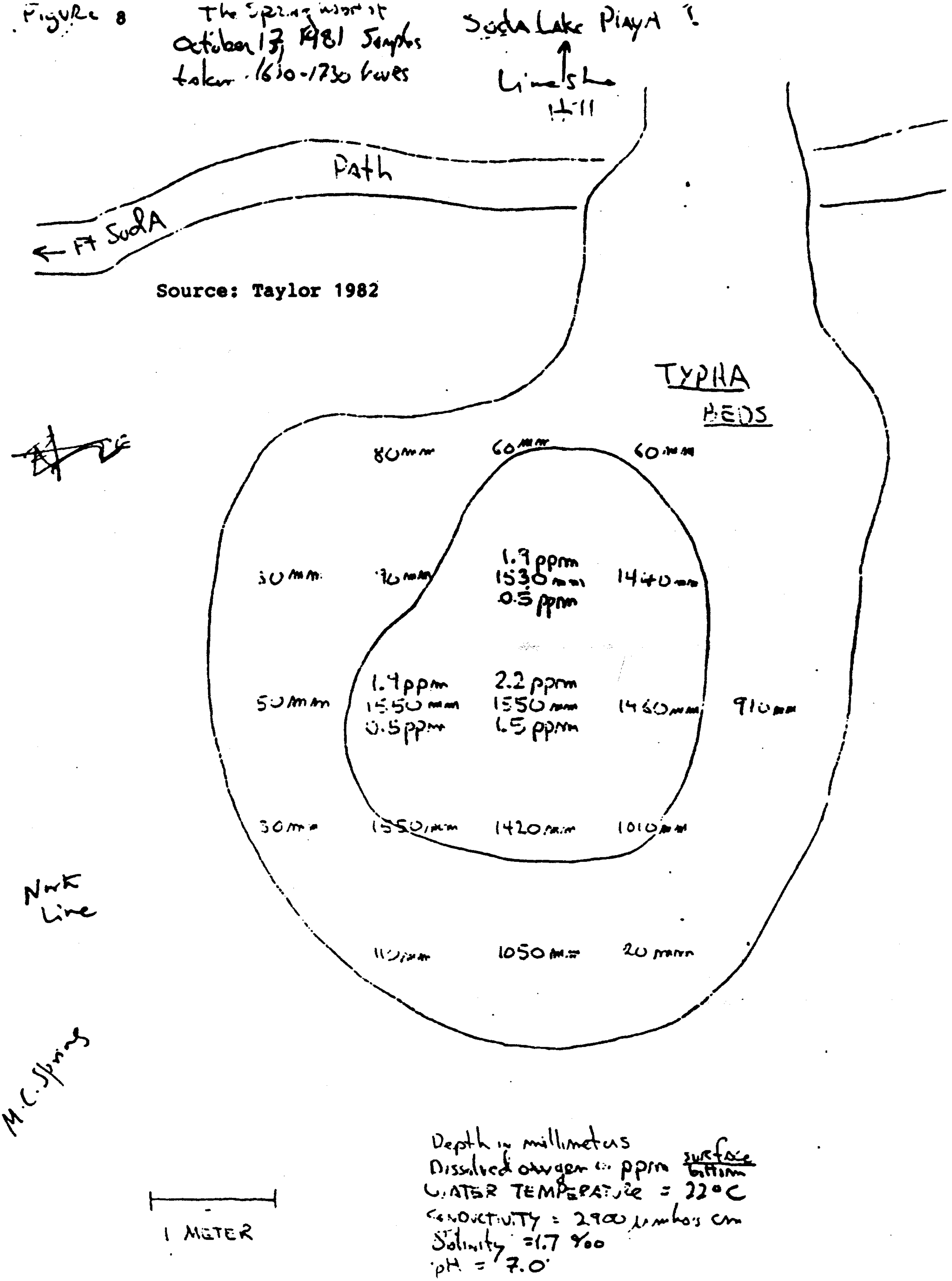


Readings at Site A
23.6°C at surface
6ppm D.O. at surface
23.4°C at 3'
5.1 ppm D.O at 3'

Readings at Site B
23.8°C at surface
5.7 ppm D.O at surface
23.1°C at 3'
4.4 ppm D.O. at 3'

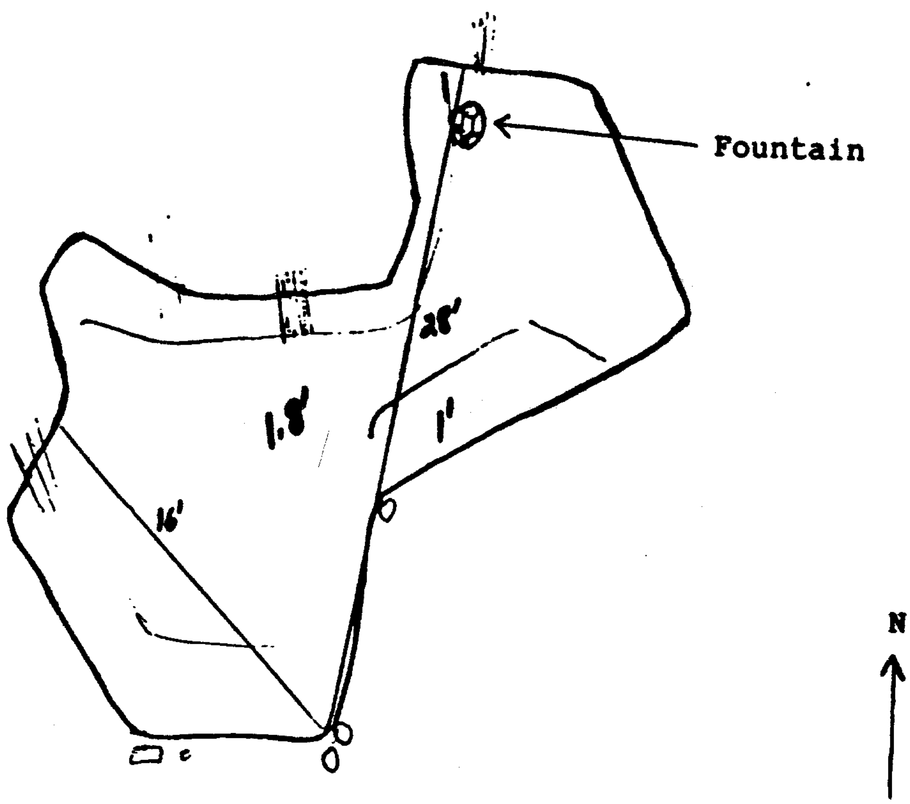
Lime Stone
Hill

East



Source: Taylor 1982

Figure 9
POND AT CALIFORNIA DESERT INFORMATION CENTER IN BARSTOW



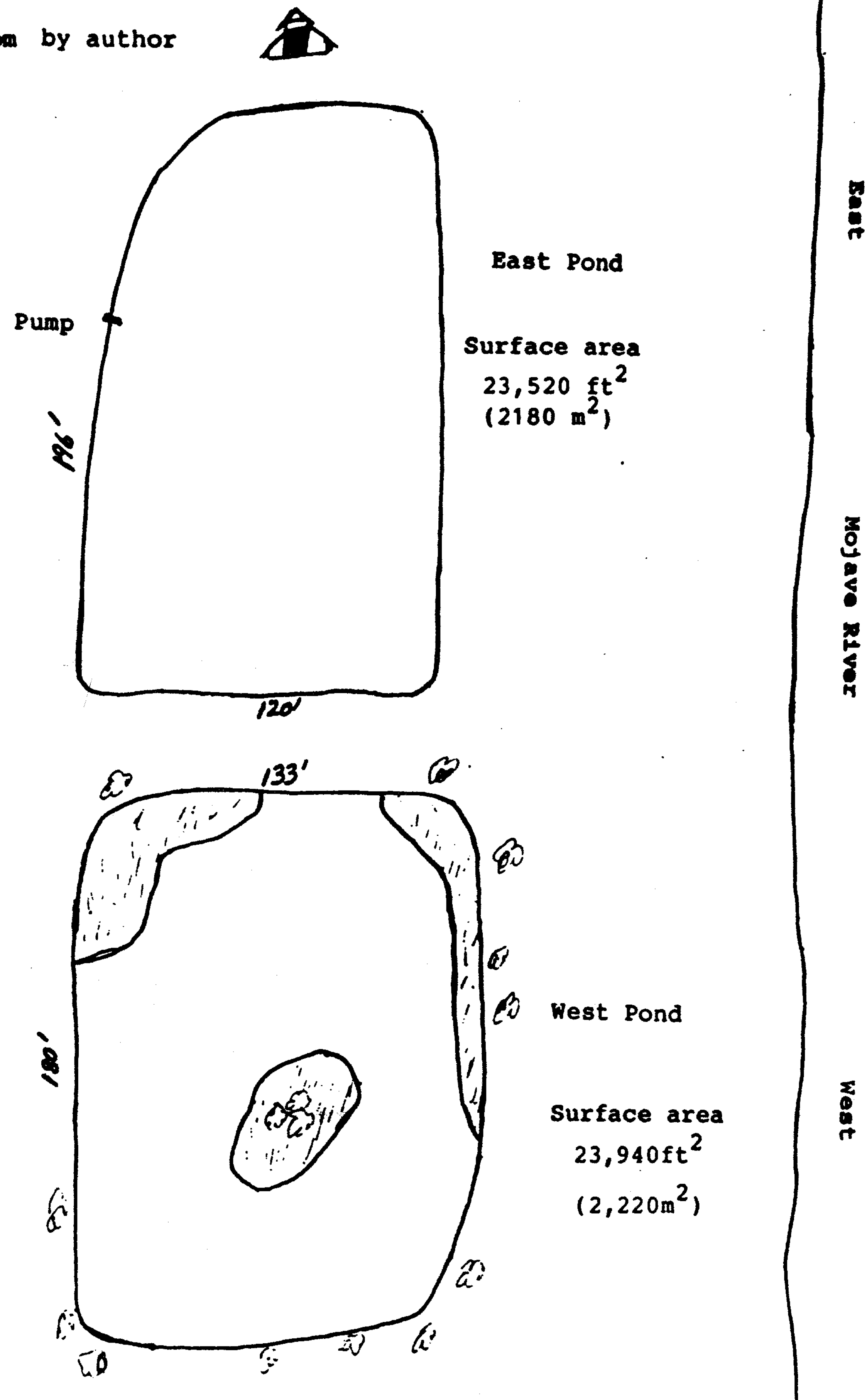
Max depth 1.8' (550 mm)

Surface area 350 ft^2 ($32.5 m^2$)

Measurements taken 6/14/94 at 4:45 pm by author.

Figure 10
CAMP CADY

6/19/94 2 pm by author



III. D. Aquifer Draw Down and Recovery Test at Soda Springs

a. Introduction

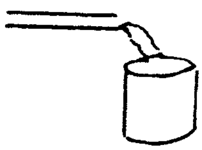
As part of Dr. Prem Saint's Water Quality Investigation and Control Course (Geo Sci 437) at California State University, Fullerton an aquifer draw down and recovery test was conducted on 11/20/93 and 11/21/93 at Soda Springs California. Water was pumped from the new pumping well for 920 minutes. The draw down caused by the pumping was monitored at both the new and old pumping wells which are 210' apart.

This test provided useful information on the groundwater resource potential of Soda Springs adjacent to West Pond and Lake Tuende. From graphs of the draw down and recovery values for storativity, S, and transmissivity, T, were generated.

This test also provided information on how or if the water quality of the well would be affected once the cone of depression reached the leach field or West Pond. If water from the leach field or West Pond was drawn through the new pumping well higher values of electroconductivity, E.C., and contaminants such as nitrates, nitrites and phosphates would be expected.

b. Methods

The pumping rate, Q, was determined volumetrically. A 32 gallon container was filled in 13 seconds by water drawn from the new pumping well. The pumping rate at the beginning and end of the test was the same. Pumping start at 16:45 on November 20th and continued until 10:30 on November 21st.



$$Q = \frac{V}{T} = \frac{32\ \text{gallons}}{13\ \text{seconds}}\left(\frac{60\ \text{seconds}}{1\ \text{minute}}\right) = 148\ \frac{\text{gallons}}{\text{minute}}$$

c. Results

From the graphs of time vs. electroconductivity reading and time vs. nitrite concentration a trend toward decreased water quality was observed. This is presumed to be the result of the cone of depression expanding to draw in water from the leach field and West Pond (see figures 11 and 12). Since the water level in Lake Tuende is maintained through water taken from the new pump well this water will affect the water quality of Lake Tuende.

Values for transmissivity and storativity were generated through the Jacob solution equations and are represented in table 2.

Figure 14 DRAW DOWN AND RECOVERY AQUIFER TEST

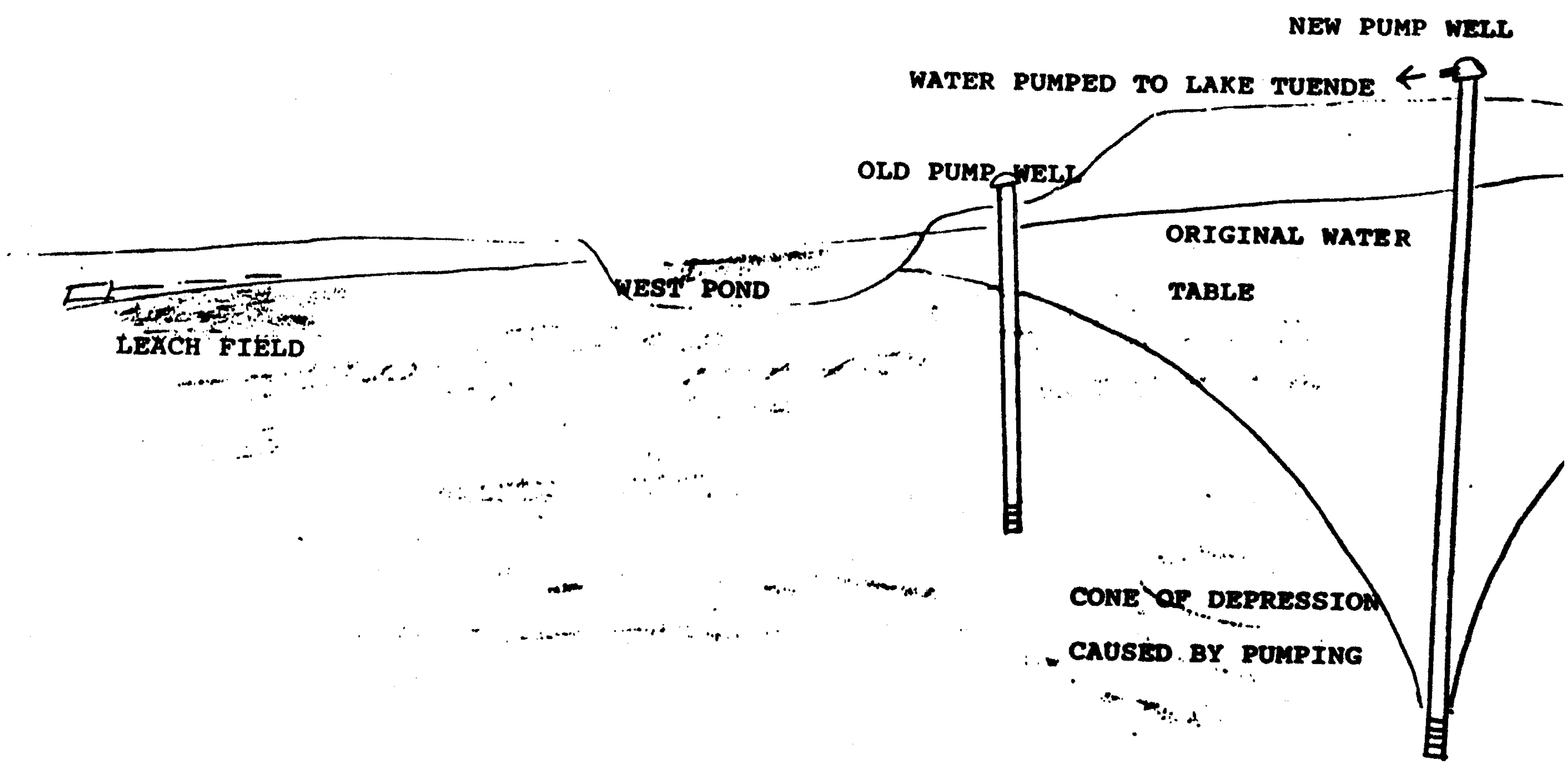
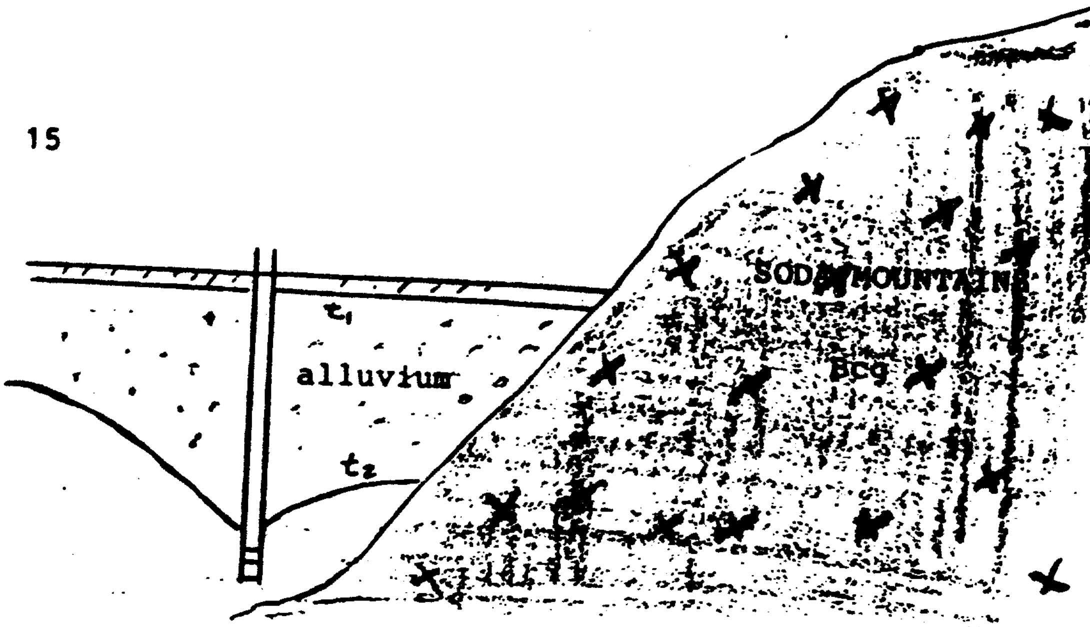


Figure 15



The values for T and S changed during the aquifer test. This change may be a result of the water stored between the new pump well and the the negative boundary of the Soda Mountains being depleted. The aquifer material close to the mountains is coarse. The aquifer material close to the playa is finer and contains more clays. The values for T and S change as water is drawn through different soil types.

III. E. Groundwater Flow Patterns

Figure 16 is a water elevation contour map of Soda Springs (Bilhorn 1985). From this map the flow of groundwater is observed to be moving downhill from higher elevations, 933', in alluvial deposits close to the Soda Mountains down to 925' at the edge of Soda Lake. The flow of fresh groundwater downhill towards Soda Lake keeps salty Soda Lake water from intruding into the alluvial deposits in which West Pond and Lake Tuende are located. The water table elevation contour map also shows that the flow of groundwater is away from M.C. Spring which has a water table elevation of 929.1'. A fracture system through Limestone Ridge provides a conduit for water to flow from the alluvial deposits of Soda Mountains to M.C. Spring.

The gradient for water table elevation is 20x as steep at Lake Tuende as it is at West Pond (Three Bats Pond). Water table elevations drop from an elevation of 933' to an elevation of 932' over a distance of 200' at West Pond. Water table elevations drop from 930' to 925' over a distance of 50' at the border of Lake Tuende. This helps explain why the water elevation at Lake Tuende must be artificially maintained and why the water level at West Pond remains relatively constant.

With an average calculated transmissivity value of 229,000 gpd/ft and estimating an aquifer thickness of 25' at Lake Tuende and 50' at West Pond K values for ground water flow can be calculated. The K values are used to calculate the velocity of groundwater flow. The velocity of water flow from Lake Tuende is aproximately 40X as great as from West Pond.

Ground Water Table Elevation Calculations

3 Bats Pond

$$I = \frac{dh}{L} = \frac{933'-932'}{200'} = .005$$

$$K = \frac{T}{M} = \frac{229,000}{50'} = 4580 \text{ gpd/ft}^2$$

$$V = \frac{KI}{7.48\ Sy} = \frac{(4580)(.005)}{(7.48)(.2)}$$

$$V = 15.3 \text{ ft/day}$$

Lake Tuende

$$I = \frac{dh}{L} = \frac{930'-925'}{50'} = .1$$

$$K = \frac{T}{M} = \frac{229,000}{25'} = 9160 \text{ gpd/ft}^2$$

$$V = \frac{KI}{7.48\ Sy} = \frac{(9160)(.1)}{(7.48)(.2)}$$

$$V = 612 \text{ ft/day}$$

The location of the leach field is adjacent to Lake Tuende and West Pond by the restroom facilities. This provides a potential source of sewage leach field contamination which is high in nutrients. The survey of ground water elevations by Bilhorn is not well defined in this location. However, due to its close proximity to the water bodies and the changes in water table elevation caused by pumping from the new pump well contamination from the leach field could enter 3 Bats

Pond directly. Based on the aquifer test data which showed increased levels of nitrites and electroconductivity as the cone of depression expanded sewage leach field nutrients could indirectly enter Lake Tuende through the new pump well which provides artificial water recharge to Lake Tuende.

Source: Bilhorn and Feldmeth 1985.

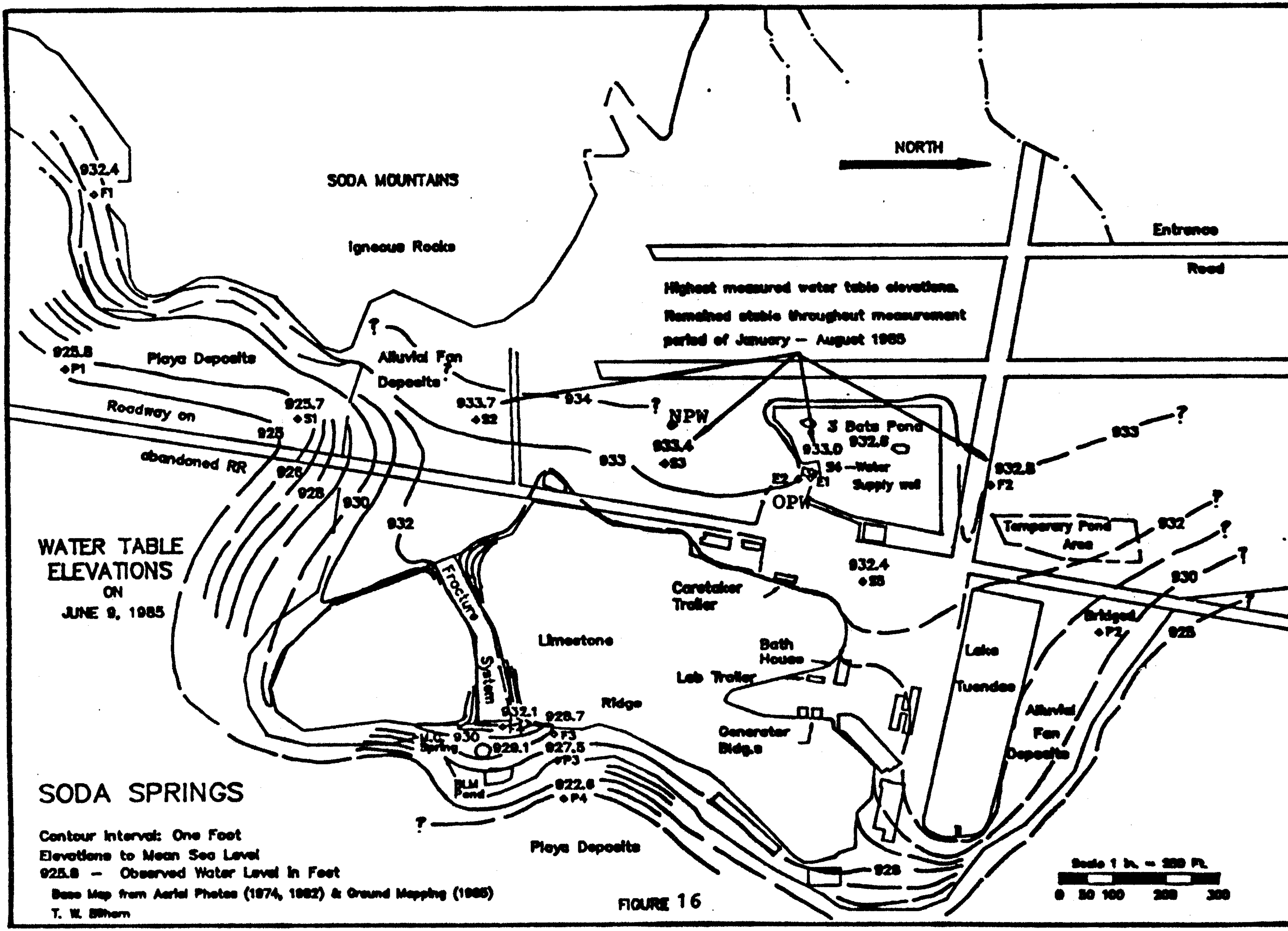


FIGURE 16

IV. WATER QUALITY

IV. A. Field Measurements

a. Soda Springs

All habitat areas at Soda Springs were measured at fixed points for temperature, depth, electroconductivity, salinity, pH, and dissolved oxygen. Table 3 shows the parameter and instrument used. Depth measurements for Lake Tuende took place on 2/25/94 (see figures 6 and 25). The other measurements at Lake Tuende occurred on 5/04/94 and 6/14/94 (see figures 20,22 and table 4). Measurements for M.C. Spring occured on 5/04/94 and 6/14/94 (see figure 7 and table 4). Measurements for West Pond occured on 5/03/94 and 6/14/94 (see figures 5, 18, 23 and table 4).

b. Camp Cady

Measurements at Camp Cady included temperature, electroconductivity, salinity, pH, and dissolved oxygen. These measurements took place on 6/19/94 and are represented in table 4.

c. Desert Studies Information Center

Measurements at the Desert Studies Information Center included depth, electroconductivity, salinity, pH, and dissolved oxygen. These measurements were taken on 6/14/94 and are represented in figure 9 and table 4.

Table 3	PARAMETER	INSTRUMENT USED
	temperature	SCT meter by YSI
	depth	measuring tape
	salinity	SCT meter by YSI
	electroconductivity	SCT meter by YSI
	dissolved oxygen	YSI model 58 D.O. meter
	dissoved oxygen	Hach model ox-2p D.O. kit

Table 4 Results of field measurements

LOCATION	TIME	WATER TEMP	E.C.	SALINITY	pH	DISSOLVED O_2
M.C. Spring - 1' below surface	13:30 6/14/94	26.0°C	3080umho	2.9 ppt	8.2	8.0 ppm
Lake Tuende - at pier, bottom	15:30 6/14/94	27.5	4560	3.0	10.0	8.0
3 Bats Pond - East side, bottom	15:30 6/14/94	26.0	16,500	10.5	9.9	8.0
Calif. Desert Info. Center, bottom	16:45 6/14/94	28.0	2350	1.0	9.1	14.0
Camp Cady West Pond- West Side, surface	13:00 6/19/94	30.0	2300	1.0	9.4	
Camp Cady East Pond- East Side, surface	16:00 6/19/94	28.0	600	<1.0	8.6	13.0

POND, FT. SODA

CONDUCTIVITY (μmho) x100

Source: Taylor 1982.

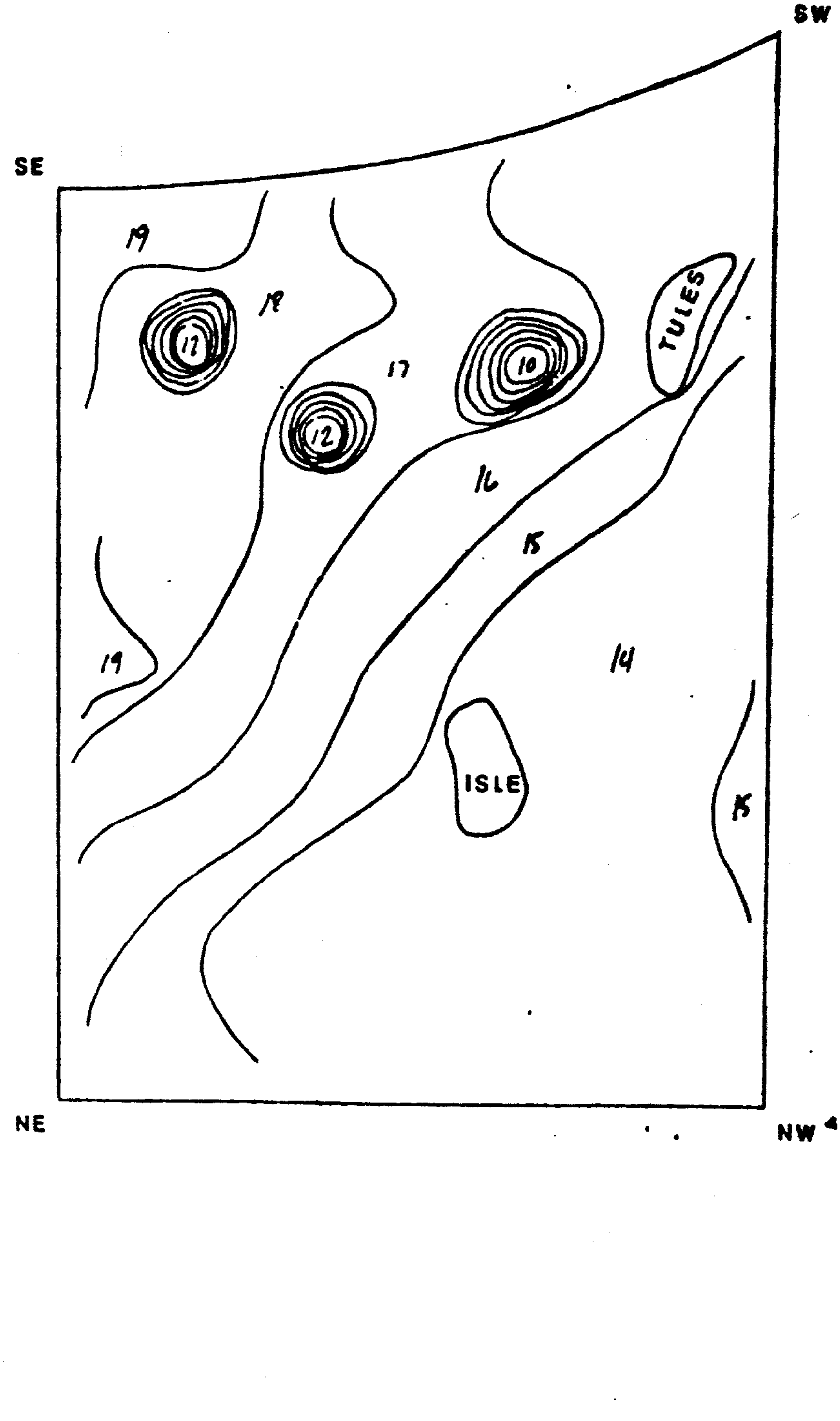


Figure 17 Surface conductivity in Three Bats Pond August 18, 1981 take[illegible] 1400-1800 hours.

WEST POND, FT. SODA

CONDUCTIVITY (μmho x 100)

<u>Surface Conductivity</u>
Bottom Conductivity

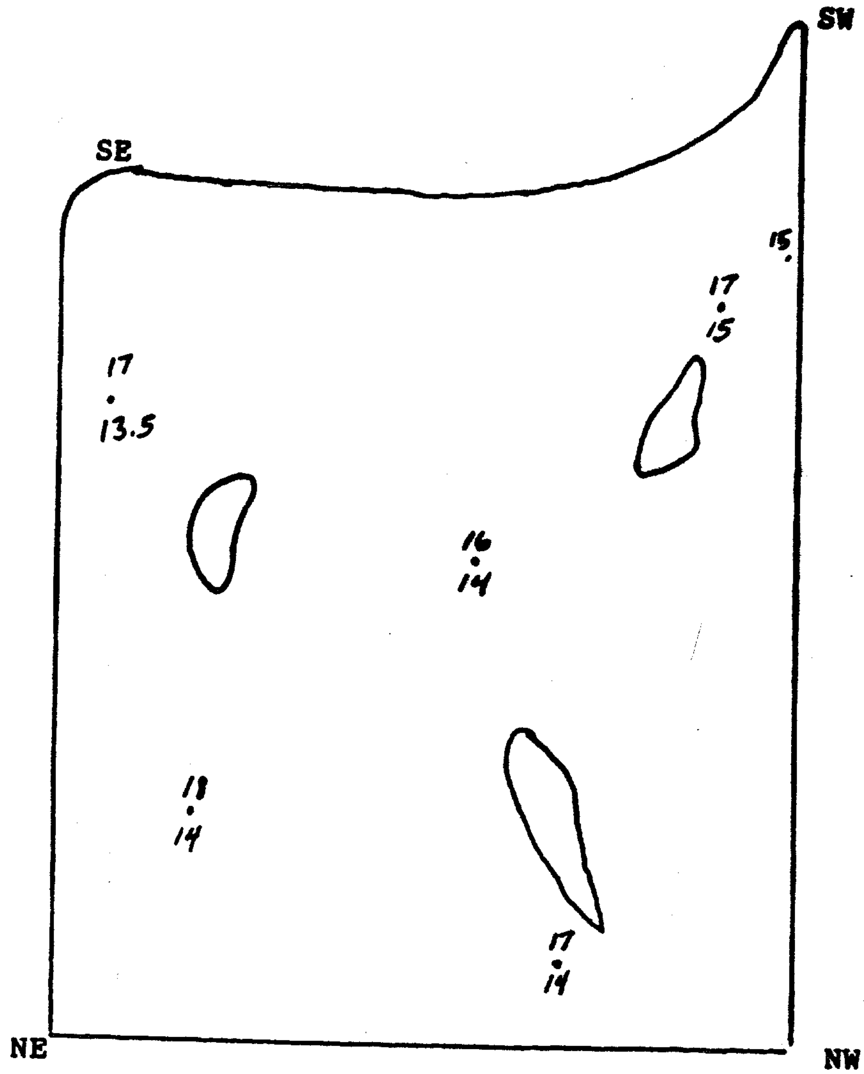
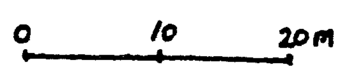


Figure 18 Conductivity in 3 Bats Pond (West Pond) 5/03/94
taken 1500-1800 hours by the author.



LAKE TUENDAE, FORT SODA CONDUCTIVITY (μmho x 100)

Source: Taylor 1982.

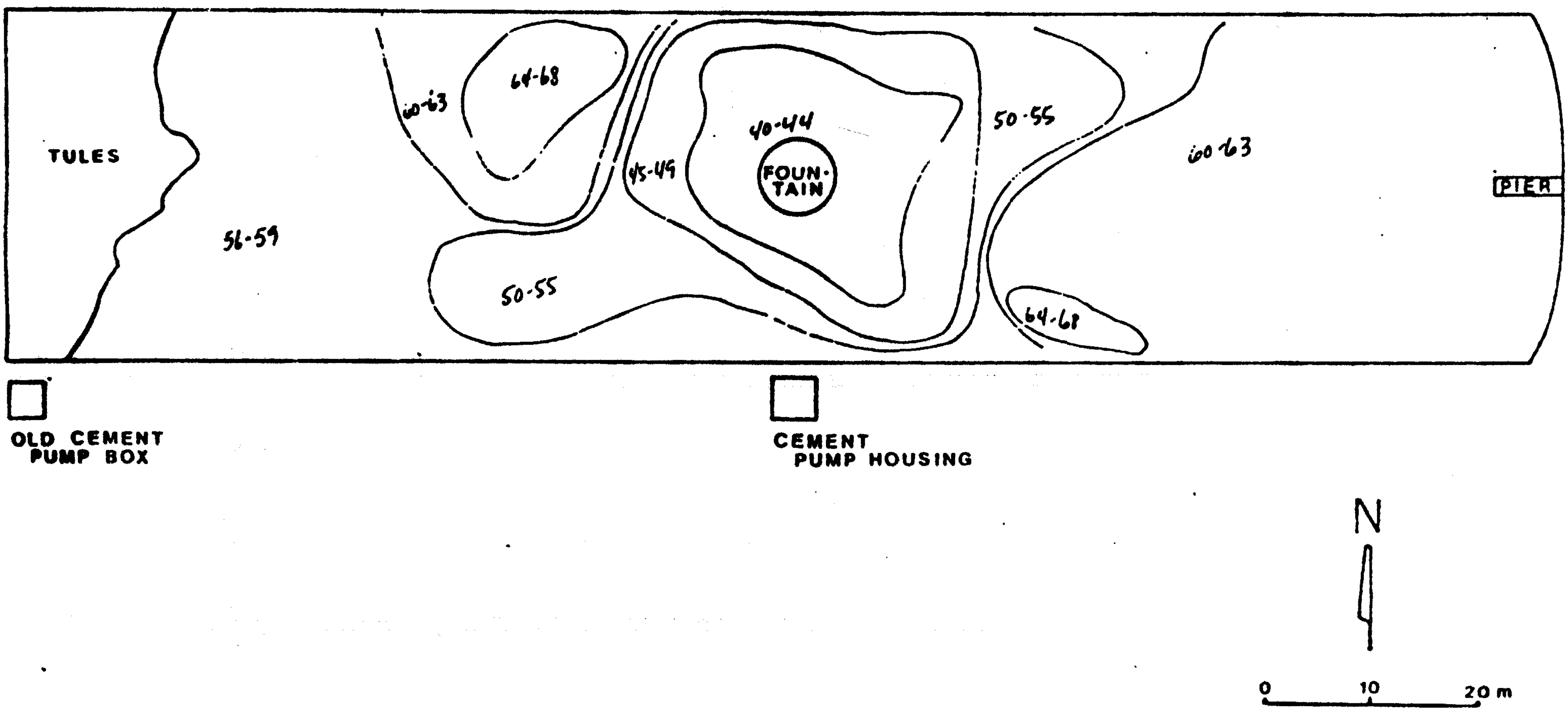


Figure 19 Surface conductivity in Lake Tuendae June 30, 1981 taken 1500-2000 hours.

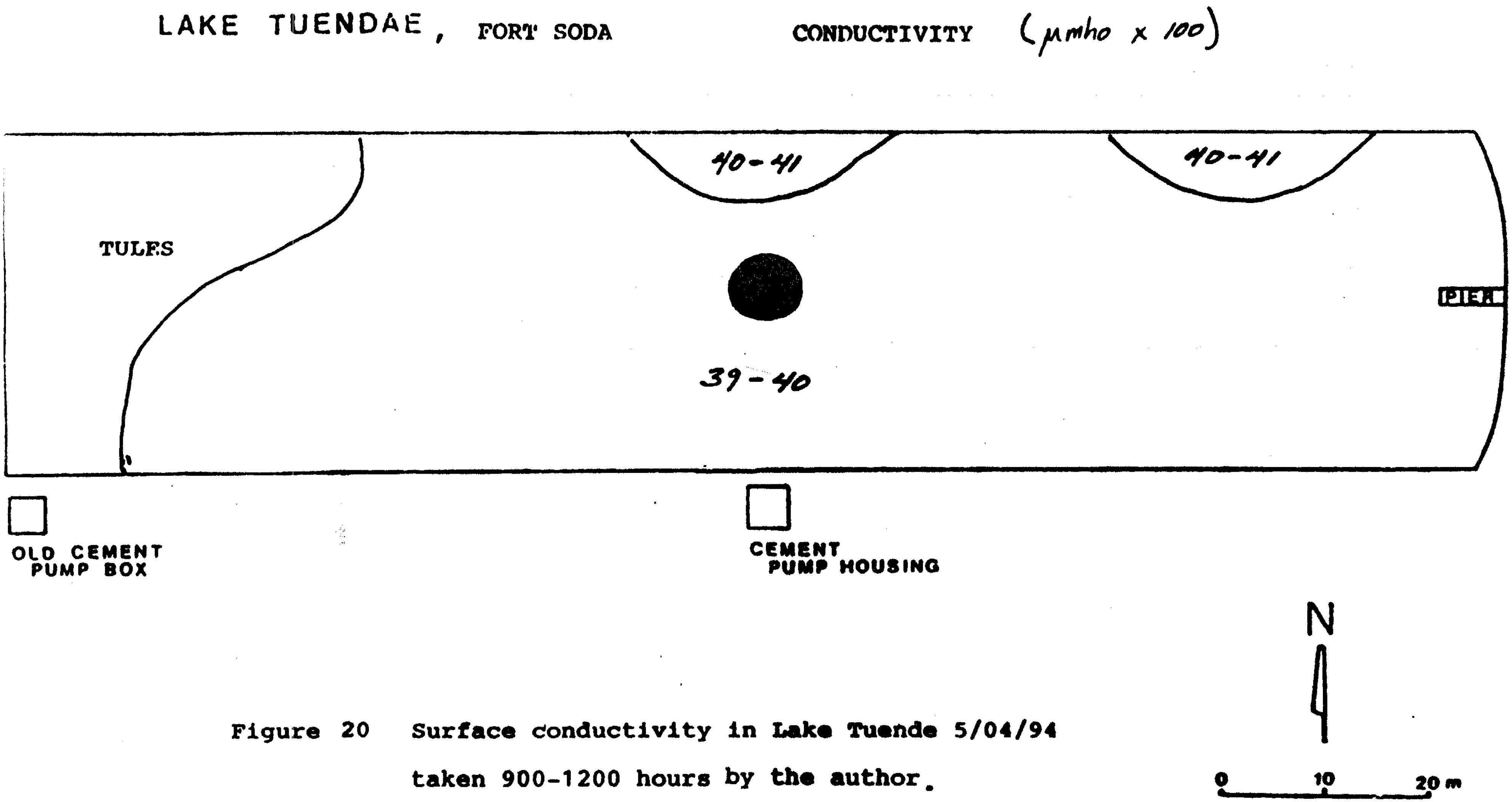


Figure 20 Surface conductivity in Lake Tuende 5/04/94 taken 900-1200 hours by the author.

LAKE TUENDAE, FORT SOLA pH

Source: Taylor 1982.

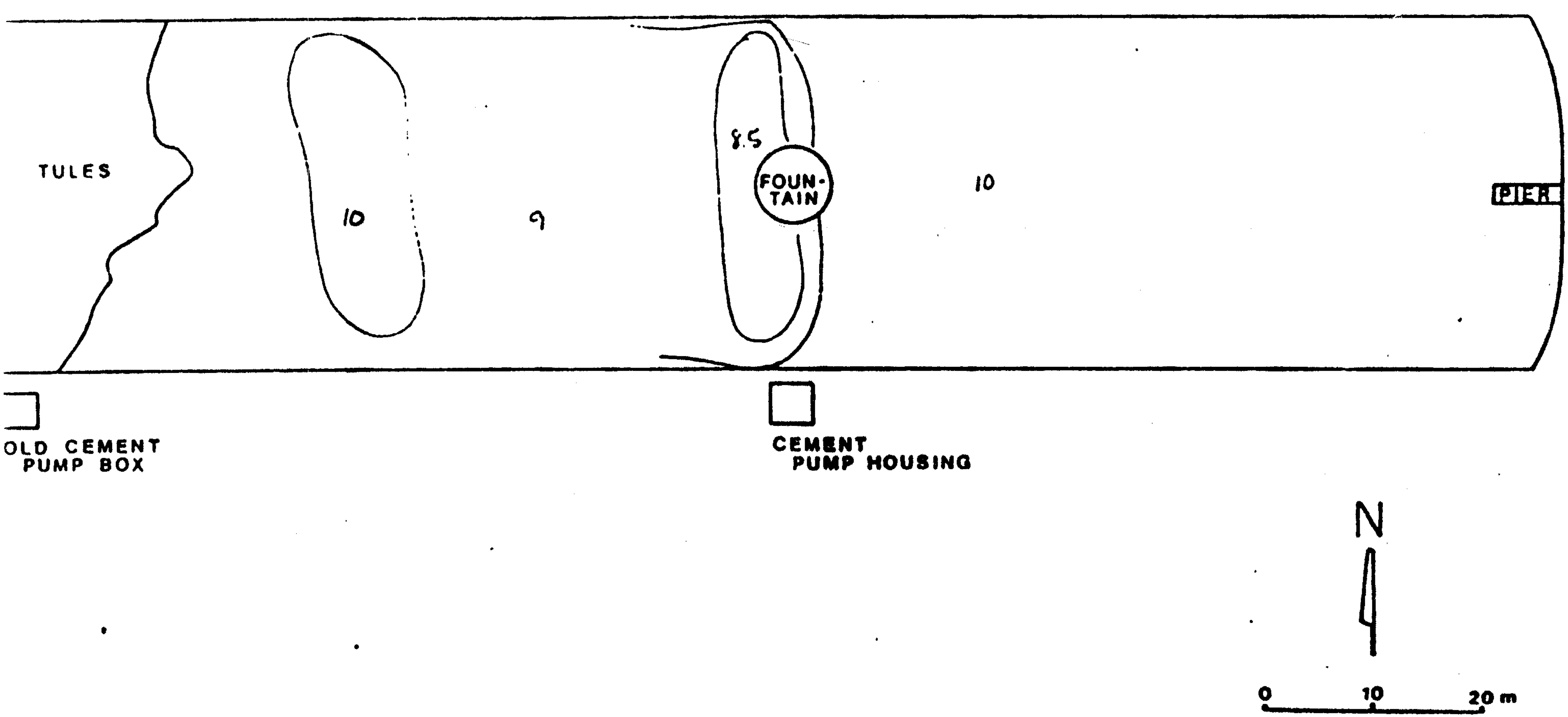


Figure 21 pH in Lake Tuendae June 30, 1981 taken 1500-2000 hours.

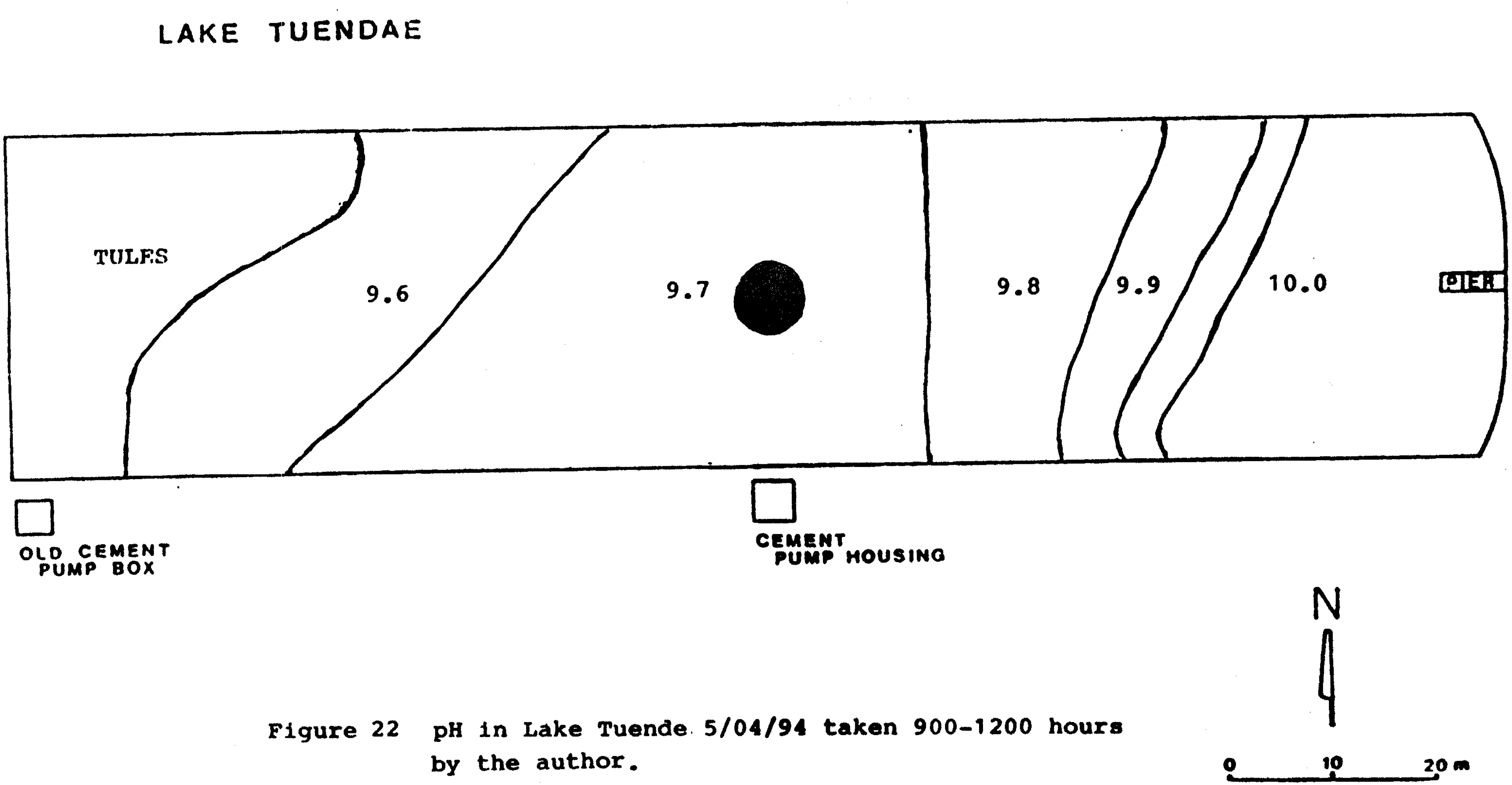


Figure 22 pH in Lake Tuende 5/04/94 taken 900-1200 hours by the author.

WEST POND, FT. SODA pH

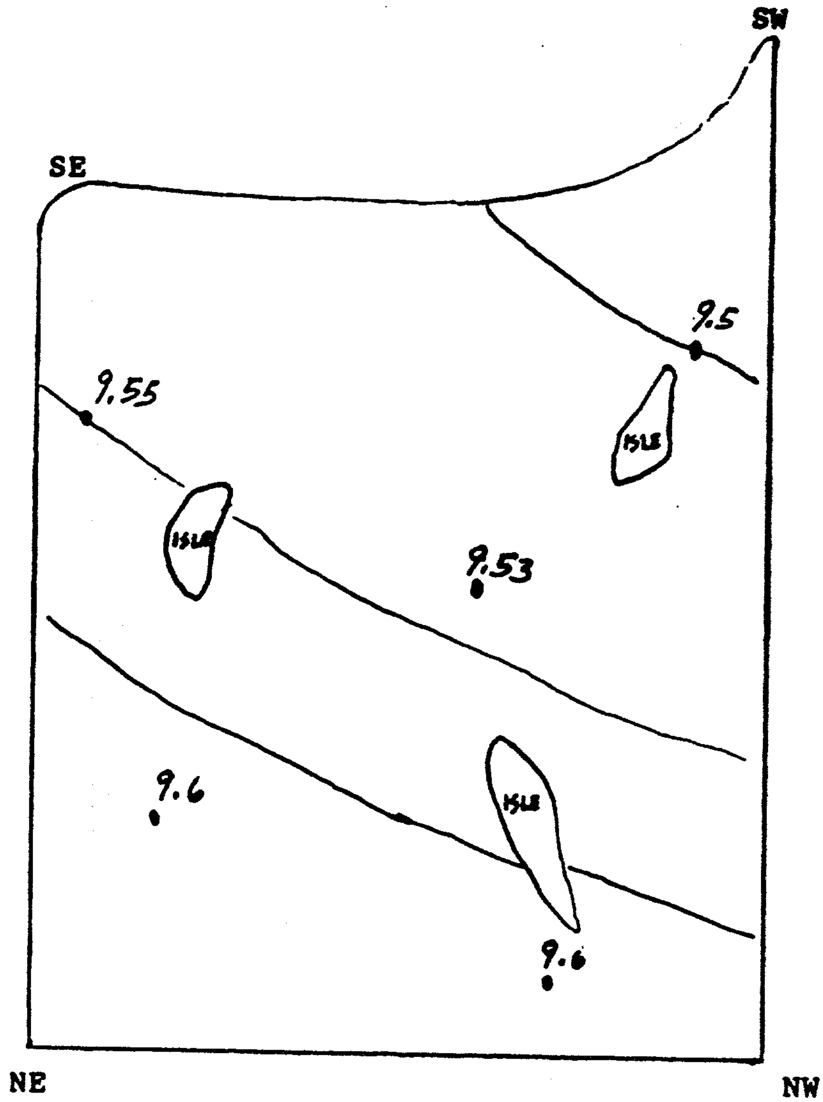


Figure 23 pH in 3 Bats Pond(West Pond) 5/03/94
taken 1500-1800 hours by the author.

LAKE TUENDAE, FORT SODA DEPTH (m)

Source: Taylor 1982.

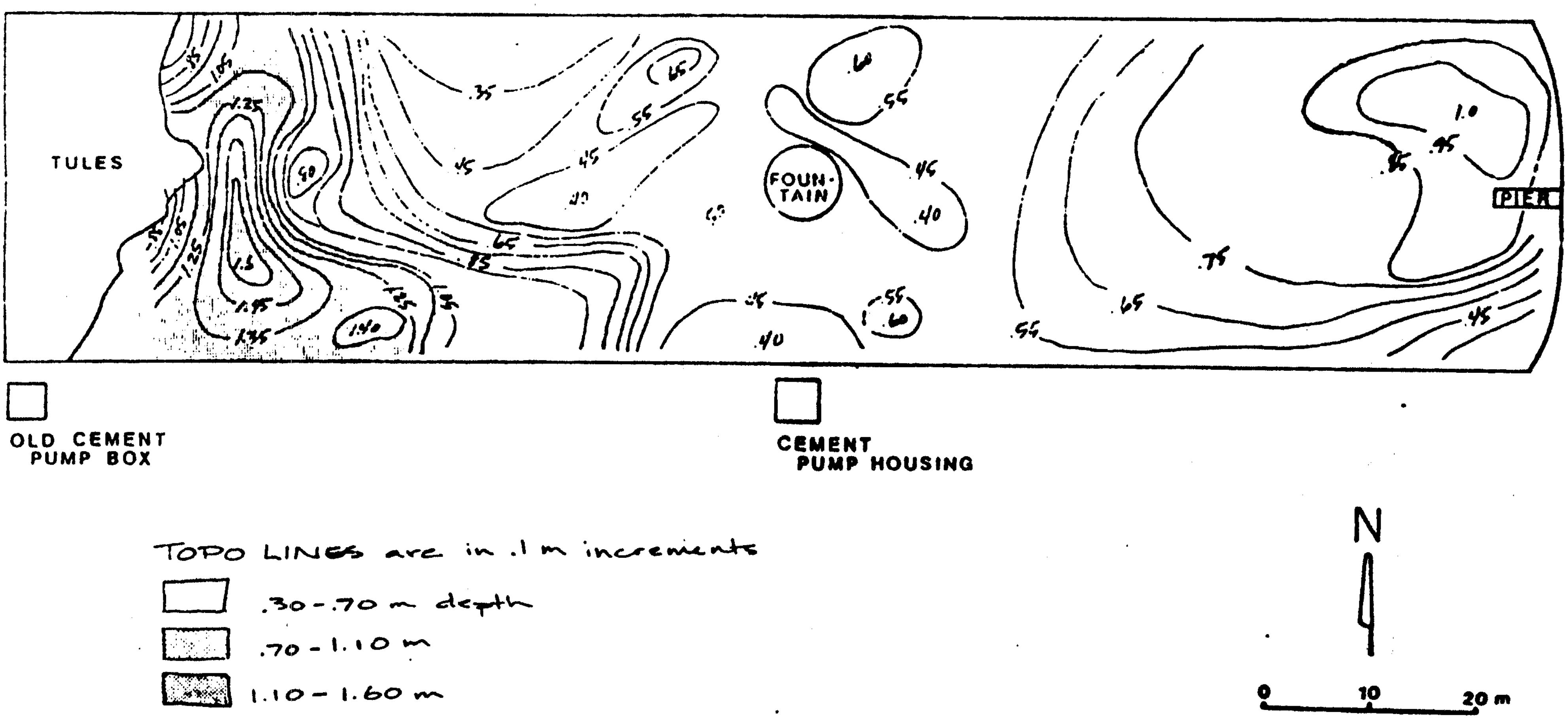


Figure 24 Depth contours in Lake Tuendae, June 30, 1981.

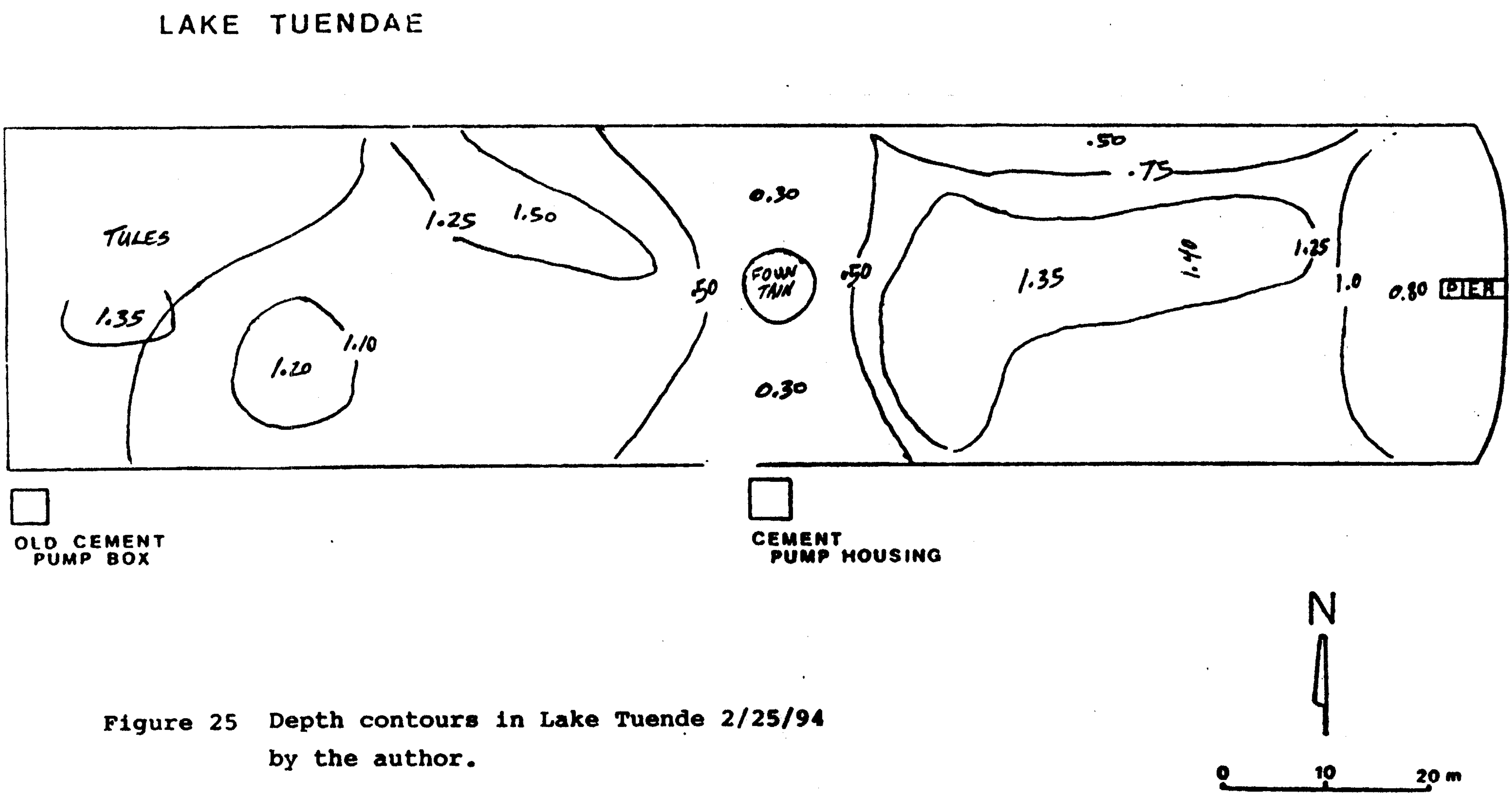


Figure 25 Depth contours in Lake Tuende 2/25/94 by the author.

POND, FT. SODA DEPTH (m)

Source: Taylor 1982.

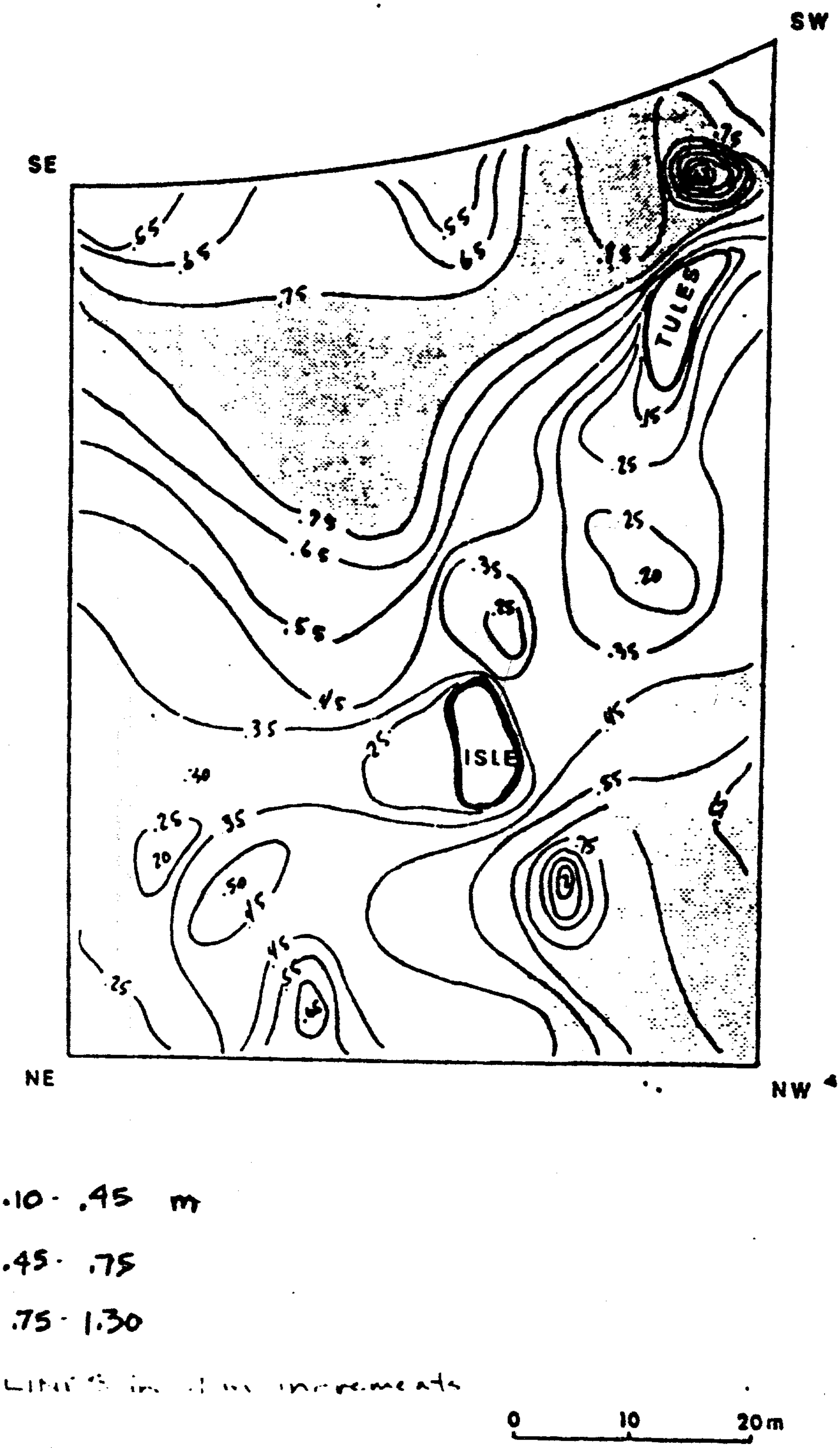


Figure 26 Depth contours in Three Bats Pond August 18, 1981.

d. <u>Discussion of Field Measurements</u>

The contour maps of conductivity at West Pond made by Taylor show three locations of lowered conductivity (Taylor 1982). These are very likely spring locations where fresh water has entered. The surface conductivity readings made by Taylor in 1981 are similar to the author's in the high level readings for West Pond. Taylor shows higher readings of electroconductivity than I do for Lake Tuende. This may be due to the fact that the water supply was from the old pump well at that time which is closer to the leach field. The water around the leach field is higher in electroconductivity. Pumping from the old pump well may have also improved the drainage from West Pond because of its close proximity to West Pond.

The salinity of 10.5 ppt measured at West Pond in Soda Springs is higher than the 10 ppt that can be tolerated by the species (Feldmeth 1984). The salinity of Lake Tuende and the salinity of M.C. Spring are well within the tolerance level of the MTC. However, at a pH of 10.0 Lake Tuende is at the upper range of pH that can be tolerated by the species (see table 2.1). An added source of alkalinity at Lake Tuende may be the concrete used around the fountain and water pump. West Pond has a concrete structure on the west side which is also in contact with the water.

Field measurements at Camp Cady and the California Desert Information Center fall within the tolerance levels of the species. However, at a depth of just 1.8' the California Desert Information Center Pond is more likely to exceed the temperature tolerance of the species than any other site in this study.

IV. B. Chemical Analysis by Babcock Laboratories

a. Method of Sampling

Samples (1-4) from M.C. Spring, Lake Tuende, West Pond (Three Bats Pond) and the California Desert Information Center at Barstow were taken on 6/14/94 and immediately placed on ice. The samples were delivered to Babcock Laboratories on 6/15/94 and a chain of custody form was placed on file. Samples 5-6 for Camp Cady West Pond and Camp Cady East Pond were taken on 6/19/94 and immediately placed on ice. These samples were delivered to Babcock Laboratories on 6/20/94 and a chain of custody form was placed on file.

b. Analysis of Results

The results of the testing by Babcock Laboratories are in Appendix C. Lake Tuende, Three Bats Pond, and the East Pond water at Camp Cady had high pH readings in the 9.5 to 9.7 range. Three Bats Pond had the highest recorded electro-conductivity (18,000 umhos) as would be expected from evaporative deposits. Three Bats Pond also had the highest Kjeldahl nitrogen level 7.2 mg/L and total phosphate level 0.10 mg/L which is indicative of contamination from the leach field which is adjacent to it.

Appendix B gives EPA water quality standards for fresh water biota. Based on these standards the samples did not exceed the water quality criteria for which they were tested. Note that Babcock Laboratories does tests only for total arsenic and does not distinguish between arsenic(pent) and arsenic (tri).

So as to whether the arsenic level exceeds chronic EPA standards for fresh water biota at Three Bats Pond (total arsenic = 130 ug/L) or at East Pond in Camp Cady (total arsenic = 130 ug/L) is inconclusive.

IV. C. Comparisons and Areas of Concern

a. Camp Cady

The ponds at Camp Cady are similar to Three Bats Pond at Soda Springs in that they are evaporative ponds. The East Pond at Camp Cady is lined with plastic and both ponds are lined with clay so very little percolation occurs and most of the water loss is through evaporation. I expect that the salinity of the Camp Cady habitats will continuously increase until these habitats can no longer support MTC if no corrective action is taken.

b. Soda Springs

Lake Tuende has high pH values which are dangerously close to exceeding the tolerance level of the species. The salinity of Lake Tuende is not building up because water flows through Lake Tuende at a much greater rate than West Pond and fresh water is continuously being added to Lake Tuende. Comparisons of Lake Tuende and West Pond with prior chemical analysis shows that the specific conductance of Lake Tuende (4700 umhos) has not appreciably changed from 1984(4580 umhos). The other chemical parameters for Lake Tuende are also very similar. West Pond has undergone a significant increase in conductivity from 14,000 uhmos in 1981 to 18,000umhos in 1994.

c. California Desert Information Center

This pond is very shallow so extremes in temperature are likely to cause a loss of fish in this habitat. At the time of this monitoring there appeared to be an overgrowth of aquatic vegetation which can lead to anoxic conditions in the early morning pre-dawn hours. A die-off of aquatic ditch grass proceeded the fish kill of 1981 in Three Bats Pond (U.S. Fish and Wildlife Service 1984). Anoxic conditions with high levels of nutrients occur when aerobic bacteria digest large amounts of dead algae and/or other aquatic vegetation.

V. 12 STEP EVALUATION SYSTEM FOR MTC HABITAT ASSESSMENT

The evaluation system can be used to determine the suitability of new habitat areas or to recognize areas that can be improved upon in existing habitat areas. The evaluation system consists of 12 parameters. Ranking is from 1 to 3. A 1 ranking is excellent. The habitat is well suited for providing stability over the long term for the MTC. A 2 ranking is average. The tolerance limits of the species are met at the time of the ranking, however, concern exists as to the long term suitability of the habitat. A 3 ranking is poor. Conditions are precariously close to exceeding the tolerance limits of the species. A U ranking means that the system is unsuitable in its present form to provide a stable habitat for the MTC.

1) Salinity/Water Flow

1: The system has a low salinity and adequate natural flow through either by percolation or change to maintain low salinity.

2: The system has artificial flow through the system and salinity levels well within the tolerance limits of the species as occurs in Lake Tuende.

3: The system will have high salinity 7.5-9.0 ppt and no flow through such that salinity will likely increase.

U: The habitat will have a salinity greater than 9.0 ppt. The tolerance limit of the species is 10.0 ppt. Osmoregulatory problems are expected to occur at 8.0 ppt (Feldmeth 1984).

2) pH	7-9	9.1-10.0	10.1-10.5	10.5+
	1	2	3	U

3) Toxins

1: The system has levels of toxic metals and other poisons well below that which can be tolerated by the species and/or the ecosystem in which it is found. Appendix B provides guidelines in this area.

2: The system will have levels of toxic metals and/or other poisons which are high enough to cause some suspicion of concern but still low enough not to measurably impact the MTC.

3: System will have levels of toxic metals and/or other poisons precariously close but not exceeding the limits that can be tolerated by a given population of MTC.

U: The system has levels of toxic metals and/or other poisons which exceed the tolerance limits of the species.

4) Nutrients

1: The system will have nutrients high enough to sustain the food chain but low enough not to cause algal blooms or overgrowth of aquatic vegetation. Phosphates are often a limiting nutrient in aquatic ecosystems.

2: The system will have an overgrowth of algae or other aquatic vegetation such that anoxic conditions are likely to result. If overgrowth appears check the system in the predawn hours for dissolved oxygen levels.

3: The system will have excessive algal blooms and a dissolved oxygen level of 2ppm during the predawn hours.

U: The system will have excessive algal blooms such that the dissolved oxygen levels drop below 2 ppm during the predawn hours.

5) Temperature

1: The system will have a history of not exceeding the temperature tolerance window of the species (2.8°C - 36.2°C) in a majority of its habitat area (McClanahan et al. 1986).

2: The system will come close but not exceed the tolerance levels of the species over a significant portion of the habitat.

3: The system will exceed the temperature tolerance limits of the species over a majority of the habitat during very hot summer days or very cold winter mornings.

U: The habitat exceeds the temperature tolerance limits of the species at its maximum depth during very hot summer days or very cold winter mornings.

To evaluate the temperature stability of a habitat test the water temperature in the early afternoon hours of a very hot summer day and a very cold winter morning at various depths. Note the wind conditions as mixing due to wind can alter the results. The turbidity is also a factor. Turbid water allows less light to penetrate.

6) Food Chain

1: The food chain will have moderate amounts of aquatic vegetation and an abundance of aquatic invertebrates of many different species.

2: The system will have an abundance of aquatic invertebrates but few species.

3: The system will have few aquatic invertebrates and little vegetation such that the ability of the ecosystem to support a population of MTC is questionable.

U: The system lacks a food chain adequate enough to support a population of MTC.

If the system has very little in the way of vegetation and invertebrates; nutrients and invertebrates can be added. To calculate how much nutrients to add first determine the volume. Match the concentration levels of nutrients with habitats of similar configuration that have a rich food chain. Caution should be exercised in not over fertilizing.

7) <u>Configuration</u>

1: The system will have a volume to area ratio of greater or equal to 5:1 to stabilize temperature and chemical fluctuations (Bilhorn and Feldmeth 1985). The habitat will also be large enough to support a population of at least 500 MTC. The average depth will be at least 1.5m (5') to hinder the growth of cattails.

2: The system will have a maximum depth of at least 1.5m (5') over a significant portion of the habitat.

3: The system will have an average depth of between 0.6m (2') and 0.9m (3') and a maximum depth of at least 1m (3.3').

U: Maximum depth is less than 1m (3.3')

If the depth is shallow the pond can be excavated. Otherwise external shading and heating may be required to keep the temperature range within the tolerance window of the species.

8) System - Natural/Unnatural

1: A natural system is one in which the water level is not artificially maintained. A system with this ranking will have a dependable water source and good water quality. A natural system is preferred because it requires less maintenance.

2: An unnatural system with a dependable water source of good quality. The water level must be artificially maintained.

3: An unnatural system in which the water source is likely to diminish during droughts.

U: An unnatural system which will likely dry up during droughts.

9) Flooding Threat

Flooding is a concern because it can result in the loss of fish and the introduction of arroyo chub.

1: If there is no threat from a 100 year flood the system receives a 1 ranking.

2: If a 50 year flood is likely to wash out the habitat it receives a 2 ranking.

3: The habitat is located in the Mojave River Bed or one of the dry lake beds which are expected to flood is adjacent to the habitat.

U: A system with a great flooding threat and a population of arroyo chub is near by.

10) Historical Range

1: The habitat is within the historic range of the species i.e. within the range of the Mojave River and/or the Mojave River drainage basin.

U: The habitat is outside the historic range of the species.

11) Presence of Arroyo Chub

1: Arroyo chub are not present.

U: Arroyo chub are present.

12) Funding/Staff Availabilty

1: Funding and staff are available to maintain the habitat on a long term basis.

2: The system is a natural one and the habitat configuration is excellent so little funding/staff are required.

3: There is intermittent funding/staff availability.

U: There is no long term commitment to maintaining the habitat.

If the habitat receives a 3 or U ranking in categories 1 through 6 or a U ranking in category 11 the habitat as a whole is considered poor or unsuitable in its present state to provide a stable habitat for the MTC. Category 7 (configuration) is double weighted due to its importance in stabilizing temperature and chemical fluctuations and providing a habitat capable of supporting at least 500 fish.

Table 5

Parameters	Camp Cady Ponds	M.C. Spring	Lake Tuende	California Desert Information Center	Three Bats Pond
1) Salinity/Water Flow	2	1	2	2	U
2) pH	1	1	2	1	2
3) Toxins	1	1	1	1	1
4) Nutrients	1	1	1	1	2
5) Temperature	1	1	1	3	1
6) Food Chain	-	-	-	-	-
7) Configuration	-	2	2	U	2
8) System Nat./Unnat.	2	1	2	2	1.5
9) Flooding Threat	2.5	3	2.5	1	2.0
10) Historical Range	1	1	1	1	1
11) Presence of Arroyo Chub	1	1	1	1	1
12) Funding/Staff	1	1	1	1	3
RANKING	1.35	1.33	1.54	3	U

VI. RECOMMENDATIONS

A. Development of New Habitat Areas

In order for the MTC to be considered for delisting by federal and state agencies from an endangered species to a threatened species, six populations consisting of at least 500 fish must be established for at least ten years (U.S. Fish and Wildlife Service 1984). These sites should be established in the MTC's historic natural range. In addition these sites must have been exposed to flood conditions before reclassification can occur (U.S. Fish and Wildlife Service 1984).

Currently three populations of MTC of populations greater than 500 exist. They are at Soda Springs, Camp Cady and the Marshlands of China Lake Naval Weapons Center.

Three more populations of MTC with populations greater than 500 must be established for reclassification to a threatened species can occur. For complete delisting to occur MTC will have to be returned to a majority of its historic habitat in the Mojave River. This would require the removal of the arroyo chub (U.S. Fish and Wildlife Service 1984).

The MTC Advisory Committee is represented by: the United States Fish and Wildlife Service, the California Department of Fish and Game, The Bureau of Land Management and the Desert Consortium. This committee has selected the following locations as the best potential new habitat areas for the MTC: Afton Canyon Campground and Mojave Narrows Regional Park (U.S. Fish and Wildlife Service 1984).

Robert Feldmeth and David Soltz have done a study on possible relocation sites. These sites included: two pools along the Mojave River in Afton Canyon, two springs located in the Lucerne Valley and Owl Hole Spring just S.E. of Death Valley National Monument. Based on their evaluation system which took into account: chemistry, temperature, oxygen, food, habitat and disturbance, they ranked Owl Hole Spring best followed by Dove Spring and Campground Pond. The other sites were eliminated from consideration based on the natural conditions which existed at the time (Feldmeth and Soltz 1985).

In considering relocation sites for the MTC the evaluation system developed in chapter five is meant to serve as an aid in selecting viable habitat relocation sites.

VI. B. Strategies to Rehabilitate West Pond

West Pond suffers from a build up of salts through evaporation. To maintain the salinity below the tolerance level of the fish the salty water must be periodically discharged. A channel could be constructed for this purpose or the water could be pumped out. The addition of fresh water from the new pump well as occurs in Lake Tuende would also help lower the salinity level.

The water pumped to Lake Tuende is delivered through a water fountain. This method of delivery increases the aeration of the pond and also acts to purify the water of volatile organics. In addition the water fountain is aesthetically pleasing. The use of a water fountain to deliver fresh water to West Pond should be favorably considered.

The relocation of the sewage leach field will improve the water quality of Lake Tuende and West Pond by removing a contamination plume of nutrients and salts which is now adjacent to Lake Tuende and West Pond. West Pond receives the brunt of the contamination plume because the water elevation of Lake Tuende is artificially raised. The flow of water is from the higher level of Lake Tuende to the lower level of the sewage leach field. The water level of West Pond is not artificially raised so the flow of contaminants to West Pond is more likely.

VI. C. <u>Measures to Improve the M.C. Spring Habitat</u>

Currently M.C. Spring must have cattails periodically removed to prevent overgrowth which could lead to diminished dissolved oxygen levels in the predawn hours. If M.C. Spring were made deep enough cattails and sedges would no longer have the tendency to inundate the spring.

If it is decided that M.C. Spring should be made larger to increase its habitat area the enlargement should occur on the Limestone Ridge side of M.C. Spring. BLM Pond which was excavated on the Soda Lake side has high salinity because of the lower groundwater table elevation causes mixing with the saltier water under Soda Lake.

To protect M.C. Spring from flooding a berm could be placed around the spring. In 1916 and 1938 flood waters filled Soda Lake and Silver Lake to a depth of 3 meters (Hubbs and Miller 1943). Because of the close proximity of M.C. Spring to Soda Lake a berm placed around the spring might prevent the fish from escaping into Soda Lake should a flood occur.

VI. D. Recommendations for Camp Cady

The Camp Cady habitat consists of two evaporative ponds. The salinity of these ponds should be monitored annually. Prior to the salinity reaching 8 ppt which has shown to cause osmoregulatory problems in MTC (Feldmeth 1984), the ponds should be partially drained and flushed with fresh water as needed to lower the salinity level. The level of arsenic at Camp Cady's East Pond which is now at 130 ug/L should also be monitored.

VI. E. Recommendations for the California Desert Information Center

It is recommended that shade be provided to this habitat so that high water temperatures greater than 35°C (Feldmeth 1984) do not exceed the tolerance level of the species in this shallow habitat. Small palm trees placed around the pond could serve this purpose. This would also aid in controlling the overgrowth of aquatic ditch grass (Ruppia maritima) by diminishing the amount of sunlight that reaches the pond. In the event of freezing temperatures the MTC would also be at risk. Some measures should be made to provide heating in the event of freezing temperatures. The alternative for achieving a temperature stable habitat would be to make the habitat deeper.

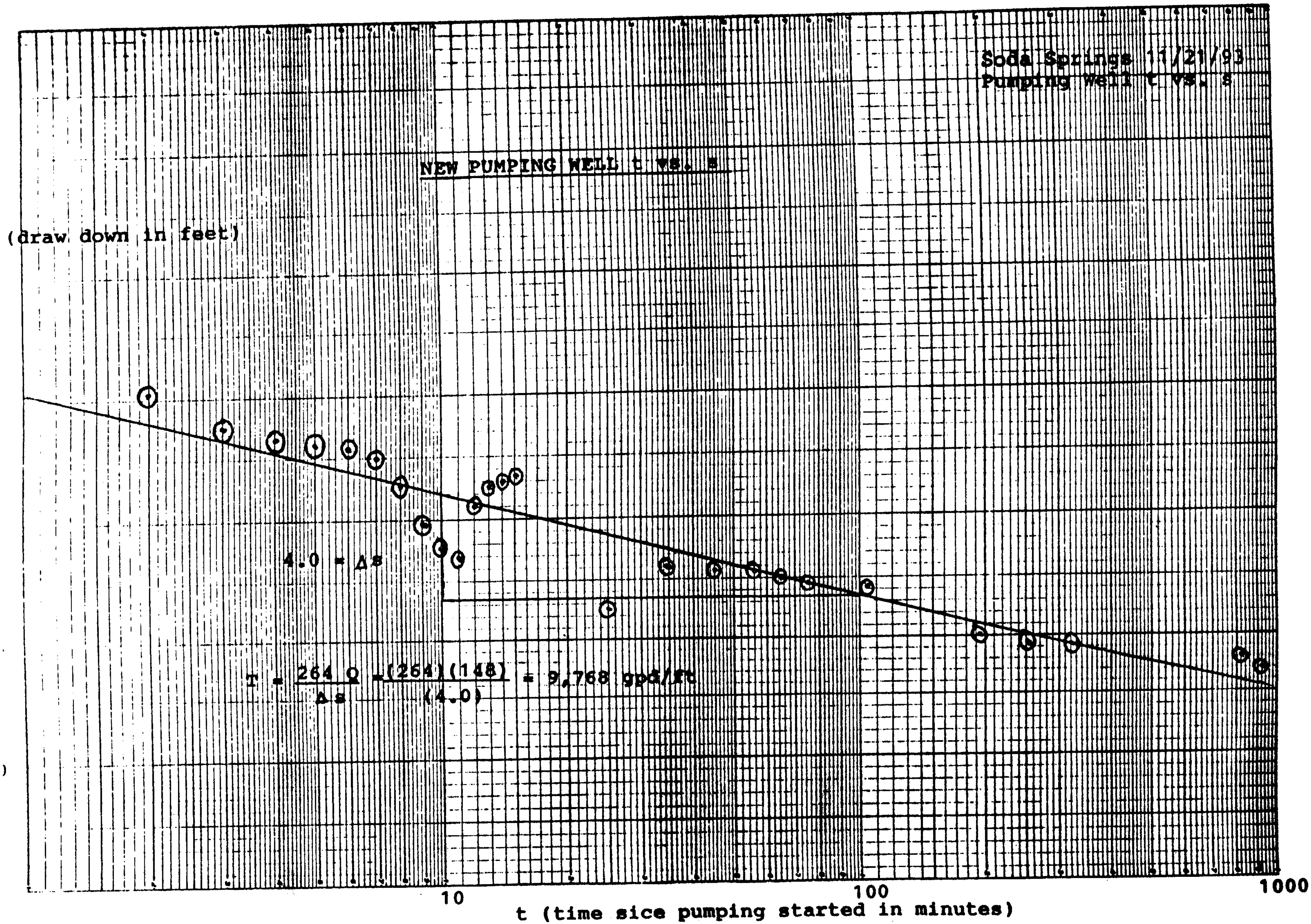
The habitat as of 6/14/94 appeared to have an overgrowth of aquatic ditch grass. Tom Egan Ph.D. (BLM Biologist) suggested that a species of catfish which feeds on vegetation could be used to control overgrowths of vegetation.

APPENDIX A: AQUIFER TEST GRAPHS

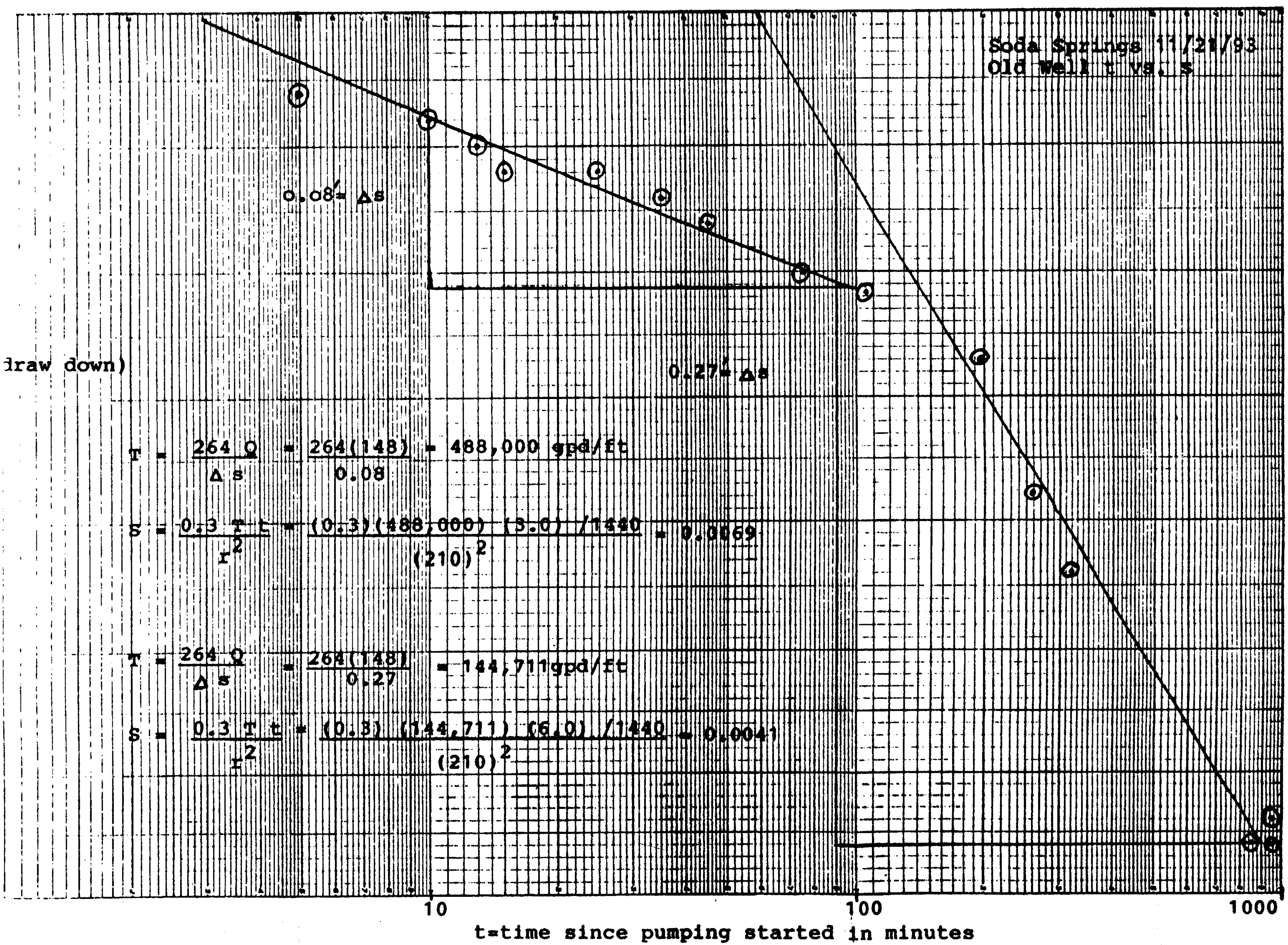
Table 2

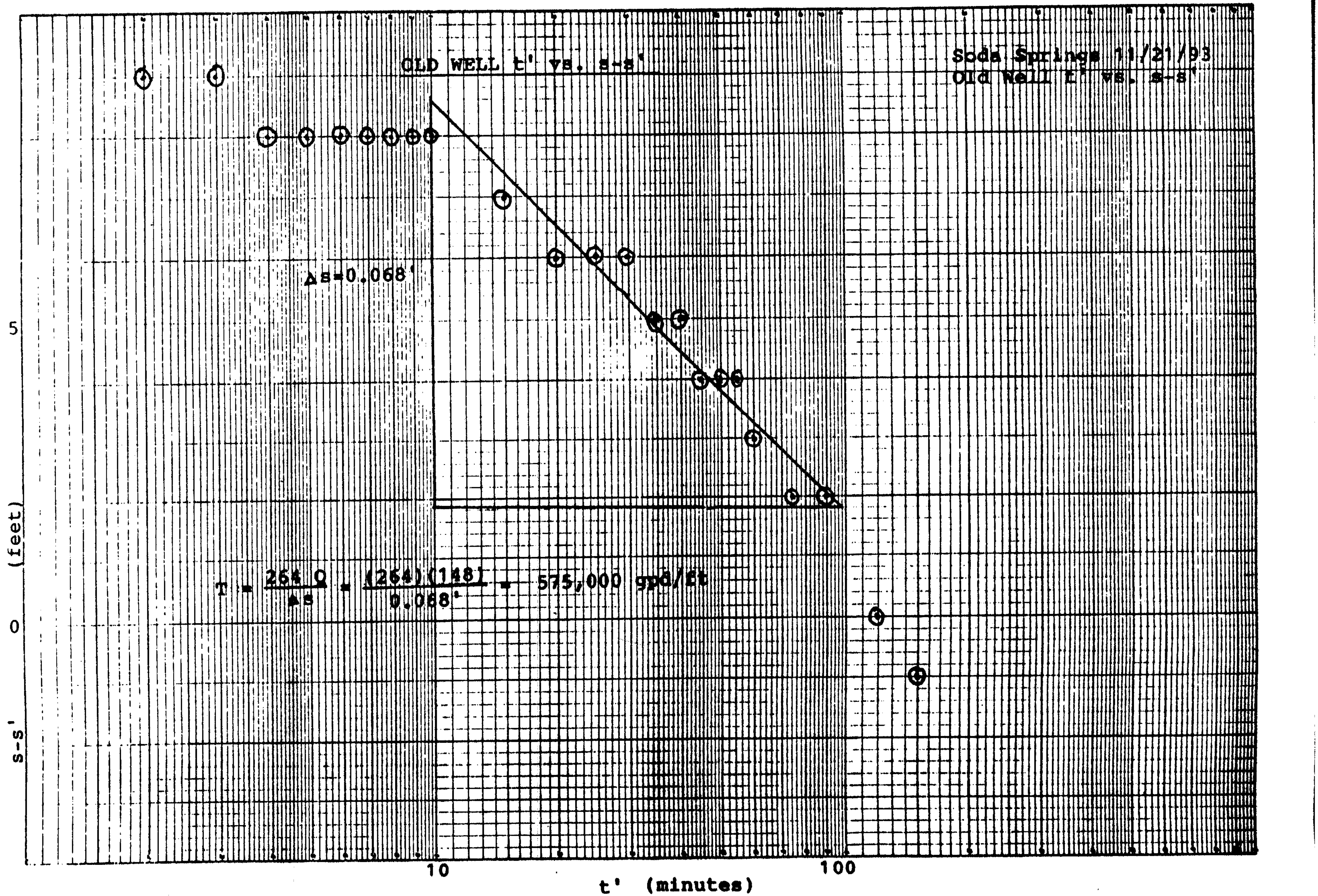
GRAPH	t (gpd/ft)	s
t vs. s NPW	9,800	
t vs. s OPW i	488,000	.0069
t vs. s OPW ii	144,700	.0041
t' vs. s-s' OPW	575,000	
t' vs. s-s' NPW	30,000	
t/t' vs. s' NPWi	27,900	
t/t' vs. s' NPWii	8,300	
t/t' vs s' OPW	550,000	

The storage coefficient, s, is a measure of the volume of water released per unit volume of soil. The transmissivity value describes the quantity of water travelling per unit distance.

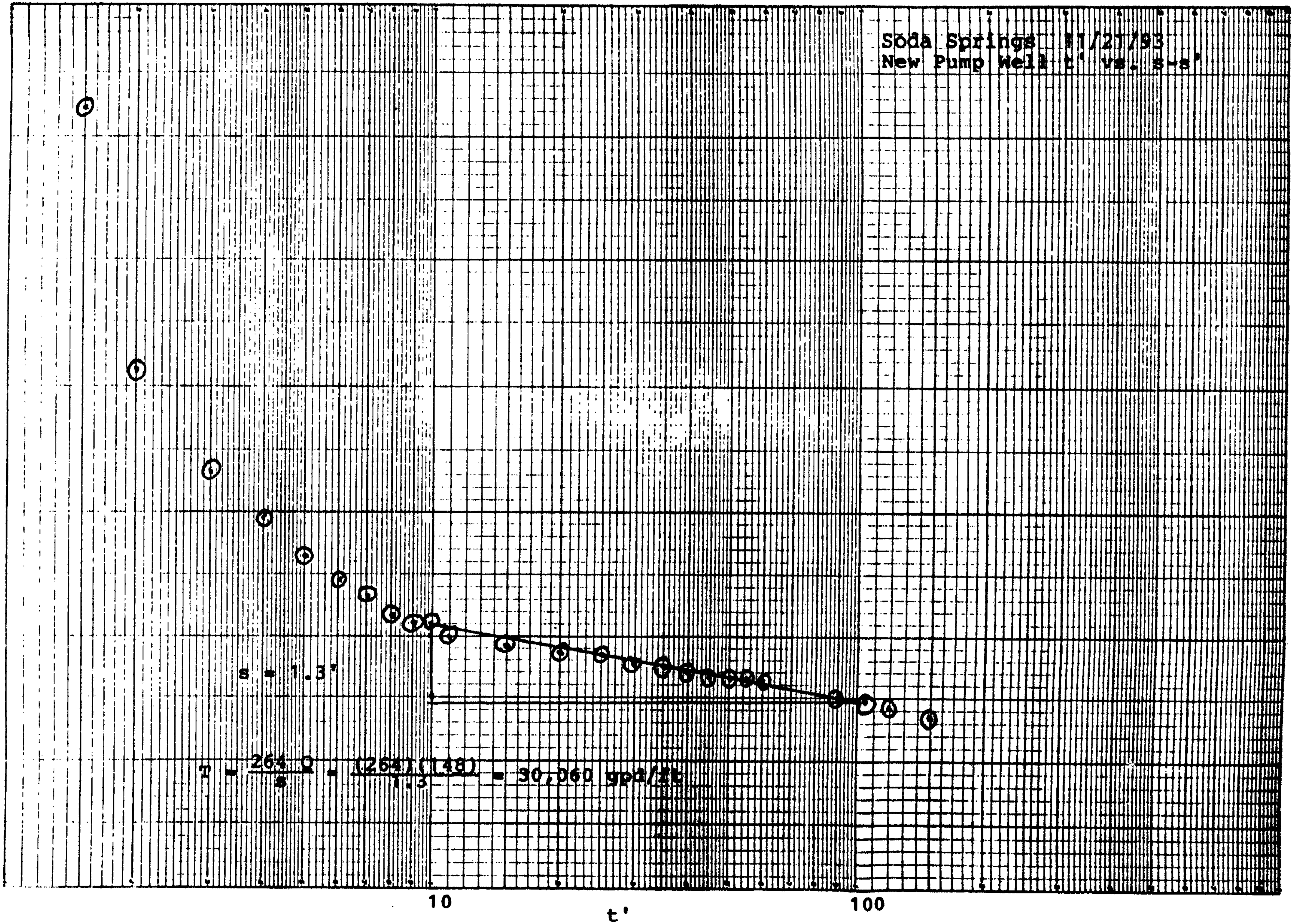


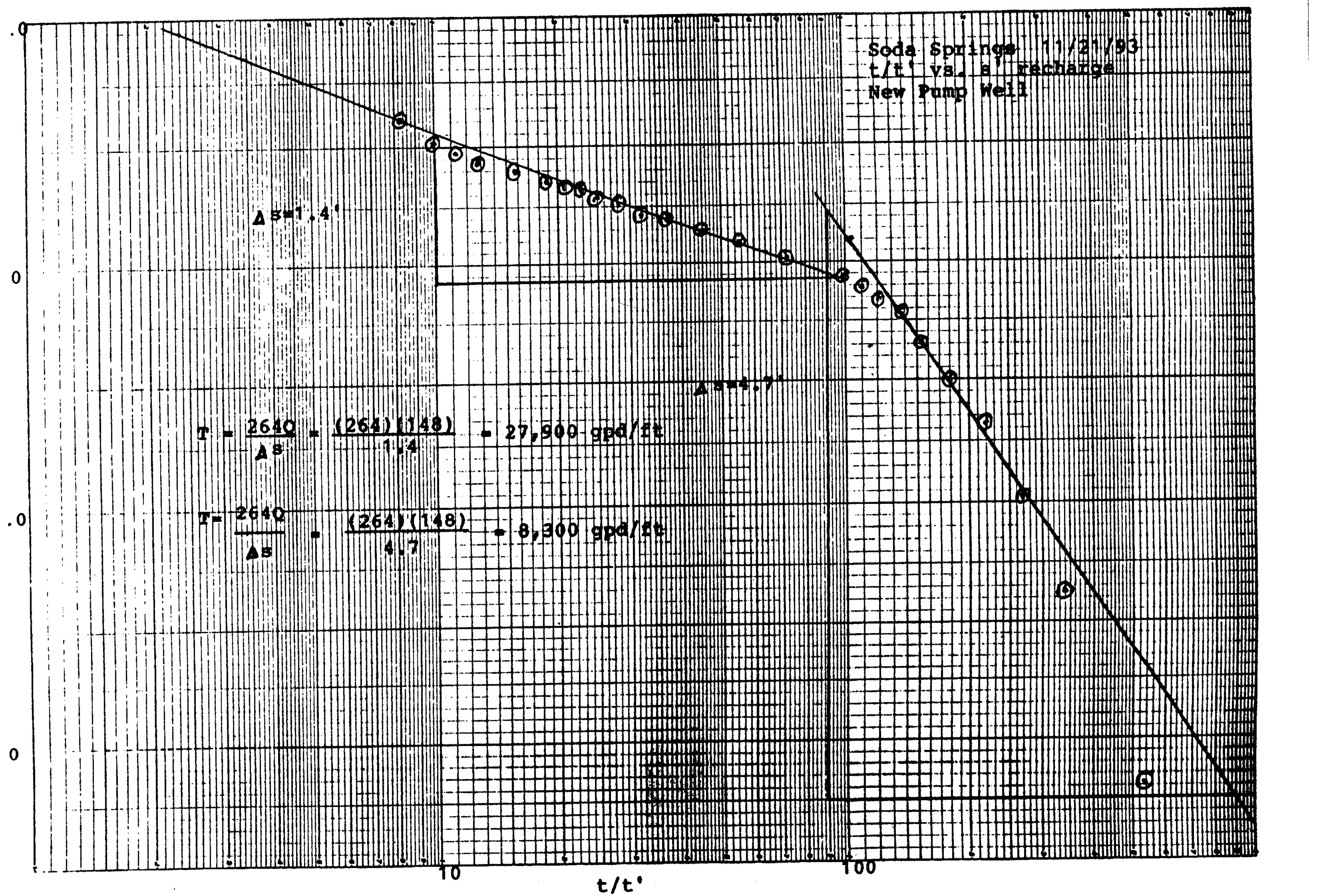
Soda Springs 11/21/93
Pumping Well t vs. s
NEW PUMPING WELL t vs. s
(draw down in feet)
4.0 = Δs
T = 264 Q / Δs = (264)(148) / (4.0) = 9,768 gpd/ft
10
100
1000
t (time sice pumping started in minutes)

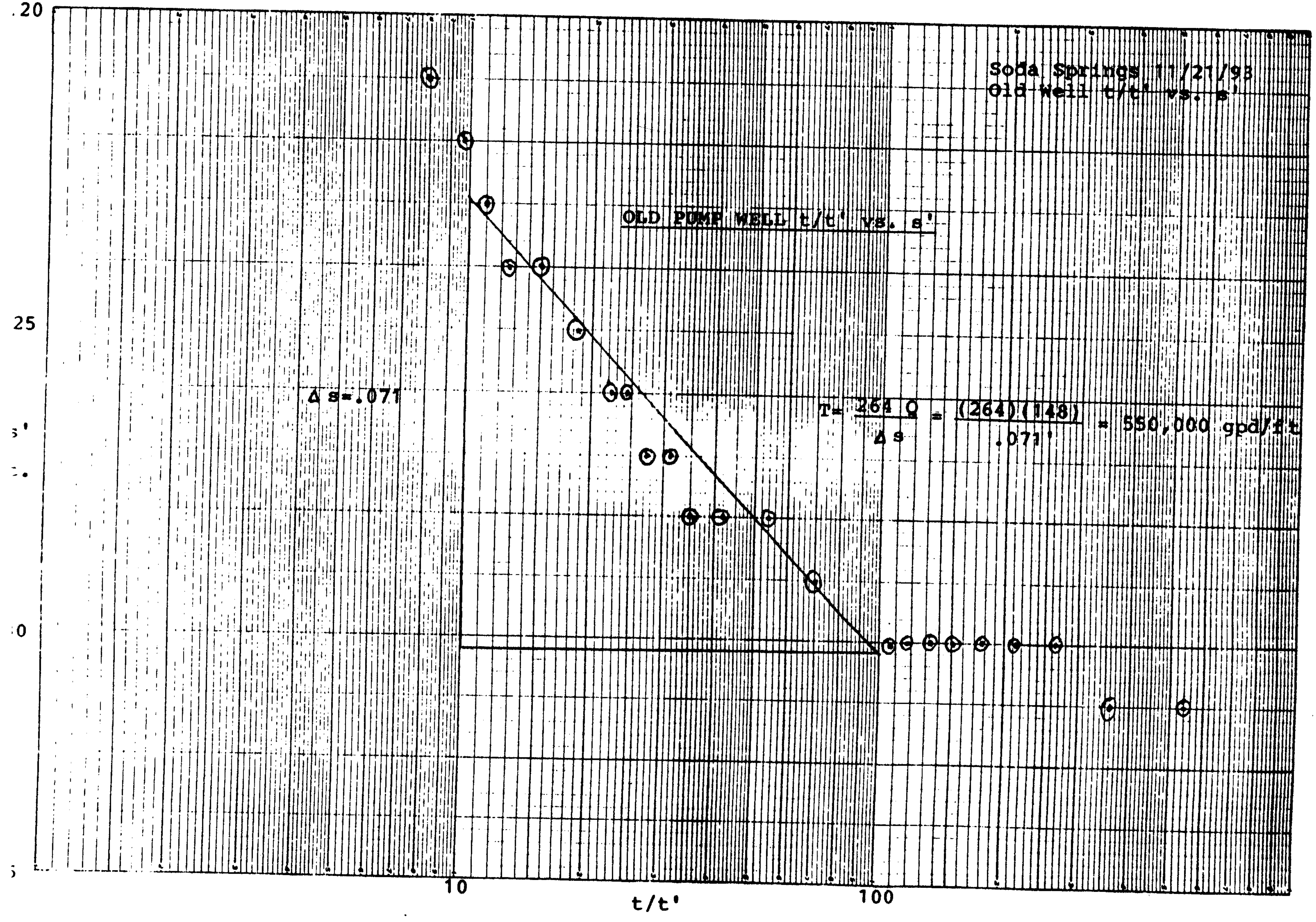

Soda Springs 11/21/93
Old Well t vs. s
0.08′ = Δs
0.27′ = Δs
draw down)
T = 264 Q / Δs = 264(148) / 0.08 = 488,000 gpd/ft
S = 0.3 T t / r^2 = (0.3)(488,000) (3.0) /1440 / (210)^2 = 0.0069
T = 264 Q / Δs = 264(148) / 0.27 = 144,711gpd/ft
S = 0.3 T t / r^2 = (0.3) (144,711) (6.0) /1440 / (210)^2 = 0.0041
10
100
1000
t=time since pumping started in minutes



Soda Springs 11/21/93
Old Well t' vs. s-s'
OLD WELL t' vs. s-s'
Δs=0.068'
T = 264 Q / Δs = (264)(148) / 0.068' = 575,000 gpd/ft
5
0
s-s' (feet)
10
100
t' (minutes)

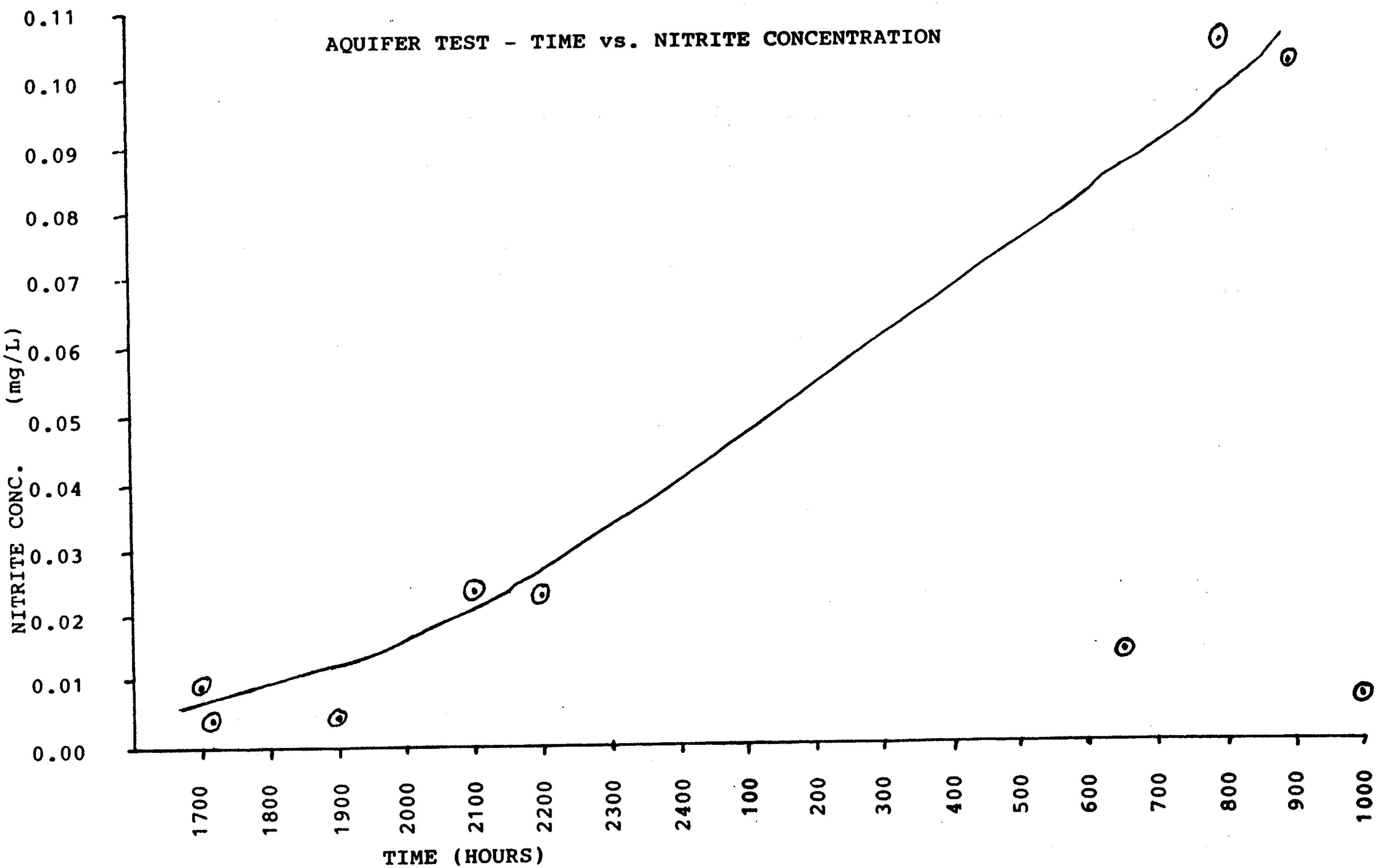

Soda Springs 11/21/93
New Pump Well t' vs. s-s'
s = 1.3'
T = 264 Q / s = (264)(148) / 1.3 = 30,060 gpd/ft
10
100
t'


Soda Springs 11/21/93
t/t' vs. s' recharge
New Pump Well
Δs=1.4'
Δs=4.7'
T = 264Q/Δs = (264)(148)/1.4 = 27,900 gpd/ft
T = 264Q/Δs = (264)(148)/4.7 = 8,300 gpd/ft
10
100
t/t'



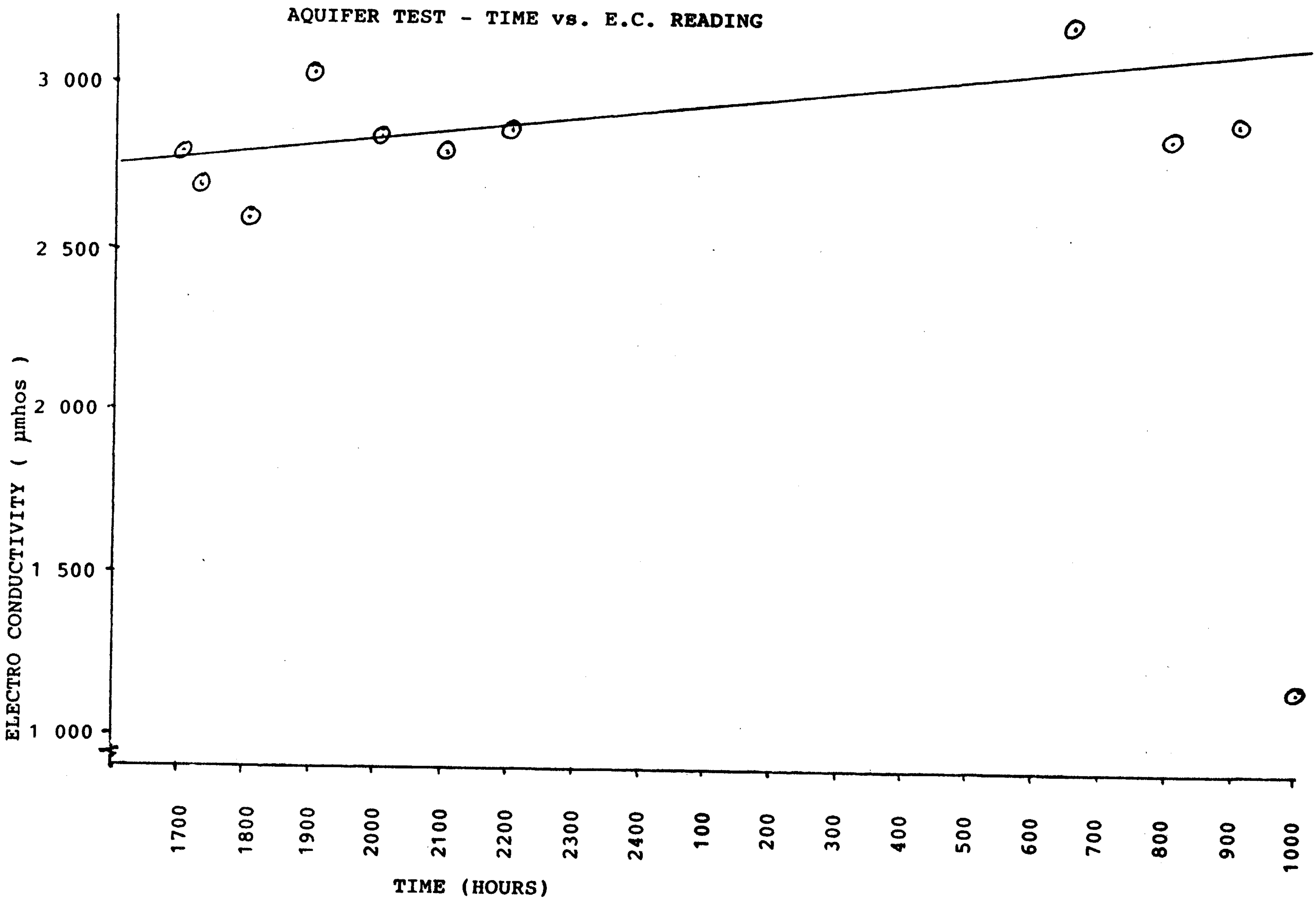
Soda Springs 11/21/93
Old Well t/t' vs. s'
OLD PUMP WELL t/t' vs. s'
Δ s=.071
T= 264 Q / Δ s = (264)(148) / .071' = 550,000 gpd/ft
.20
25
s'
10
100
t/t'

SODA SPRINGS 11/21/93
figure 11 by author



Soda Springs 11/21/93

figure 12 by author



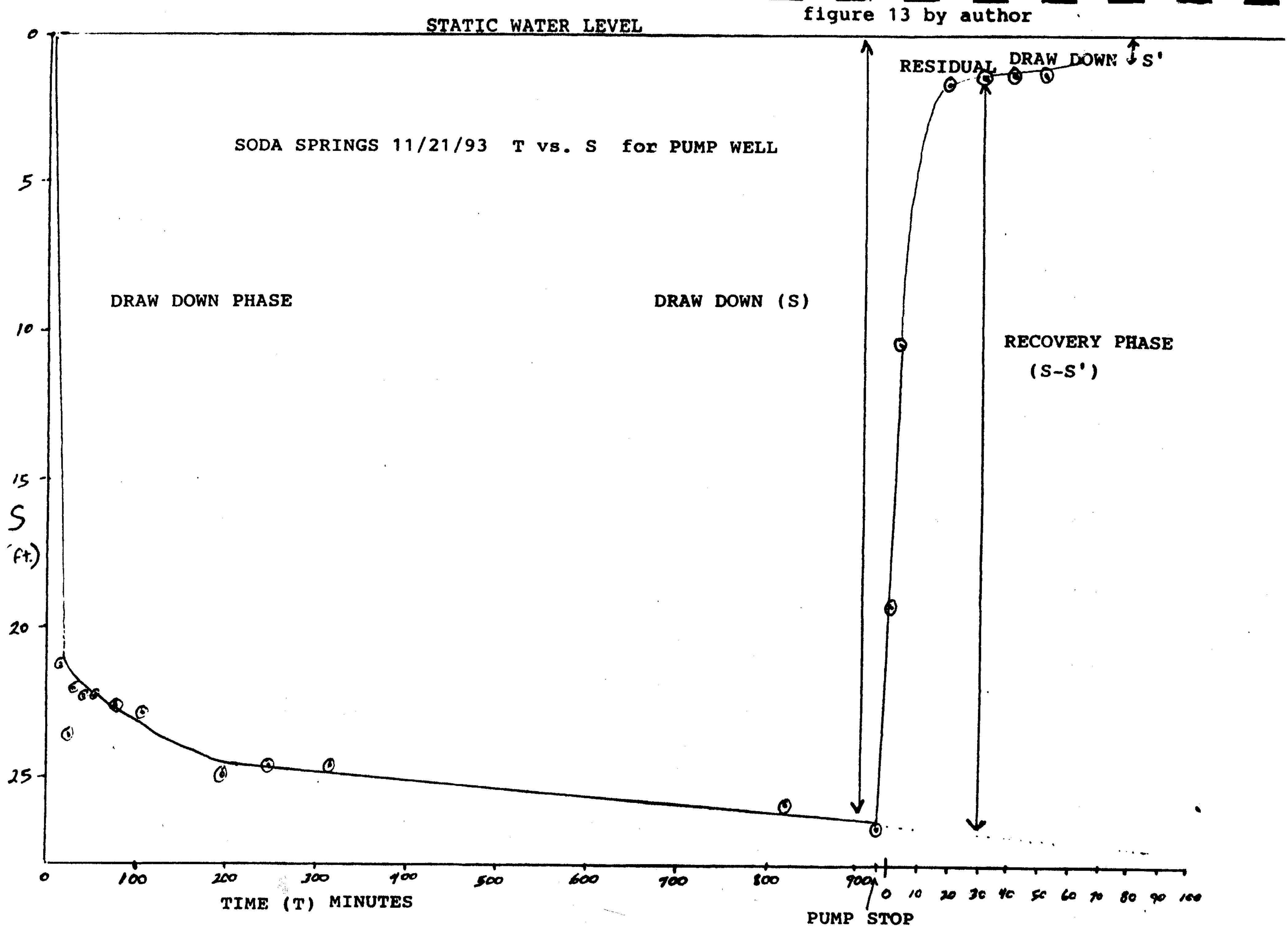


figure 13 by author
STATIC WATER LEVEL
SODA SPRINGS 11/21/93 T vs. S for PUMP WELL
DRAW DOWN PHASE
DRAW DOWN (S)
RESIDUAL DRAW DOWN S'
RECOVERY PHASE
(S-S')
S (ft.)
0
5
10
15
20
25
TIME (T) MINUTES
0
100
200
300
400
500
600
700
800
900
PUMP STOP
0
10
20
30
40
50
60
70
80
90
100

Appendix B. Water Quality Standards Chart

(modified from EPA 1986)

Compound or factor	Priority pollutant[a]	Suspected carcinogen[a]	Acute and chronic toxicity to aquatic life (concentrations in µg/L): Fresh acute criteria	Fresh chronic criteria	Marine acute criteria	Marine chronic criteria
Acenapthene	Y	N	1,700[b]	520[b]	970[b]	710[b]
Acrolein	Y	N	68[b]	21[b]	55[b]	—[b]
Acrylonitrile	Y	Y	7,550[b]	2,600[b]	—	—
Aldrin	Y	Y	3.0	—	1.3	—
Alkalinity	N	N	—	20,000	—	—
Ammonia	N	N	Criteria are pH and temperature dependent—see document			
Antimony	Y	N	9,000[b]	1,600[b]	—	—
Arsenic (pent)	Y	Y	850[b]	48[b]	2,319[b]	13[b]
Arsenic (tri)	Y	Y	360	190	69	36
Bacteria	N	N	For primary recreation and shellfish uses—see document			
Barium	N	N	NA	NA	NA	NA
Benzene	Y	Y	5,300[b]	—	5,100[b]	700[b]
Benzidine	Y	Y	2,500[b]	—	—	—
Beryllium	Y	Y	130[b]	5.3[b]	—	—
BHC	Y	N	100[b]	—	0.34[b]	—
Cadmium	Y	N	3.9[c]	1.1[c]	43	9.3
Carbon tetrachloride	Y	Y	35,200[b]	—	50,000[b]	—
Chlordane	Y	Y	2.4	0.0043	0.09	0.004
Chlorinated benzenes	Y	Y	250[b]	50[b]	160[b]	129[b]
Chlorinated naphthalenes	Y	N	1,600[b]	—	7.5[b]	—
Chlorine	N	N	19	11	13	7.5
Chloroalkyl ethers	Y	N	238,000[b]	—	—	—
Chloroform	Y	Y	28,900[b]	1,240[b]	—	—
Chlorophenol 2	Y	N	4,300[b]	2,000[b]	—	—
Chlorophenol 4	N	N	—	—	29,700[b]	—
Chlorpyrifos	N	N	0.083	0.041	0.011	0.0056
Chloro-4-methyl-3-phenol	N	N	30[b]	—	—	—
Chromium (hex)	Y	N	16	11	1,100	50
Chromium (tri)	N	N	1,700[c]	210[c]	10,300[b]	—
Color	N	N	Narrative statement—see document			
Copper	Y	N	18[c]	12[c]	2.9	2.9
Cyanide	Y	N	22	5.2	1	1
DDT	Y	Y	1.1	0.001	0.13	0.001
DDT metabolite (DDE)	Y	Y	1,050[b]	—	14[b]	—
DDT metabolite (TDE)	Y	Y	0.06[b]	—	3.6[b]	—
Demeton	Y	N	—	0.1	—	0.1
Dichlorobenzenes	Y	N	1,120[b]	763[b]	1,970[b]	—
Dichloroethane 1,2	Y	Y	118,000[b]	20,000[b]	113,000[b]	—
Dichloroethylenes	Y	Y	11,600[b]	—	224,000[b]	—
Dichlorophenol 2,4	N	N	2,020[b]	365[b]	—	—

Source: U.S. Fish and Wildlife Service 1990

Appendix B. *Continued.*

Compound or factor	Priority pollutant[a]	Suspected carcinogen[a]	Acute and chronic toxicity to aquatic life (concentrations in μg/L) Fresh acute criteria	Fresh chronic criteria	Marine acute criteria	Marine chronic criteria
Dichloropropane	Y	N	23,000[b]	5,700[b]	10,300[b]	3,040[b]
Dichloropropene	Y	N	6,060[b]	244[b]	790[b]	—
Dieldrin	Y	Y	2.5	0.0019	0.71	0.0019
Dimethylphenol 2,4	Y	N	2,120[b]	—	—	—
Dinitrotoluene	N	Y	330[b]	230[b]	590[b]	370[b]
Dioxin (2,3,7,8-TCDD)	Y	Y	0.01[b]	0.00001	—	—
Diphenylhydrazine 1,2	Y	N	270[b]	—	—	—
Endosulfan	Y	N	0.22	0.056	0.034	0.0067
Endrin	Y	N	0.18	0.0023	0.037	0.0023
Ethylbenzene	Y	N	32,000[b]	—	430[b]	—
Fluoranthene	Y	N	3,960[b]	—	40[b]	16[b]
Gases, total dissolved	N	N	Narrative statement—see document			
Guthion	N	N	—	0.01	—	0.01
Haloethers	Y	N	380[b]	122[b]	—	—
Halomethanes	Y	Y	11,000[b]	—	12,000[b]	6,400[b]
Heptachlor	Y	Y	0.52	0.0038	0.053	0.0036
Hexachloroethane	N	Y	980[b]	540[b]	940[b]	—
Hexachlorobutadiene	Y	Y	90[b]	9.3[b]	32[b]	—
Hexachlorocyclohexane (Lindane)	Y	Y	2.0	0.08	0.16	—
Hexachlorocyclopentadiene	Y	N	7[b]	5.2[b]	7[b]	—
Iron	N	N	—	1,000	—	—
Isophorone	Y	N	117,000[b]	—	12,900[b]	—
Lead	Y	N	82[c]	3.2[c]	140	5.6
Malathion	N	N	—	0.1	—	0.1
Manganese	N	N	NA	NA	NA	NA
Mercury	Y	N	2.4	0.012	2.1	0.025
Methoxychlor	N	N	—	0.03	—	0.03
Mirex	N	N	—	0.001	—	0.001
Naphthalene	Y	N	2,300[b]	620[b]	2,350[b]	—
Nickel	Y	N	1,400[c]	160[c]	75	8.3
Nitrate/Nitrite	N	N	NA	NA	NA	NA
Nitrobenzene	Y	N	27,000[b]	—	6,680[b]	—
Nitrophenols	Y	N	230[b]	150[b]	4,850[b]	—
Nitrosamines	Y	Y	5,850[b]	—	3,300,000[b]	—
Oil and grease	N	N	Narrative statement—see document			
Oxygen dissolved	N	N	Warmwater and coldwater criteria matrix—see document			
Parathion	N	N	0.065	0.013	—	—
PCB's	Y	Y	2.0	0.014	10	0.03
Pentachlorinated ethanes	N	N	7,240[b]	1,100[b]	390[b]	281[b]
Pentachlorophenol	Y	N	20[d]	13[d]	13	7.9[b]
pH	N	N	—	6.5–9	—	6.5–8.5
Phenol	Y	N	10,200[b]	2,560[b]	5,800[b]	—
Phosphorus elemental	N	N	—	—	—	0.1
Phthalate esters	Y	N	940[b]	3[b]	2,944[b]	3.4[b]
Polynuclear aromatic hydrocarbons	Y	Y	—	—	300[b]	—
Selenium	Y	N	260	35	410	54

APPENDIX C: LABORATORY ANALYSIS OF HABITATS

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION E756

LABORATORIES
6100 QUAIL VALLEY COURT, RIVERSIDE

E.S. BABCOCK & SONS, INC.
ESTABLISHED 1906

909/653-3351
FAX 909/653-1662

P.O. BOX 432
RIVERSIDE, CA 92502

07/12/94

To: Bureau of Land Management
Attn: Dolores Conti
6221 Box Springs Blvd.
Riverside, CA 92507-0714

Lab No.	940616-1283
Invoice No.	54607

Sample Marked:
McSpring MC461481
Mojave Club Habitat Water

Submitted	Sampled
CA	CA
06/15/94	06/14/94
10:40	12:00

Chain of Custody on file: Y

Parameter Name	Results	Parameter Name	Results
Total Hardness as $CaCO_3$	56 mg/L	pH	8.3 unit
Calcium (Ca)	14 mg/L	Specific Conductance	3300 µmho
Magnesium (Mg)	5 mg/L	Total Filterable Residue	1810 mg/l
Sodium (Na)	660 mg/L	Aluminum (Al)	0.19 mg/l
Potassium (K)	13 mg/L	Arsenic (As)	0.016 mg/l
Total Cations	30.15 me/L	Barium (Ba)	<0.1 mg/l
Total Alkalinity as $CaCO_3$	200 mg/L	Cadmium (Cd)	<0.001 mg/l
Hydroxide (OH)	<1 mg/L	Total Chromium (Cr)	<0.01 mg/l
Carbonate (CO_3)	12 mg/L	Copper (Cu)	<0.01 mg/l
Bicarbonate (HCO_3)	220 mg/L	Iron (Fe)	0.06 mg/l
Sulfate (SO_4)	320 mg/L	Lead (Pb)	<0.005 mg/l
Chloride (Cl)	690 mg/L	Manganese (Mn)	<0.01 mg/l
Nitrate (NO_3)	5 mg/L	Mercury (Hg)	<0.001 mg/l
Fluoride (F)	8.6 mg/L	Selenium (Se)	<0.005 mg/l
Total Anions	30.64 me/L	Silver (Ag)	<0.01 mg/l
MBAS	<0.05 mg/L	Zinc (Zn)	<0.01 mg/l
Ammonium Nitrogen (NH_4-N)	<0.1 mg/L		
Kjeldahl Nitrogen	0.4 mg/L		
Nitrite Nitrogen (NO_2-N)	<0.1 mg/L		

Date analysis completed: 07/06/94
Notes:

cc: Chris Archbold

Edward S. Babcock & Sons, Inc.

[signature]

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION 1156

P.O. BOX 432
RIVERSIDE, CA 92502

E.S. BABCOCK & SONS, INC.
ESTABLISHED 1906

909/653-3351
FAX 909/653-1662

LABORATORIES
6100 QUAIL VALLEY COURT
RIVERSIDE, CA 92507

07/28/94

To: Bureau of Land Management
Attn: Dolores Conti
6221 Box Springs Blvd.
Riverside, CA 92507-0714

Lab No.	940713-922
Invoice No.	55442

Sample Marked:
McSpring MC4614S1
Mojave Chub Habitat Water
Ref#940615-1283

Submitted	Sampled
CA 06/15/94 10:40	CA 06/14/94 12:00

Chain of Custody on file: Y

Parameter Name	Results	Parameter Name	Results
Cyanide (CN)	<0.01 mg/L		
Total Phosphorus (P)	<0.05 mg/L		

Date analysis completed: 07/25/94
Notes:

cc: Chris Archbold

Edward S. Babcock & Sons, Inc.

Allison Mackenzie

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION E756

LABORATORIES
6100 QUAIL VALLEY COURT, RIVERSIDE

E.S. BABCOCK & SONS, INC.
ESTABLISHED 1906

909/653-3351
FAX 909/653-1662

P.O. BOX 432
RIVERSIDE, CA 92502

07/12/94

To: Bureau of Land Management
Attn: Dolores Conti
6221 Box Springs Blvd.
Riverside, CA 92507-0714

Lab No.	940615-1284
Invoice No.	54507

Sample Marked:
Lake Tnende MC4614-2
Mojave Chub Habitat Water

SAMPLED AT SURFACE BY THE PUMP

Submitted	Sampled
CA	CA
06/15/94	06/14/94
10:40	12:40

Chain of Custody on file: Y

Parameter Name	Results	Parameter Name	Results
Total Hardness as $CaCO_3$	47 mg/L	pH	9.7 unit
Calcium (Ca)	12 mg/L	Specific Conductance	4700 µmho
Magnesium (Mg)	4 mg/L	Total Filterable Residue	2560 mg/L
Sodium (Na)	980 mg/L	Aluminum (Al)	0.18 mg/L
Potassium (K)	15 mg/L	Arsenic (As)	0.017 mg/L
Total Cations	43.92 me/L	Barium (Ba)	<0.1 mg/L
Total Alkalinity as $CaCO_3$	245 mg/L	Cadmium (Cd)	<0.001 mg/L
Hydroxide (OH)	<1 mg/L	Total Chromium (Cr)	<0.01 mg/L
Carbonate (CO_3)	78 mg/L	Copper (Cu)	<0.01 mg/L
Bicarbonate (HCO_3)	140 mg/L	Iron (Fe)	0.17 mg/L
Sulfate (SO_4)	450 mg/L	Lead (Pb)	<0.005 mg/L
Chloride (Cl)	1100 mg/L	Manganese (Mn)	0.01 mg/L
Nitrate (NO_3)	<1 mg/L	Mercury (Hg)	<0.001 mg/L
Fluoride (F)	13 mg/L	Selenium (Se)	<0.005 mg/L
Total Anions	45.95 me/L	Silver (Ag)	<0.01 mg/L
MBAS	0.17 mg/L	Zinc (Zn)	<0.01 mg/L
Ammonium Nitrogen (NH_4-N)	<0.1 mg/L		
Kjeldahl Nitrogen	1.4 mg/L		
Nitrite Nitrogen (NO_2-N)	<0.1 mg/L		

Date analysis completed: 07/05/94
Notes:

cc: Chris Archbold

Edward S. Babcock & Sons, Inc.

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION 1156

P.O. BOX 432
RIVERSIDE, CA 92502

E.S. BABCOCK & SONS, INC.
ESTABLISHED 1906

909/653-3351
FAX 909/653-1662

LABORATORIES
6100 QUAIL VALLEY COURT
RIVERSIDE, CA 92507

07/28/94

To: Bureau of Land Management
Attn: Dolores Conti
6221 Box Springs Blvd.
Riverside, CA 92507-0714

Lab No. 940713-923
Invoice No. 55442

Sample Marked:
Lake Tnende MC4614-2
Mojave Chub Habitat Water
Ref#940615-1284

Submitted	Sampled
CA	CA
06/15/94	06/14/94
10:40	12:40

Chain of Custody on file: Y

Parameter Name	Results	Parameter Name	Results
Cyanide (CN)	<0.01 mg/L		
Total Phosphorus (P)	0.05 mg/L		

Date analysis completed: 07/25/94
Notes:

cc: Chris Archbold

Edward S. Babcock & Sons, Inc.

[signature]
Allison Mackenzie

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION E756

LABORATORIES
6100 QUAIL VALLEY COURT, RIVERSIDE

E.S. BABCOCK & SONS, INC.
ESTABLISHED 1906

909/653-3351
FAX 909/653-1662

P.O. BOX 432
RIVERSIDE, CA 92502

07/12/94

To: Bureau of Land Management
Attn: Dolores Conti
6221 Box Springs Blvd.
Riverside, CA 92507-0714

Lab No.	940615-1285
Invoice No.	54507

Sample Marked:
West Pond MC4614-3 (3 BATS POND)
Mojave Chub Habitat Water

SAMPLED AT SURFACE WEST SIDE

Submitted	Sampled
CA	CA
06/15/94	06/14/94
10:40	13:15

Chain of Custody on file: Y

Parameter Name	Results	Parameter Name	Results
Total Hardness as $CaCO_3$	88 mg/L	pH	9.5 unit
Calcium (Ca)	20 mg/L	Specific Conductance	18000 µmho
Magnesium (Mg)	9 mg/L	Total Filterable Residue	12000 mg/L
Sodium (Na)	4200 mg/L	Aluminum (Al)	0.06 mg/L
Potassium (K)	72 mg/L	Arsenic (As)	0.13 mg/L
Total Cations	186 me/L	Barium (Ba)	<0.1 mg/L
Total Alkalinity as $CaCO_3$	1230 mg/L	Cadmium (Cd)	<0.001 mg/L
Hydroxide (OH)	<1 mg/L	Total Chromium (Cr)	<0.01 mg/L
Carbonate (CO_3)	456 mg/L	Copper (Cu)	<0.01 mg/L
Bicarbonate (HCO_3)	573 mg/L	Iron (Fe)	0.03 mg/L
Sulfate (SO_4)	2000 mg/L	Lead (Pb)	0.006 mg/L
Chloride (Cl)	4600 mg/L	Manganese (Mn)	0.02 mg/L
Nitrate (NO_3)	3 mg/L	Mercury (Hg)	<0.001 mg/L
Fluoride (F)	51 mg/L	Selenium (Se)	<0.005 mg/L
Total Anions	199 me/L	Silver (Ag)	<0.01 mg/L
MBAS	0.44 mg/L	Zinc (Zn)	<0.01 mg/L
Ammonium Nitrogen (NH_4-N)	0.1 mg/L		
Kjeldahl Nitrogen	7.2 mg/L		
Nitrite Nitrogen (NO_2-N)	<0.1 mg/L		

Date analysis completed: 07/05/94
Notes:

cc: Chris Archbold

Edward S. Babcock & Sons, Inc.

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION 1156

P.O. BOX 432
RIVERSIDE, CA 92502

E.S. BABCOCK & SONS, INC.
ESTABLISHED 1906

909/653-3351
FAX 909/653-1662

LABORATORIES
6100 QUAIL VALLEY COURT
RIVERSIDE, CA 92507

07/28/94

To: Bureau of Land Management
Attn: Dolores Conti
6221 Box Springs Blvd.
Riverside, CA 92507-0714

Lab No.	940713-924
Invoice No.	55442

Sample Marked:
West Pond MC4614-3
Mojave Chub Habitat Water
Ref#940615-1285

Submitted	Sampled
CA	CA
06/15/94	06/14/94
10:40	13:15

Chain of Custody on file: Y

Parameter Name	Results	Parameter Name	Results
Cyanide (CN)	<0.01 mg/L		
Total Phosphorus (P)	0.10 mg/L		

Date analysis completed: 07/25/94
Notes:

cc: Chris Archbold

Edward S. Babcock & Sons, Inc.

Allison Mackenzie

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION E756

LABORATORIES
6100 QUAIL VALLEY COURT, RIVERSIDE

E.S. BABCOCK & SONS, INC.
ESTABLISHED 1906

909/653-3351
FAX 909/653-1662

P.O. BOX 432
RIVERSIDE, CA 92502

07/12/94

To: Bureau of Land Management
Attn: Dolores Conti
6221 Box Springs Blvd.
Riverside, CA 92507-0714

Lab No. 940615-1286
Invoice No. 54507

Sample Marked:
Barstow Pond MC4614-4 (CALIFORNIA DESERT INFORMATION
Mojave Chub Habitat Water CENTER IN BARSTOW)

Submitted	Sampled
CA	CA
06/15/94	06/14/94
10:40	16:20

Chain of Custody on file: Y

Parameter Name	Results	Parameter Name	Results
Total Hardness as $CaCO_3$	298 mg/L	pH	9.2 unit
Calcium (Ca)	49 mg/L	Specific Conductance	2400 µmho
Magnesium (Mg)	42 mg/L	Total Filterable Residue	1450 mg/L
Sodium (Na)	380 mg/L	Aluminum (Al)	<0.05 mg/L
Potassium (K)	20 mg/L	Arsenic (As)	0.053 mg/L
Total Cations	22.98 me/L	Barium (Ba)	<0.1 mg/L
Total Alkalinity as $CaCO_3$	125 mg/L	Cadmium (Cd)	<0.001 mg/L
Hydroxide (OH)	<1 mg/L	Total Chromium (Cr)	<0.01 mg/L
Carbonate (CO_3)	30 mg/L	Copper (Cu)	0.01 mg/L
Bicarbonate (HCO_3)	92 mg/L	Iron (Fe)	0.05 mg/L
Sulfate (SO_4)	580 mg/L	Lead (Pb)	<0.005 mg/L
Chloride (Cl)	340 mg/L	Manganese (Mn)	<0.01 mg/L
Nitrate (NO_3)	<1 mg/L	Mercury (Hg)	<0.001 mg/L
Fluoride (F)	1.7 mg/L	Selenium (Se)	<0.005 mg/L
Total Anions	24.25 me/L	Silver (Ag)	<0.01 mg/L
MBAS	0.06 mg/L	Zinc (Zn)	<0.01 mg/L
Ammonium Nitrogen (NH_4-N)	<0.1 mg/L		
Kjeldahl Nitrogen	1.2 mg/L		
Nitrite Nitrogen (NO_2-N)	<0.1 mg/L		

Date analysis completed: 07/06/94
Notes:

cc: Chris Archbold

Edward S. Babcock & Sons, Inc.

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION 1156

P.O. BOX 432
RIVERSIDE, CA 92502

E.S. BABCOCK
& SONS, INC.
ESTABLISHED 1906

909/653-3351
FAX 909/653-1662

LABORATORIES
6100 QUAIL VALLEY COURT
RIVERSIDE, CA 92507

07/28/94

To: Bureau of Land Management
Attn: Dolores Conti
6221 Box Springs Blvd.
Riverside, CA 92507-0714

Lab No.	940713-925
Invoice No.	55442

Sample Marked:
Barstow Pond MC4614-4
Mojave Chub Habitat Water
Ref#940615-1286

Submitted	Sampled
CA	CA
06/15/94	06/14/94
10:40	16:20

Chain of Custody on file: Y

Parameter Name	Results	Parameter Name	Results
Cyanide (CN)	<0.01 mg/L		
Total Phosphorus (P)	<0.05 mg/L		

Date analysis completed: 07/25/94
Notes:

cc: Chris Archbold

Edward S. Babcock & Sons, Inc.

Allison Mackenzie

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION 1156

P.O. BOX 432
RIVERSIDE, CA 92502

E.S. BABCOCK & SONS, INC.
ESTABLISHED 1906

909/653-3351
FAX 909/653-1662

LABORATORIES
6100 QUAIL VALLEY COURT
RIVERSIDE, CA 92507

07/06/94

To: Bureau of Land Management
Attn: Dolores Conti
6221 Box Springs Blvd.
Riverside, CA 92507-0714

Lab No. 940620-1744
Invoice No. 54680

Sample Marked:
Mojave Chub Habitat
Camp Cady West Pond Water

SAMPLED AT SURFACE BY NW CORNER

Submitted	Sampled
CA	CA
06/20/94	06/19/94
16:00	17:00

Chain of Custody on file: Y

Parameter Name	Results	Parameter Name	Results
Total Hardness as $CaCO_3$	50 mg/L	pH	8.8 units
Calcium (Ca)	15 mg/L	Specific Conductance	570 µmho/cm
Magnesium (Mg)	3 mg/L	Total Filterable Residue	360 mg/L
Sodium (Na)	106 mg/L	Aluminum (Al)	0.11 mg/L
Potassium (K)	2 mg/L	Arsenic (As)	0.013 mg/L
Total Cations	5.66 me/L	Barium (Ba)	<0.1 mg/L
Total Alkalinity as $CaCO_3$	140 mg/L	Cadmium (Cd)	<0.001 mg/L
Hydroxide (OH)	<1 mg/L	Total Chromium (Cr)	<0.01 mg/L
Carbonate (CO_3)	6 mg/L	Copper (Cu)	<0.01 mg/L
Bicarbonate (HCO_3)	159 mg/L	Iron (Fe)	0.07 mg/L
Sulfate (SO_4)	71 mg/L	Lead (Pb)	<0.005 mg/L
Chloride (Cl)	57 mg/L	Manganese (Mn)	<0.01 mg/L
Nitrate (NO_3)	<1 mg/L	Mercury (Hg)	<0.001 mg/L
Fluoride (F)	1.4 mg/L	Selenium (Se)	<0.005 mg/L
Total Anions	5.96 me/L	Silver (Ag)	<0.01 mg/L
MBAS	0.05 mg/L	Zinc (Zn)	<0.01 mg/L
Nitrite Nitrogen (NO_2-N)	<0.1 mg/L		
Cyanide (CN)	<0.01 mg/L		
Ammonium Nitrogen (NH_4-N)	<0.1 mg/L		
Kjeldahl Nitrogen	0.6 mg/L		

Date analysis completed: 07/05/94
Notes:

cc: Chris Archbald

Edward S. Babcock & Sons, Inc.

Allison Mackenzie

Allison Mackenzie

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CA DHS CERTIFICATION 1156

P.O. BOX 432
RIVERSIDE, CA 92502

E.S. BABCOCK & SONS, INC.
ESTABLISHED 1906

909/653-3351
FAX 909/653-1662

LABORATORIES
6100 QUAIL VALLEY COURT
RIVERSIDE, CA 92507

07/06/94

To: Bureau of Land Management
Attn: Dolores Conti
6221 Box Springs Blvd.
Riverside, CA 92507-0714

Lab No.	940620-1745
Invoice No.	54680

Sample Marked:
Mojave Chub Habitat
Camp Cady East Pond Water

Submitted	Sampled
CA	CA
06/20/94	06/19/94
16:00	15:30

SAMPLED AT SURFACE BY SW CORNER

Chain of Custody on file: Y

Parameter Name	Results	Parameter Name	Results
Total Hardness as $CaCO_3$	26 mg/L	pH	9.6 units
Calcium (Ca)	7 mg/L	Specific Conductance	3200 µmho/cm
Magnesium (Mg)	2 mg/L	Total Filterable Residue	1830 mg/L
Sodium (Na)	620 mg/L	Aluminum (Al)	0.57 mg/L
Potassium (K)	19 mg/L	Arsenic (As)	0.13 mg/L
Total Cations	27.97 me/L	Barium (Ba)	<0.1 mg/L
Total Alkalinity as $CaCO_3$	495 mg/L	Cadmium (Cd)	<0.001 mg/L
Hydroxide (OH)	<1 mg/L	Total Chromium (Cr)	<0.01 mg/L
Carbonate (CO_3)	130 mg/L	Copper (Cu)	<0.01 mg/L
Bicarbonate (HCO_3)	336 mg/L	Iron (Fe)	0.63 mg/L
Sulfate (SO_4)	350 mg/L	Lead (Pb)	<0.005 mg/L
Chloride (Cl)	410 mg/L	Manganese (Mn)	0.02 mg/L
Nitrate (NO_3)	<1 mg/L	Mercury (Hg)	<0.001 mg/L
Fluoride (F)	2.7 mg/L	Selenium (Se)	<0.005 mg/L
Total Anions	28.94 me/L	Silver (Ag)	<0.01 mg/L
MBAS	0.10 mg/L	Zinc (Zn)	0.02 mg/L
Nitrite Nitrogen (NO_2-N)	<0.1 mg/L		
Cyanide (CN)	<0.01 mg/L		
Ammonium Nitrogen (NH_4-N)	0.2 mg/L		
Kjeldahl Nitrogen	0.5 mg/L		

Date analysis completed: 07/02/94
Notes:

cc: Chris Archbald

Edward S. Babcock & Sons, Inc.

Allison Mackenzie

Allison Mackenzie

BACTERIOLOGY
WATER TESTING
HAZARDOUS WASTE TESTING
CALIF. DHS CERTIFIED
PHONE (714) 684-1881
LABORATORIES
3215 CHICAGO AVE.

ESTABLISHED 1906
EDWARD S. BABCOCK & SONS, INC.
P.O. BOX 432
RIVERSIDE, CALIFORNIA 92502

07/31/89

To: Bureau of Land Management
1695 Spruce Street
Riverside, CA 92507
Attn: Bob Van Doren

Lab No. 890714-14
Invoice No. 51963

Sample Marked:
Soda Springs New Well

Submitted	Sampled
Bob	Bob
07/14/89	7/14
11:45	11:20

Chain of Custody on file: N

Parameter Name	Results	Parameter Name	Results
Calcium (Ca)	39 mg/L		
Magnesium (Mg)	6 mg/L		
Sodium (Na)	89 mg/L		
Potassium (K)	11 mg/L		
Ammonium (NH_4)	0.1 mg/L		
Sulfate (SO_4)	397 mg/L		
Nitrate (NO_3)	5 mg/L		

Notes:

cc:

Edward S. Babcock & Sons, Inc.

Allison Mackey

AGRICULTURAL CON
CHEMISTS
APPROVED WATER L ...ATORY

PHONE 684-1881
AREA CODE 714

LABORATORIES
3215 CHICAGO AVE

ESTABLISHED 1906

EDWARD S. BABCOCK & SONS, INC.

P O BOX 432
RIVERSIDE, CALIFORNIA 92502

12/17/84

To: Bureau of Land Management
1695 Spruce Street
Riverside, CA. 92507
351-6394

Lab No. 841128-99
Invoice No. 37929

	Submitted	Sampled
By	Endo	Endo
Date	11/28	11/28
Time	3:55	11:30

Sample Marked: Ft. Soda #1
East End Of Lake

PARAMETER	RESULT		PARAMETER	RESULT	
Total Hardness as $CaCO_3$	58	mg/L	Specific Conductance	4580	umho/cm
			pH	9.6	
Calcium (Ca)	13	mg/L	Total Filterable Residue	2635	mg/L
Magnesium (Mg)	6	mg/L			
Sodium (Na)	980	mg/L			
Potassium (K)	17	mg/L	Color	40	
Total Cations	44.20	me/L	Odor	8	TON
			Turbidity	10	NTU
Total Alkalinity as $CaCO_3$	290	mg/L	Boron (B)	4.2	mg/L
			Fluoride (F)	12	mg/L
Hydroxide (OH)	None	mg/L	Iron (Fe)	0.06	mg/L
Carbonate (CO_3)	105	mg/L	Manganese (Mn)	<0.1	mg/L
Bicarbonate (HCO_3)	140	mg/L	Total Phosphorus	0.1	mg/L
Sulfate (SO_4)	504	mg/L			
Chloride (Cl)	960	mg/L	Dissolved Oxygen	13.6	mg/L
Nitrate (NO_3)	3	mg/L			
Total Anions	42.90	me/L			

EDWARD S. BABCOCK & SONS, INC.

[signature]

The Resources Agency

Memorandum

To : Files

Date : January 7, 1982

From : Department of Fish and Game

Subject: Zzyzx Springs Water Quality Related to a Recent Die-off of Mojave Chubs

Field analyses of six parameters were made during two visits to Zzyzx Springs (11-17-81 and 12-4-81). Samples were also collected on 11-17-81 and sent to the Fish and Wildlife Water Pollution Control Laboratory in Sacramento to be analyzed for arsenic, boron, cadmium, copper and mercury. Analyses were made on samples taken from the pond and the lake and compared to see if there were any differences that may account for the mojave chubs dying in the pond.

The results from the field and laboratory analyses are listed in the accompanying table.

The only significant difference between the two waters was conductivity. This may or may not pose a problem depending on the salinity tolerance of the mojave chub. No information was found regarding salinity tolerance of mojave chubs, and most likely such work has not been done on this species.

George Faggella
Water Quality Biologist

Attach.

cc: Keith Anderson, FMS

JAN 14

RECEIVED

WATER QUALITY ANALYSIS OF ZZYZX SPRINGS

	LAKE		POND	
Parameter	11-17-81	12-4-81	11-17-81	12-4-81
Dissolved Oxygen (mg/l)	10.5	12.5	12.0	7.8
Conductivity (umho/cm)	2000	3200	14000	8200
Temp. (°C)	12	13	19	11
pH	9.6	7.5	9.2	8
NH_3 (mg/l)	< 0.1	< 0.1	< 0.1	0.35
H_2S (mg/l)	< 0.1	-	< 0.1	-
Arsenic (mg/l)	0.02	-	0.04	-
Boron (mg/l)	1.3	-	3.6	-
Cadmium (mg/l)	< 0.01	-	< 0.01	-
Copper (mg/l)	< 0.01	-	< 0.01	-
Mercury (ug/l)	< 0.2	-	< 0.2	-

APPENDIX D: PHOTOGRAPHS OF HABITATS EVALUATED

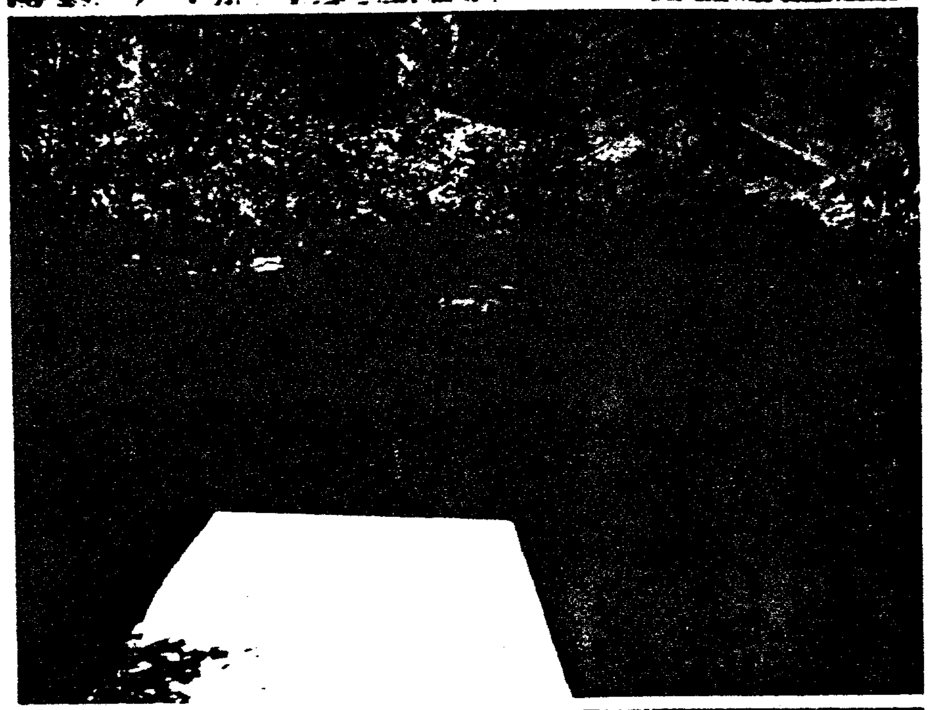
SODA SPRINGS

M.C. Spring

6/14/94

Lake Tuende

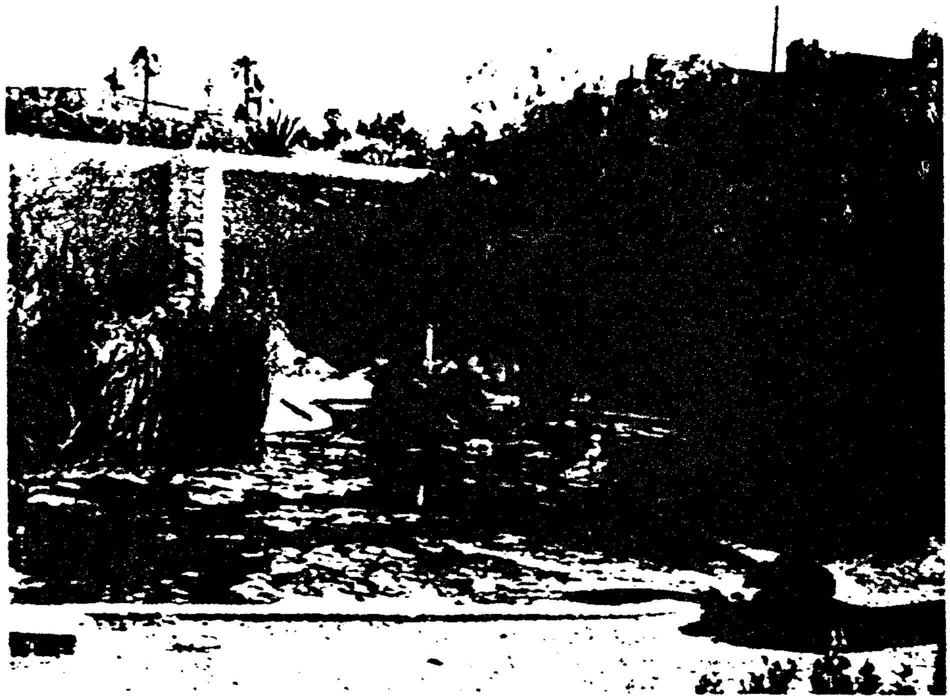
6/14/94



West Pond

6/14/94

California Desert
Information Center
at Barstow
6/14/94



Camp Cady West Pond
6/19/94

Camp Cady East Pond
6/19/94

REFERENCES CITED

Alabaster, J. S. and R. Lloyd. 1982. Water Quality Criteria for Freshwater Fish. Butterworth Scientific, Boston.

Bilhorn, T. W. and R. C. Feldmeth. 1985. Water Quality and Hydrology Studies at Soda Springs, San Bernardino California.

Bureau of Land Management. 1994. Special Status Fishes Plan for the California Desert District. BLM, California Desert District; Riverside, California. 34pp.

Bureau of Land Management. 1989. Memorandum: Hazardous Waste Cleanup at Soda Springs.

California Dept. of Fish and Game. 1990. Interim Management Plan.

Castleberry, D. T. and J. J. Cech. 1986. Physiological Responses of a Native and Introduced Desert Fish to Environmental Stressors. Ecology 67 (4): 912-918.

Day, P. G. and E. T. Garside. 1976. Lethal Levels of pH for Brook Trout. Can. J. Zool. 53, 639-641.

Feldmeth, C. R. 1984. A Natural Resources Survey of the Lark Seep System with Special Emphasis on the Endangered Mohave Tui Chub. Draft Report. U.S. Navy. China Lake Naval Weapons Center. 89pp.

Feldmeth, C. R. and D. L. Soltz. 1985. An Examination of Potential Relocation Sites for the Mohave Tui Chub. Ecological Research Services Report. 20pp.

Foster, J. H. 1984. Geology and Geohydrology of Soda Lake, California Lago de Sosa Mine and Area. Lilburn and Associates. 16pp.

Hoover, F. and J. St. Amant. 1983. Results of Mohave Tui Chub, Gila bicolor mohavensis, Relocation in California and Nevada. California Department of Fish and Game. 69 (57): 307-308.

Hubbs, C. L. and R. R. Miller. 1943. Mass Hybridization of Two Genera of Cyprinid Fishes in the Mohave Desert, California. Paps. Michigan Academy of Arts and Letters. 28:343-378.

McClanahan, L. L. et al. 1986. Energetics, Salinity and Temperature Tolerance in the Mohave Tui Chub, Gila biclor mohavensis. Copeia, 1986(1): 45-52.

Miller, R. R. 1961. Man an the Changing Fish Fauna of the American Southwest. Paps. Michigan Academy of Arts and Letters. 46: 365-404.

Miller, R. R. 1968. Records of Some Native Freshwater Fishes Transplanted into Various Waters of California, Baja California, and Nevada. California Fish and Game. 54: 170-179.

Morgan, N. L. and J. L. Turner. 1976. Calculation of Unionized Ammonia for Freshwater. California Fish and Game Environ. Service Branch Admin. Report 77-1.

Moyle, P. B. 1976. Inland Fishes of California. Univ. of California Press, Berkeley.

Snyder, J. 1918. The Fishes of Mohave River, California. Proc. U.S. Nat. History Museum. 54: 297-299.

Taylor, T. L. Population Size and Age Growth of Mohave Tui Chubs at Fort Soda, California. Draft Report to the Bureau of Land Management. 24pp.

U.S. Fish and Wildlife Service. 1984. Recovery Plan for the Mohave tui Chub, _Gila bicolor mohavensis_. Portland, Oregon. 56pp.

Vickers, C. E. 1973. Aspects of the Life History of the MTC, _Gila bicolor mohavensis_ from Soda Lake, California. M.S. thesis. California State University Fullerton.,