

**ELEMENTS OF A HABITAT MANAGEMENT PLAN FOR
THE MOHAVE TUI CHUB AT THE CHINA LAKE NAVAL WEAPONS CENTER
RELATIVE TO THE CITY OF RIDGECREST'S
WASTEWATER RECLAMATION PROJECT**

Prepared for: Beverly J. Kohfield
Environmental Project Office
Code 008
Naval Weapons Center
China Lake, CA 93555-6001

Prepared by: Thomas W. Bilhorn, Natural Resource Hydrologist
C. Robert Feldmeth, Aquatic Ecologist
Ecological Research Services
P.O. Box 298
Claremont, CA 91711

October 21, 1991(r)

TABLE OF CONTENTS

INTRODUCTION	1
Background	1
TASK 1. DESCRIPTION OF HYDROLOGIC FEATURES OF THE LARK AND	
G-1 SEEP SYSTEM	1
Groundwater Regime	3
Pump Test Data	7
Controlling Features	8
Volumetric and Elevational Requirements of the Seep Systems	9
PLATE DESCRIPTIONS AND AREA MEASUREMENTS	15
TASK 2. ANALYSIS OF CITY OF RIDGECREST'S RECLAMATION PROJECT ..	18
Summary of City's Project	18
Protection of Mohave Tui Chub Habitat	19
Projected Impacts of the Wastewater Reclamation Project	21
Water Quality Concerns	21
TASK 3. DESIGN OF WATER DELIVERY SYSTEM TO MAINTAIN TUI	
CHUB HABITATS	23
Design Criteria	23
Proposed Design	24
Health Concerns	27
TASK 4. PROPOSED MONITORING SYSTEM	27
Monitoring Well Levels	27
Monitoring Water Flows	28
Water Quality Monitoring	29
Water Temperature	29
Dissolved Oxygen	30
Adjustments	30
REFERENCES	31
APPENDIX	32

LIST OF FIGURES

Figure 1. Daily Evapotranspiration Barstow, CA. - at page 11.
 Figures 2 through 13, Water Table Elevations of 17 wells are included in the Appendix.

LIST OF PLATES

Plates are enclosed in the back pocket

- Plate 1. China Lake Area Map, Lark and G-1 Seeps; with Seasonal Low Water Table Elevations. Scale 1" = 1000'.
- Plate 2. Geological Cross Section - Ridgecrest WTF Ponds to Lark Seep, Showing Top of Water Table Aquifer at Seasonal Low Level. Scale 1" = 1000'.
- Plate 3. Lark Seep Habitat Units, July 1991. Scale 1" = 250'.
- Plate 4. Lark Seep Channel and Lagoon System. Scale 1" = 50'.
- Plate 5. G-1 Habitat Units, China Lake NWC - July 1991. Scale 1" = 250"
- Plate 6. Proposed Water Delivery System to Maintain Habitat at Lark and G-1 Seeps. Scale 1" = 50'.

INTRODUCTION

The following report consists of an assigned portion of the Mohave tui chub (Gila bicolor mohavensis) Habitat Management Plan relative to the City of Ridgecrest's Municipal Wastewater Treatment Plant Groundwater Extraction Project hereinafter known as the City of Ridgecrest Wastewater Reclamation project (Bechtel 1991). Our firm was contracted by the Environmental Project Office of the China Lake Naval Weapons Center to develop a plan for preserving Mohave tui chub habitat related to possible impacts resulting from implementation of the City of Ridgecrest wastewater reclamation project.

BACKGROUND

The City of Ridgecrest received a Cease and Desist Order (6-89-119) from the California Water Quality Control Board (Lahontan Region) that required certain problems pertaining to the City-run wastewater treatment facility to be resolved. Finding a solution to these problems has the potential to impact a federally-listed endangered fish species, the Mohave tui chub. Because the percolating facility ponds exist on the Naval Weapons Center (NWC) under a Grant of Easement and because the Navy will be issuing other permits as part of the City's resolution, the Navy is required under the Endangered Species Act to undergo a Section 7 consultation with the U.S. Fish and Wildlife Service on how to mitigate and/or prevent impacts to this fish species. The Navy has conducted this consultation. The Biological Opinion issued by the U.S. Fish and Wildlife Service requires development of an implementable Habitat Management Plan for this species before the City is allowed to begin Phase I of its wastewater reclamation project. The purpose of this contract to Ecological Research Services is thus to develop certain essential parts of the Habitat Management Plan (HMP).

TASK 1. DESCRIPTION OF HYDROLOGIC FEATURES OF THE LARK AND G-1 SEEP SYSTEM

The habitat areas of Lark and G-1 Seeps were mapped by using aerial and ground-based photographs, augmented by field work to provide ground truthing to verify habitat distinctions and interpretations. Field work also included analysis of aerial photographs and necessary

surveying to provide scale for habitat mapping and essential water and ground levels. At our request certain existing observation wells and three new monitoring wells were surveyed by NWC personnel to assure accurate elevations and locations. Most of the surveying data were provided by the NWC and were taken in 1991. Additional surveying was performed by the authors during the contract period to determine channel geometries and specific weir and water level relationships. Channel widths and depths were measured in the field as shown on the detailed drawings. With the aid of the survey data, map distances for hydrologic features in the key areas of the seeps, ponds and adjacent wells are accurate to better than 1%.

Aerial photographs used for the maps were flown on August 27, 1989. They are the most current photographs available. Although they are high quality vertical photographs, well placed over the subject area, they are high altitude black and white. Cultural features such as roads are easily located, however the differing green tones of the several vegetational associations do not produce significant gray-tone differences.

With one exception, the mapped vegetational communities represent the circumstances of this area as of July, 1991. The system of channels are depicted without inclusion of the existing Typha (cattail) growth along and within channels. As these plants are subject to an annual program of mechanical removal in October - November per the 1983 U. S. Fish and Wildlife Service Biological Opinion, their occurrence is transitory. The current cattail growth within the channels is hydrologically and biologically significant because of its density. In the freshwater marsh communities, Scirpus and Juncus (sedge and wire grass) plant communities were found to intergrade and exist in small units adjacent to one another. Scirpus did occur at lower topographic elevation levels, but the intermixing made separate mapping of these two vegetation types infeasible.

The transitional nature of the ecotone from Distichlis spicata (saltgrass) to an upland vegetational association, makes that boundary less precise than those of the other units. The uncertainty is greatest in the area west and southwest of the Scirpus/Juncus and cattail units which make up the western portion of Lark Seep. Acreage measured for the saltgrass association is believed accurate within about 10%. The remaining habitat units of open water, cattail and Scirpus/Juncus have sharper boundaries and acreage are believed accurate to within about 2%.

Ground elevations were digitized from two U.S.G.S. 7.5 minute quadrangle maps. Portions of the maps produced in this report have only 20 foot contour intervals available from the U.S.G.S. maps. Using NWC-supplied spot elevations, our survey data and stereographic views, contours have been adjusted in some areas and interpolated in others to provide an overall 5 foot contour interval. The agreement between the U.S.G.S. maps and the elevation surveys was generally very good so that shapes and trends are reliable. In the area of Lark Seep, the 1991 survey data has been used to determine water levels, culvert inverts (bottoms) and channel depths.

GROUNDWATER REGIME

The Lark and G-1 Seep habitats exist because of a combination of urban water uses and their geologic settings. Stratigraphic changes are many and rapid because of the site's location at the margin of an ancient lake bed. These changes cause water within a small area of 100's of feet to become perched, trapped and channeled. The following paragraphs provide a qualitative and quantitative description of the hydrologic system that controls these two habitat areas.

As shown in Plate 1 *CHINA LAKE AREA MAP, LARK & G-1 SEEPS, With Seasonal low Water Table Elevations*, the higher water table elevations (water mounds) are found at the intersection of Lauritsen and Pole Line Roads, ponds associated with the City wastewater treatment facility (WTF), and the golf course and housing area (located immediately south of North Knox Road). These three "highs" or water mound areas indicate sources of water. The flow gradient within this water table aquifer system is to the northeast (into the Lark Seep system) and north toward the area of Water and Pole Line Roads. The contoured elevations shown in Plate 1 represent the lowest seasonal water table elevation of recent years. This elevation is considered the "safe" elevation for continuation of the existing habitat. Water level monitoring should be compared with the values shown on Plate 1. Twenty three individual or clusters of wells were used to determine the water table elevation. As marsh systems are critically dependent upon water level changes on the order of 0.5 feet or less and channel flows on changes of a few tenths, the NWC was asked to re-survey well elevations in this network. Well-to-well relationships along with depth below ground are believed to be accurate within about 0.25 feet.

Two clusters of wells (M wells and H wells) occur in land section 22 in the southwest corner of the mapped area. Because this area represents the highest detected water levels, the NWC was also asked to include these wells in the elevation check. Although the City of Ridgecrest consultant (Bechtel, 1989) could not find a specific water source and therefore did not include a "mound" in this City area, the data from the 5 monitored wells clearly show the water table to rise to about 2205 feet msl. The water source may be a diffuse aggregation of irrigation percolation, wash-down and other commercial water discharge and transmission line leaks. There is no reliable means of calculating the contribution from this area. However, the geometry and near-surface stratigraphic sequence of transmissive sediments suggest the contribution is not trivial and could be, a quarter of the total northward water table flow.

The second water source is the golf course. The north-south alignment of the 2185 and 2190 contours and their greater spreading show the influence of the extensive irrigation with reclaimed water (see Plate 1). As planimetered from the 1989 photography, the golf course has an area of 136 acres. Since 1985 the City WTF has supplied an average of 218 million gallons of water per year. Using warm season turf grass coefficients and evapotranspiration data from the Barstow area (described more fully later), we calculate that as much as 4.5 million feet³ (103 acre feet) per year are added to the water table. From calculations shown later, this quantity is about 17% of the flow entering Lark Seep.

The third water source is pond leakage from the City's WTF pond system. As no observation wells exist immediately within or surrounding the pond system, the specific height and location of a groundwater mound is not known (thus the dashed contours). Well "J" and the new monitoring wells (MW-1, MW-2, MW-3) provide detail of the direction and slope of the water table on the down gradient side.

The depth to water and stratigraphic information is presented in Plate 2 *GEOLOGIC CROSS SECTION - RIDGECREST WTF PONDS TO LARK SEEP*, Showing Top of Water Table at Seasonal Low Level. To the south, the water table surface is about 20 feet below the ground surface. At well "J", 700 feet northeast of WTF pond 7, the depth to water is 5.5 feet. At the start of the freshwater marsh community (the Scirpus/Juncus vegetational association), the water table is at an elevation of 2179, about one foot below ground level.

At well "I", located on the north edge of Water Road and 190 feet east of the East Shop

channel, the water elevation is 2181 feet, also one foot below ground level. However, Well 'H', about 300 feet west of George Road at Water Road, has an elevation of 2174, 1.5 feet below ground level and is seven feet lower than the water table elevation at well "I", an unusually steep gradient for this area. Along the west side of North Knox Road and the dirt road running north from Water Road along the east side of the East Shop channel, water elevations are high. At several locations water continuously seeps westward across the dirt road into the East Shop channel. This north-south zone appears to be the principle conduit for water feeding Lark Seep. Wells "J", MW-1, MW-2 and well "I" are the four wells most indicative of any water table changes affecting Lark Seep.

To the west and north of Lark Seep, the water table slopes gradually and predictably toward the low China Lake playa elevation of 2155 feet. As discussed later, the G-1 channel, running between Lark Seep and G-1 Seep conveys water from Lark Seep and also intercepts groundwater in the stretch from Lark Seep to approximately mid-way between George and Pole Line Roads. At Pole Line Road the channel contributes to ground water, as evidenced by the high and non-fluctuating water level in well "D".

Figures 2 through 13 (see appendix) plot times series for 17 local wells most frequently read and with the longest period of record. The interval runs from November 1985 to August 1989. These records provide information on seasonal fluctuations and trends for this nearly four-year period. It was also possible to compare adjacent wells and when data gaps appeared, to assume unchanging relationships to persist. Supplemental to this recent record are data presented by Leedshill (Leedshill-Herkenhoff, 1983) for three wells that have measurements dating back to the early 1950's and that run to the end of 1981. These earlier well graphs show a continuous increase in elevation, the greatest increase occurring in the well located between the golf course and WTF ponds (probably well "L-2" on Plate 1). The large increase at this well, 6 feet, occurred in the mid-1950's. A sudden increase of 3 feet occurred in 1977. The two other wells, one located near Armitage Field (not plotted on Plate 1) and the other well located near the intersection of Water and Pole Line Roads (probably well "C-1"), show increases of 5 and 3 feet, respectively.

The most significant wells in providing groundwater information for Lark Seep are "J", "I" and "H". Well "J" shows a small seasonal variation of about 0.75 feet and no four-year change. Well "I" is the most constant in the network showing something less than a 0.25 feet

seasonal change and no change over the period of record. Well "H" is transitional between the moderate upslope wells that have small seasonal changes and the group of playa wells that vary seasonally by about 1.5 feet. This playa well variation is typical of desert dry lake systems where moderate upward water migration occurs. Water levels are typically only a few feet below the surface and vary because of the seasonal evaporative regime. The playa wells show no significant trend for the four years. The "K" and "L" wells show a four-year decline of perhaps 0.5 feet; the "M" wells about 0.25 feet. Well "A" and the two "B" wells show seasonal changes of 2.5 to 3 feet and the greatest period decline - 1.5 to 2 feet.

The network of observational wells contains mostly shallow wells of about 60 feet depth. No deep aquifer data water level data is available in this area. Lacking this deep-well pressure-height data, a determination of the thickness, continuity and directions of any flow between the water table and deeper aquifers become dependent upon stratigraphic information. Plate 2 provides a synthesis of available stratigraphic data and water levels. The most significant element is the existence of a thick clay sequence extending northward under the dry lake bed. Wells "B&B", "23D1", and "14B2" encounter this thick clay. As encountered at the "B&B" well (at the southwestern end of cross section A-A', in section 22, T26S/R40E), this stratum is found 86 feet beneath the surface and is 469 feet thick. The B&B well is the only one of the three that drilled completely through the clays. This well continued through sands with some clays and penetrated igneous bedrock at 1,355 feet below ground (903.7 ft. msl). Northward, well "D1" had drilled through 324 feet of clays when stopped. This well lies about 1,500 southwest of STP pond 1. 6,000 feet northeast of well "D1", well "B2" drilled through 540 feet of clay when stopped. This well is located about 1,000 feet north of STP pond 9. The bed is about 75 feet beneath the ground surface at D1 and 60 feet beneath the surface at B2. Well "23B2", drilled by the Navy to about 360 feet, shows a more coarse grained sequence of beds. It is located approximately 2,500 east of well "23D1" and 1200 south of pond 3. Two clay units 30 and 85 feet thick were encountered. The clay beds seen in the three western wells provide an effective hydrologic barrier. The clays in the eastern well are probably also effective and are believed to thicken northward under the WTF ponds.

Within the water table aquifer, two wells, "Leedshill #12" and "23B2" encountered coarse sand and gravel. Such beds are extremely transmissive, creating a "short circuit" and can be the dominate influence on an aquatic system. No other wells encountered this coarse material. It is possible that the WTF ponds overlying this lithologic unit could be major water

contributors to the Lark Seep system.

In June, 1991, per the U. S. Fish and Wildlife Service Biological Opinion, the NWC contracted for three monitoring wells (MW-1, MW-2 and MW-3) each with a total depth of about 60 feet. Discussions with NWC staff led to the recommendation of the locations shown on Plate 1. The placement attempted to satisfy both the need for early warning of water table lowering and for lithologic data on the horizontal continuity of the shallow aquifer. Wells "MW-1" and "MW-2" drilled through fine, clayey sands, a moderately transmissive unit. Well "MW-3" drilled through finer sediments, mostly clayey silts. These beds are less transmissive and act to retard and divert horizontal flows.

PUMP TEST DATA

Pump test data by Leedshill (1983) and Bechtel Environmental (1991) attempt measurement of aquifer conductivity and transmissivity. These values allow calculation of rates of flow and thus the reaction time of downslope water levels to decreases in supply. The Leedshill well work covered a broader area. Particularly, the Leedshill tests include two wells in the playa, north of Lark Seep as well as two wells on the south side of the WTF ponds. The test data clearly show the change from an alluvial (slope wash) environment of coarser material to lacustrine (ancient lake bed) fine, clayey sediments. For the desired prediction of response time, the alluvial slope data is the controlling factor. The Leedshill values for hydraulic conductivity range from about 1000 ft/day to 3,500 ft/day. We caution that this permeability coefficient cannot directly be divided into a distance, but requires also multiplication by the hydraulic head. Using the distances and vertical heights illustrated in the cross section of Plate 2 (4,800 foot distance from the ponds to well "I" at the East Shop channel and a hydraulic head of 6 feet), an approximate calculation of the travel time can be made. The Leedshill values indicate these times to range from about 3 to 7 years. Bechtel Environmental, in their 1989 report calculated a horizontal conductivity value of 40 ft/day. The travel time for such a low value is on the order of 25 years. It is our experience that recent alluvium/playa environments can be typified by the very irregular nature of sedimentary units and thin, but horizontally very conductive layers of gravel or coarse sand can drastically affect the hydrologic system. We believe the use of a response time of a year or two, certainly less than 5 years, best fits the geologic circumstances of this site and the history of the creation of Lark Seep.

CONTROLLING FEATURES

From the available information, we believe the shallow hydrologic system that controls Lark and G-1 Seeps can be described by the following characteristics:

- In the alluvial slope area underlying the WTF ponds and leading to Water Road there are two controlling horizontal hydrologic components. One component is a transmissive section that leads water to the corridor along the west side of North Knox Road and supplies the East Shop channel and adjacent area. The second component is a less transmissive unit, composed of interbedded thin layers of silt, fine sand and some clay that leads water northward from the WTF area onto the old lake bed.
- The lake bed sediments underlying Lark and G-1 Seeps consist of more continuous layers of clay and fine silty and clayey sands. These sediments act to restrict vertical flows. Well "H", at Water and George Road had an artesian flow (flowed above the ground surface) when first drilled. These clay sequences and the small upward vertical flow act to perch the added water that has created the two seeps. The time series of wells north of the ponds are similar to those seen in other playas where groundwater migrates very slowly upwards and evaporates before saturating the surface.
- Although definitive shallow/deep well pressure head information is lacking in the WTF pond area, we conclude that the thick clay beds found 60 to 80 feet beneath the ground surface effectively eliminate vertical flow, upward or downward, between the water table aquifer and geologic units beneath it. The water table aquifer is then, a separate hydrologic unit with a thickness varying from about 60 to 90 feet.
- The creation and maintenance of Lark Seep is caused by the incremental addition of water from 3 sources: the broad City of Ridgecrest area (with the highest water table elevation located in land section 22), the golf course and the WTF pond system. The added water from these sources lies on top of pre-existing water table and raises it about 7-8 feet near Lark Seep. The WTF ponds and golf course areas are most important to Lark Seep. The broader city area is most important to G-1 Seep, because of the interception of this water by the G-1 channel. This intercepted water augments that being conveyed from Lark Seep.

- Wells "J", "MW-1", "MW-2", "MW-3" and "I", provide the needed water level data for monitoring and warning for Lark Seep. Wells "J" and "MW-2" will provide the first evidence of lowering, if any, from pond sealing. The "B" and "C" wells will give warning of any lowering that could affect the augmented flow of the G-1 channel and thus change the supply of water to the G-1 Seep.

VOLUMETRIC AND ELEVATIONAL REQUIREMENTS OF THE SEEP SYSTEMS

The current habitat systems have been defined and measured as described in previous sections. We have carefully measured elevations of points which control or define the vegetational and aquatic system. Using those data and interpretations and assumptions discussed below, we have calculated the annual, maximum daily and minimum daily volumes of water required to maintain the existing system. The hydrologic budget of each seep is estimated. The budget used here differs somewhat from the generalized drawing presented in the Wastewater Reclamation Project EIR (City of Ridgecrest, 1991, Figure 3-2B).

Certain water surface elevations are critical to maintenance of the open water areas and the flows in the channels. Plate 3. Lark Seep Habitat Units, July 1991 and Plate 4. Lark Seep Channel and Lagoon System show details of the two habitat systems. At Lark Seep the principle tui chub population is contained in the south and north segments of the East Shop channel. For flow and water exchange to occur in the south segment, the water surface must remain above the concrete apron which forms the bottom of the bottom of the road culvert. The elevation of this apron is 2175.0 msl. The water surface elevation measured in July, 1991 was 2175.2 feet (probably about the seasonal low) that provides a minimum flow for this segment.

On the north side of Water Road the East Shop channel water surface elevation is 2173.9 feet. The adjacent well "I" water surface elevation is 2,181 feet. The 7.1 foot differential is important to maintaining the 2173.9 level and providing the necessary bank seepage throughout the seep area. At the lagoon, the water surface elevation is 2171.9 feet. As the water depth is only about one foot and the terrain has little relief, the lagoon area is highly dependent upon surface elevation. Water surface elevations were not measured in the West Shop and George Road channels because of the current heavy cattail growth.

At the eastern end of the G-1 channel, where water is collected leaving Lark Seep, the water surface elevation is 2168.1 feet. As the channel passes under Pole Line Road, the elevation is 2260.9 feet. At G-1 Seep the channel water surface the July, 1991 elevation is about 2156.3 feet.

Evapotranspiration (ET) data is now available from a network of stations which report to a computer data base operated by the California Department of Water Resources. The network, the California Irrigation Management Information System (CIMIS) provides hourly measurements of a variety of controlling factors including solar radiation, air and ground temperature, vapor pressure, wind, and precipitation. A reference evapotranspiration is calculated that represents a field of 4 to 7 inch tall grass. For the specific plant or surface area of interest a coefficient is applied to the reference ET. For China Lake we have used records of the Barstow data station. Figure 1. *Daily Evapotranspiration Barstow, CA.*, shows daily ET losses for a typical year. The annual reference ET is about 70 inches. Coefficients applied for the China Lake habitat units are given below. Weir data on channel flows were used wherever possible to confirm the ET estimates and water budgets.

The maximum water demands for Lark and G-1 Seeps were calculated by applying the ET coefficients to the planimetered areas of the vegetative units. The winter minimum values were calculated by reducing the maximum value by 0.29, the ratio of minimum to maximum shown by the curve of Figure 1. For G-1 Seep, the winter minimum added the standing water area to the vegetative units.

ET Evapotranspiration from Lark Seep (ET_L) and G-1 Seep (ET_G):

Open water - 6.4 ft/yr.

Cattail - 6.0 ft/yr.

Scirpus/Juncus - 5 ft/yr

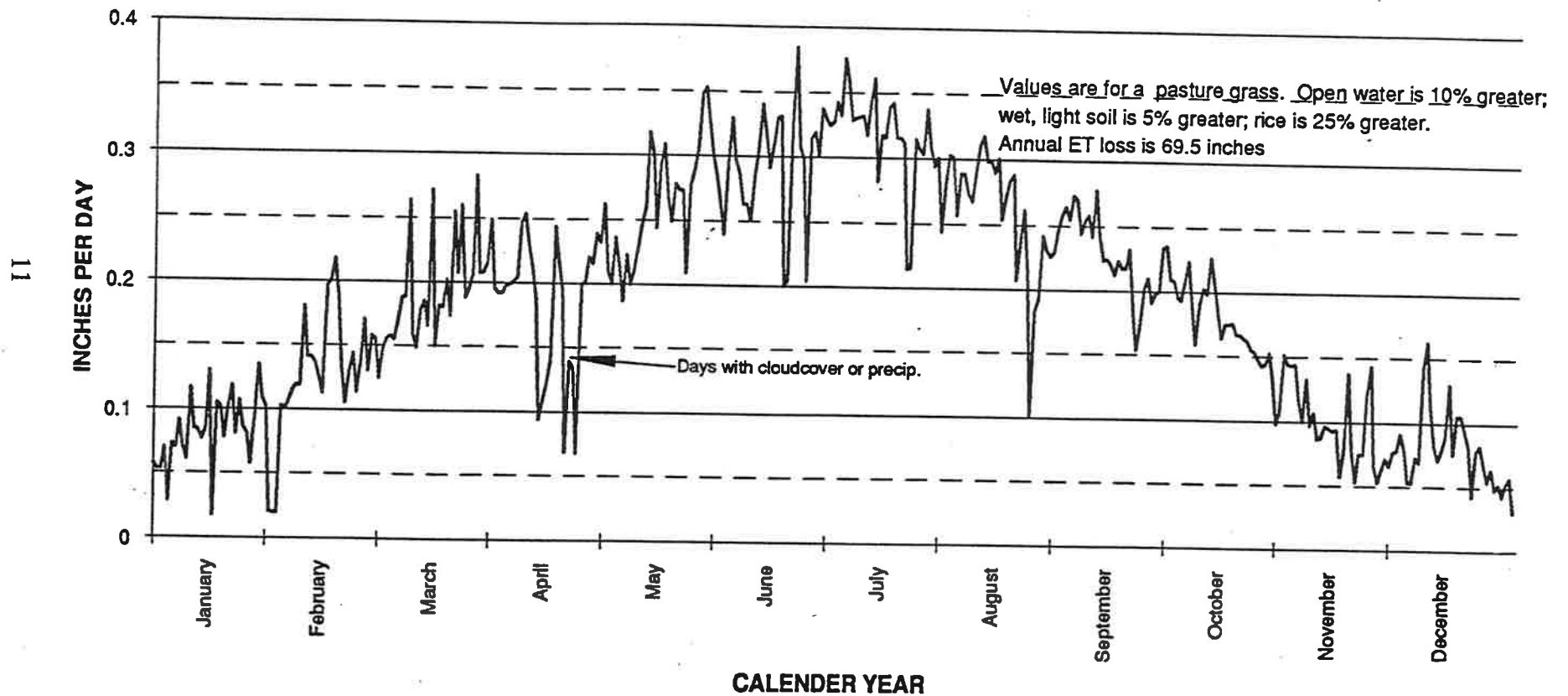
Tamarix - 6 ft/yr.

Alkali flat (water table approximately 2-3 feet below ground) - 4 ft/yr

V Vertical groundwater flows. As described above this term is given a value of 0.

H Horizontal groundwater flows. Near-surface flows from the north edge of Lark Seep

DAILY EVAPOTRANSPIRATION BARSTOW, CA



Source: Calif. Irrigation Management System (CIMIS) data base & U. Cal. Leaflet 21427

T. W. Bilhorn, E.S.C., 9/91

Figure 1.

and the northwestern portion of G-1 channel. A value of 0 is used because of the collector drain effect of G-1 channel at Lark Seep. This channel loses some water in the section from east of Pole Line Road to G-1 Seep, but because of the very low hydraulic head and low conductivity of the playa sediments, the quantity is believed insignificant. Photographic examination supports the lack of a downslope water mound. No horizontal groundwater flows are calculated for G-1 Seep because of the essentially flat terrain and low conductivity.

- D** Flow draining from Lark Seep intercepted by the G-1 channel, measured at weirs S-4 and S-6.

Lark Seep

$$\text{Annual Volume } V = ET_L + V + H + D = 386 + 0 + 0 + 219 = 605 \text{ acre feet/year}$$

$$\text{Annual Volume } V \text{ for area north of Water Road} = 202 + 219 = 419 \text{ acre feet/year}$$

G-1 Seep

$$\text{Annual Volume } V = ET_G + V + H = 421 + 0 + 0 = 421 \text{ acre feet/year}$$

As the discharge **D** (219 acre feet), from Lark Seep flows to G-1 Seep, only the increase of the intercepted 200 acre feet is needed to provide the total water demand of the two systems.

The total Lark and G-1 Seep annual water demand is 805 acre feet/year, 619 acre feet/year omitting the area south of Water Road.

In our 1984 report we estimated this water demand to be about 1,400 acre feet/year. The difference occurs primarily from an assumption that the G-1 channel carried 810 feet of water per year. With the now-available weir data, that figure is cut in half. New mapping and revised ET coefficients, and the new CIMIS data account for the remaining differences.

Weir measurements along G-1 channel allow checking of the G-1 Seep water demand. At the east end of the channel the annual flow is 219 acre feet. At Pole Line Road the annual flow has increased by 200 acre feet to a total of about 420 acre feet. The annual water budget agreement, 420 and 421, is excellent. We have also calculated daily maximum and minimum water demands for use in sizing facilities and for operating guidelines. Maximum water demand occurs in late June and early July. The demands of the system components are given below:

Maximum Demands

Lark Seep vegetation and interior channels north of Water Road (from ET demand data):

433,350 gallons per day = 40.2 feet³/min

Discharge into G-1 channel from Lark Seep (from weir data):

107,700 gpd = 10 feet³/min

totals 541,000 gpd = 50.2 feet³/min

G-1 Seep (from ET demand data):

559,600 gpd = 52.0 feet³/min

As the above calculations include the Lark Seep discharge to the G-1 channel of 10 feet³/min, the net additional need is:

451,900 gpd = 42.0 feet³/min

Total seasonal maximum Lark and G-1 Seep system demand:

993,000 gpd = 92.2 feet³/min

Minimum Demands

Minimum demands are 29% of the maximums and occur in late December and early January.

Lark Seep vegetation and interior channels north of Water Road:

$$125,670 \text{ gpd} = 2.9 \text{ feet}^3/\text{min}$$

Discharge into G-1 channel from Lark Seep (from weir S-4 winter data)

$$\underline{323,136 \text{ gpd}} = \underline{30.0 \text{ feet}^3/\text{min}}$$

$$\text{totals} \quad 448,806 \text{ gpd} = 41.7 \text{ feet}^3/\text{min}$$

G-1 Seep (from ET demand data):

For G-1 Seep an additional unit, the winter standing water area, is included in the demand calculation.

$$496,500 \text{ gpd} = 46.1 \text{ feet}^3/\text{min}$$

Minus received channel flow:

$$\underline{323,136 \text{ gpd}} = \underline{30.0 \text{ feet}^3/\text{min}}$$

$$\text{totals} \quad 173,364 \text{ gpd} = 16.1 \text{ feet}^3/\text{min}$$

Total seasonal minimum Lark and G-1 Seep system demand:

$$\underline{622,170 \text{ gpd}} = \underline{57.8 \text{ feet}^3/\text{min}}$$

The G-1 Seep winter minimum can be checked against weir data collected at Pole Line Road (weir S-6). This weir shows a flow in late December and January of about 43 feet³/min, 93% of the calculated figure. Such very close agreement indicates that the hydrologic system is reasonably characterized.

PLATE DESCRIPTIONS AND AREA MEASUREMENTS

Plates are in pockets after the Appendix

- Plate 1. *China Lake Area Map, Lark and G-1 Seeps, with Seasonal Low Water Table Elevations*, is plotted at a scale of 1" = 1000' and includes an area running from south of the City of Ridgecrest wastewater treatment ponds to the northern edge of G-1 Seep. Land surface contours at a 5 foot interval are provided along with key habitat and structures. The plate also includes elevation contours of the top of the water table aquifer representing the current seasonal low water table elevation. The plate includes the newly constructed monitoring wells.
- Plate 2. *Geological Cross Section - Ridgecrest WTF Ponds to Lark Seep, Showing Top of Water Table at Seasonal Low Level*. Horizontal scale 1" = 1,000 ', vertical scale 1" = 50'. Plate shows the strata within and underlying the water table aquifer.
- Plate 3. *Lark Seep Habitat Units, July 1991*, is plotted at a scale of 1" = 250 ' and includes an area from the north edge of the treatment ponds to the north side of Lark Seep. Six habitat units (vegetative associations) were mapped and their areas planimetered (map creation and planimetry was done using AutoCad Ver. 10, 386 computer program). Five of the units are shown on this Plate. The units and their areas are:

North of Water Road

OPEN WATER LAGOON	2.23 acres
CATTAIL	20.07 acre
SALTGRASS	9.03 acres
SCIRPUS/JUNCUS	5.19 acres
TAMARIX	0.86 acres

South of Water Road

Cattail	6.10 acres
Saltgrass	23.25 acres
Scirpus/Juncus	4.52 acres
<u>Tamarix</u>	0.20 acres

Plate 4. *Lark Seep Channel and Lagoon System*, is plotted at a scale of 1" = 50'. This plate includes information on current channel water depths. The indicated widths are of the water surface. We have broken the system into four units identified as follows:

East Shop Channel: The widest and deepest channel system, it runs along the east side of the building on Water Road, closest to North Knox Road. This channel is 151 feet in length in the portion south of Water Road and varies from 10 feet wide at the south to 27 feet wide at the Water Road culvert. It is 1.9 feet deep at the southern end, has an intervening 5.3 foot deep hole, and shallows to 2.2 feet at the edge of the concrete sill at the Water Road culvert. Over this sill the water is only 2 inches deep. This sill is the critical controlling elevation point for this channel segment. The sill has a sea level elevation (its invert) of 2,175 feet. North of Water Road, the channel is 793 feet long and varies from about 15 to 18 feet in width. The depth for most of its length is 2 feet. Near the north end, the water depth reaches 4.5 feet. As it passes through the railroad culvert, the depth is 3.4 feet. Both segments support dense stands of cattail (*Typha domingensis*).

West Shop Channel: A much smaller and irregular channel on the west side of the shop building extends for 363 feet on the south side of Water Road. It is heavily overgrown and contains only intermittent pools of shallow water with a maximum depth of about 3 inches. On the north side of Water Road, the channel runs east-west, connecting to the East Shop channel. The West Shop channel on the north side of Water Road is 240 feet long as a continuous channel and has a water depth of 1.7 feet. It is also choked with a heavy growth of cattail.

George Road: A straight channel with one bend runs northeasterly from the corner

of George and Water Roads and connects at the west side of the railroad culvert with the East Shop Channel. It has a total length of 1050 feet. For most of its length it is 4.5 feet wide and 0.3 feet deep. Near the north end it widens and is 4.5 feet wide and 0.3 feet deep. Near the north end it widens to 8.5 feet where the depth is 3.2 feet. It is also heavily invaded with cattail.

Open Water Lagoon: The area (plotted at the same 1" = 50' scale) is shown by inclusion as an insert. The distance from the end of the channels as they end at the culvert under the railroad track to the open water on the east side of the railroad bed is 725 feet. The open water area covers 2.23 acres. The water depth is fairly even at one foot. The bottom is now layered with a very soft and easily disturbed mix of silt and vegetative debris.

Plate 5. *G-1 Seep Habitat Units, China Lake, NWC, July, 1991.* Plotted at scale of 1' = 250', map of vegetational units taken from black and white 1989 vertical aerial photographs and July 1991 low altitude oblique color photographs. The two photo sets show differences in unit boundaries. The most recent is used. The mapped vegetative units also include a winter standing water area that seasonally floods.

OPEN WATER	1.41 acres
CATTAIL	0.45 acres
SALTGRASS	41.28 acre
SCIRPUS/JUNCUS	12.6 acres
WINTER STANDING WATER	110.16 acres

Plate 6. *Proposed Water Delivery System to Maintain Habitat at Lark and G-1 Seeps.* Plotted at scale of 1" = 50'. Shows the layout and discharge points of the piped water system. A cross section of the proposed detention pond is also shown.

TASK 2. ANALYSIS OF CITY OF RIDGECREST'S RECLAMATION PROJECT

SUMMARY OF CITY'S PROJECT

As previously described, the City of Ridgecrest operates a wastewater treatment plant located within the China Lake Naval Weapons Center boundaries. Over the last ten years, problems with high ground water levels have led to damage to several roadways and other facilities within the NWC. A ground water mound is present near the City of Ridgecrest-Naval Weapons Center joint wastewater treatment facility and it is believed to be related to percolation from some of the 11 facility ponds (both facultative and evaporative). Concerns regarding the possible migration of ground water from these ponds to wells used by Indian Wells Valley residents and by Trona to extract potable water has lead the City to develop a plan to minimize percolation from the ponds into the soil.

The Lahontan Region of the California Regional Water Quality Control Board issued a Cease and Desist Order to the City regarding the above ground water issue. Both the City and the Navy are anxious to stabilize the ground water mound and yet they must be sensitive to the endangered Mohave tui chub (Gila bicolor mohavensis) that lives within the channels and a lagoon area formed by the groundwater as it migrates out onto the playa surface of China Lake.

The City thus put into place a two phase plan to meet the above objectives. Phase I will involve construction of a 20-inch pipeline from an existing evaporative pond to the inactive treatment ponds on San Bernardino Road. Construction of this new line will replace an existing 6-inch pipeline that presently carries up to 500 thousand gallons per day to the pasture area and golf driving range located adjacent to the inactive treatment ponds. Water would be taken from Pond 9 by the installation of an effluent pond pump station. It would then go through an in-line chlorine injection facility at the existing treatment plant on the NWC. This reclaimed water would then be piped to the inactive ponds for Phase II reuse.

Phase II of the project would involve use of the reclaimed water for an existing tree farm, pasture area and golf driving range. Areas irrigated by this water would be expanded over

three stages as needed.

A key part of the Phase II program would be the sequential sealing of the evaporation ponds at the City wastewater treatment facility. Pond 10 (see Plate 1) would be sealed with bentonite clay in the first year of the project (1992). This clay liner is expected to eliminate about 90 percent of the pond's percolation. Pond 9 would be sealed the following year. Ponds 8 and 11 would be allowed to evaporate completely and would be used on an as-needed basis only. The effect of the sealing of ponds 9 and 10 on the Mohave tui chub habitat within the Lark and G-1 Seep system would be monitored as required. Any possible changes in the water supply to Lark Seep because of pond sealing should be detected first at the wells rather than at the habitat (City of Ridgecrest EA/EIR, 1991).

The City's phase II plan involves sealing pond 11 in the summer of 1994. In the summer of 1996, pond 8 would also be sealed. A new sealed pond (12) would be constructed, if needed, to accommodate increased effluent flow. The sequential sealing of ponds 9, 10 and 11 would result in insignificant percolation from the evaporative ponds. The facultative ponds (1-7) would continue their assumed minimal percolation. As facultative ponds develop bottom deposits, they may be less prone to leakage. However, well data tend to support ponds 1 - 7 contributing to the groundwater mound (see Plate 1.)

PROTECTION OF MOHAVE TUI CHUB HABITAT

The growth of the aquatic habitat (marsh, channels and lagoon areas) at Lark Seep corresponds to the increased volume of treated wastewater at the joint facility over the last 25 years and the contribution to groundwater associated with city growth and irrigation. Ground water levels near the facility ponds and Lark Seep have been measured as part of this report (see Task 1) and by Bechtel Environmental, Inc. The sealing of the evaporative ponds and the subsequent diversion of effluent by the 20-inch line to the area adjacent to the old treatment facility on San Bernardino Road will mean there will now be less ground water supplying the aquatic habitats of the Lark Seep area.

The tui chub population grew from about 400 hundred fish when introduced into Lark Seep lagoon in 1971 to a number estimated at 18,500 by 1988 (Feldmeth, et al., 1989). The

sequential sealing of ponds and subsequent diversion of effluent will decrease the water flow to the Lark Seep system. Although no regular censuses of the entire China Lake tui chub system were made, it is possible to predict the impact of the diversion of treated effluent away from Lark Seep. In the 1983-84 study of the Mohave tui chub and its associated habitat at Lark Seep, fish were found in slightly lower densities in similar habitats than they were in 1988 (Feldmeth, et al., 1984; 1989). Large numbers of tui chubs continue to be concentrated in the deep southern portion of the East Shop channel (south of Water Road, adjacent to the "Camera Shop").

The northern portion of the East Shop channel (north of Water Road) that flows toward Lark Seep lagoon and marsh, is also extremely good habitat. These areas range from 3 to 5 feet in depth and have cattails only on the margins. In the 1988 tui chub population study, approximately 85 percent of the tui chubs were estimated to occur in these deeper channel areas. The G-1 channel that runs west of the marsh on to the G-1 seep is much more shallow, ranging in depth from 1 to 2 feet and become almost entirely choked with cattail (Typha domingensis). Tui chubs were much less common in these shallow channels and in the shallow waters of Lark Seep lagoon. The Mohave tui chubs at China Lake thus prefer the deeper channel areas.

From an examination of old aerial photographs taken of the Lark Seep area beginning in the late 1940's, the sequence of aquatic habitat development can be reconstructed. Photos taken in 1949 and 1952 show no water (lagoon) present and no marsh vegetation. By 1956, however, a lagoon was present and marsh vegetation can clearly be seen. It was into this lagoon habitat that the first tui chubs were introduced in 1971. The next aerial photograph in the sequence, taken in 1973, shows a larger lagoon and the presence of a sizeable cattail marsh west of the railroad tracks.

In the late 1970's, with the combining of the City's wastewater system to that of the NWC, ground water levels increased. To drain these marshy areas, a series of channels were dredged that conveyed water out onto the China Lake playa forming the G-1 seep. Tui chubs then migrated from the lagoon into the deeper channel areas just south of the lagoon (McGill, personal communication). Through the 1980's, water volumes flowing to the marsh continued to increase. To drain the marsh areas and subsequently lower the ground water, the channels were deepened and cleared of cattails. This combination of increased water flow and deeper

channels provided better habitat for the tui chub and their numbers also increased.

PROJECTED IMPACTS OF THE WASTEWATER RECLAMATION PROJECT

As the sequential lining of the evaporative ponds takes place in the mid-1990's, there probably will be a decrease in ground water levels and therefore less water flow to the Lark Seep system. If no measures are taken to preserve tui chub habitat, we predict that water levels will decline in the channels and that the general optimal habitat in the East Shop channel north and south of Water Road will degrade. Water flow in the shallower G-1 channel that crosses Pole Line Road and flows out to G-1 seep also may be reduced. Lark Seep lagoon probably will remain, as it was first to form and was present well before the City's wastewater was treated at the NWC. We estimate that this would result in a 70 to 80 percent reduction in the Mohave tui chub population.

WATER QUALITY CONCERNS

The physiological tolerance tests performed on the Mohave tui chubs from the NWC clearly show this species cannot tolerate high salinity. At Fort Soda this fish occurs in Lake Tuendae, a pond maintained by the daily pumping of well water that has a relatively high mineral content of 12,500 mg/L total dissolved solids - a specific conductance 19,100 umho/cm (Bilhorn, Feldmeth 1985). A small population also occurs in a small refugium north of Hinkley (Havelka and Bittman, 1980), also in a pond maintained by well water. The Mohave tui population at China Lake is certainly the largest and also most secure in terms of water supply. The question of the present water quality conditions and how water quality may change with the implementation of the City of Ridgecrest's wastewater reclamation project must now be examined.

Water quality parameters of the channels and Lark Seep Lagoon have been monitored in 1983-83 and in 1988-89. Temperature and dissolved oxygen levels are discussed under Task 4 (PROPOSED MONITORING SYSTEM). Conductivity for the water in the Lark Seep system ranges from 4,000 to 6,000 umho/cm, two to three times less than the tui chub habitat

at Fort Soda (Feldmeth, et al., 1989). Nutrient levels and other possible problem substances such as heavy metals and other toxics are not significant at this time. As the source water is a product of urban uses, changes could occur and water quality monitoring is necessary.

Water chemistry analyses were carried out for samples taken from 15 wells near the facility ponds and the general Lark Seep area in 1982 (Leedshill-Herkenhoff, 1983). Water out on the China Lake playa was extremely high in salts with total dissolved solid (TDS) content ranging from 44,200 to 72,100 ppm. However the water that was sampled in the wells between the facility ponds and the Lark Seep system ranged in TDS from 920 to 6,830 ppm.

Water in the facility ponds has also been regularly analyzed chemically. Pond 9, one of the evaporative ponds that probably contributes to the ground water that forms Lark Seep, has a TDS of 583 to 783 ppm, depending on the laboratory conducting the analysis.

From these data it is clear that as water percolates into the soil and then flows northward toward Lark Seep it picks up dissolved salts and other mineral substances. Once in the Lark Seep system, TDS continues to increase as evaporation occurs. If water is diverted directly from pond 9 into the Lark Seep system, as proposed in Task 3, the chemical makeup will be considerably more dilute than water that percolates into the ground and flows northward to emerge at Lark Seep. There is no indication that this better quality water (lower TDS) will present any problems for the Mohave tui chub as this species appears to have evolved in the large pluvial lakes of the Pleistocene. In fact, for the past 10,000 years this species has persisted in the Mohave River, a shallow stream that flows from the north slope of the San Bernardino Mountains. Former Mohave tui chub habitats along the lower reaches of the Mohave River, in Afton Canyon for example, have TDS values ranging from 550 to 1,000 ppm (Feldmeth and Soltz, 1985). So this fish is not adapted to highly saline or alkaline waters, in fact considerable Mohave tui chub mortality occurred in the West Pond at Fort Soda when high evaporation associated with low inflow rates, pushed salinity into the lethal range for this fish (>10 parts per thousand). There is therefore no significant concern that the water taken directly from the treated wastewater ponds to the Lark Seep area will have too low a total dissolved solid content. Currently Mohave tui chubs are thriving in waters with a considerable range in mineral levels.

We thus see no problems with alkalinity or salinity adversely affecting the Mohave tui chub if water from evaporative pond 9 is piped to Lark Seep to maintain chub habitat.

Ammonia and nitrate levels in pond 9 also do not appear to be a problem. Nitrate levels ranged from 1.6 to 5.1 ppm and ammonia levels were 1.6 to 9.6 (City of Ridgecrest EA/EIR, 1991). As water flows through cattail and other emergent plant species, nutrient levels will soon decrease to even lower levels. Indeed, some nutrients are desirable to promote plant primary productivity and aquatic invertebrate secondary production to provide a source of food for the tui chubs.

TASK 3. DESIGN OF WATER DELIVERY SYSTEM TO MAINTAIN TUI CHUB HABITATS

DESIGN CRITERIA

The protection design presented here is based on criteria regarding habitat priority, construction, operation and environmental policy. These criteria are:

1. The key emphasis is on Mohave tui chub channel habitat with a surrounding buffer of marsh vegetation.
2. Quantities and locations of supplied water are designed to maintain channels and to meet water demands of the currently existing associated vegetative communities at Lark and G-1 Seeps, but the design does not attempt to "freeze-in-place" the existing pattern and size of these communities.
3. Federal policy for jurisdictional wetlands is "no net loss". A wetlands determination was not performed in this work, however we believe the mapped units are a fair approximation of federal "wetlands" under current Joint Agency criteria (Federal Interagency Committee) or the older U.S. Army Corps of Engineers delineation manual of 1987. Where a loss or change is recommended, an offsetting habitat mitigation is proposed.
4. The systems should be as operationally simple as possible, requiring infrequent

adjustment and maintenance. As some periodic channel maintenance is unavoidable - and highly disruptive, tui chub safety be specifically addressed.

PROPOSED DESIGN

Three pipe discharge areas have been selected. The points of discharge are north of Water Road, at the heads of three channels. These are; the East Shop channel, the George Road channel, and the G-1 connector channel (see Plate 6.). The discharges to the East Shop and George Road channels are intended to maintain the present day water surface elevation in the east channel and raise somewhat, the elevation of the George Road channel. The G-1 connector channel is used only as a means of providing water to the G-1 channel and therefore, the elevation may vary. The quantities given are derived from the ET calculations and measured flows. Where we were able to check ET values against weir measurements, agreement was excellent. They should provide safe estimates of maximum flows. We doubt these values will be reached however, as our analysis of vertical and horizontal flows between the City and the seeps shows that other sources also contribute to the seeps and will continue to do so. As these cannot be reasonably calculated from existing data, we believe the prudent and not expensively over-designed pipe system is one based on the assumption that the WTF ponds are the only water source.

As annual weed removal is a current practice, we urge consideration of improving the channels to the recommended depths and widths. This should help reduce the frequency of this work. The remainder of the proposed system does not need to be constructed until a well level drop is noted. We expect the system can be constructed within 2 - 4 months, a short enough period of time before any habitat loss occurs.

A water supply to the vegetative units south of Water Road has not been provided as we believe long term maintenance of this vegetation as it now exists is not practically possible. Maintaining a soil moisture profile for specific marsh plants requires a water level control of better than 2 to 3 inches. Marsh vegetation surrounding a pool or channel (essentially a point source) can be rather easily sustained by visually controlling water levels with structures or adjusting input flows. When the water source is a diffuse groundwater flow, buried exfiltration pipes would have to be placed to mimic the system. The flow would have to be adjusted to match seasonal evapotranspiration - using shallow monitoring wells, tensiometers and the like.

These buried pipes tend to either plug or channel and the ability to sense and then adjust the flow has considerable lag. The soil moisture therefore is likely to oscillate widely around the correct value.

In addition to the 34 acres of vegetative units just described, the 600 foot West Shop channel has also not been provided with a water supply. This narrow, weed choked and shallow system has seen intermittent flow and has no tui chub habitat value. We do not include maintenance of the south extension of the East Shop Channel (the feeding pool area). This short 150 foot segment is presently very close to becoming an isolated pool with little circulation. For safety from inadvertent entry of competitive species, inappropriate and harmful food and chemicals, personnel access probably should be more limited. As the proposed East Shop channel pipe passes along side this area, it is easily possible to add an outlet if continuance of this section is desired.

We recommend that WTF pond 9 be used as the water source. Other ponds such as 10 often become shallow and even dry in some portions. Pond 9 has maintained a consistent water level and has good water quality characteristics. Water taken from pond 9 and piped to the existing tui chub habitat at Lark Seep will allow the maintenance of the high quality aquatic environment that exists there now.

Water supplied to a deepened and widened George Road channel and the adjacent pond meets several design criteria. We propose the flow to Lark Seep be equally split between this channel and the East Shop Channel. Doing so provides the necessary total water needed for Lark Seep and matches the flow velocities we have measured (on the order of 1 foot per second). The George Road channel probably contains a few, if any tui chub at its northern extreme. The 1050 foot length would therefore become additional habitat, replacing that lost south of Water Road. This channel habitat also provides a significant degree of redundancy for protection during dredging and the possible inadvertent introduction of chemicals or species into the East Shop channel.

The East Shop and George Road channels should be cleared and reshaped. We recommend a depth of 5 feet to reduce the maintenance cost and habitat disruption of weed removal. The width would be about 5 feet at the water surface. These dimensions provide a cross sectional area that will convey water at a very low, non-scouring velocity. The maximum summer flows

to each channel should be 25 feet³/min or slightly more. This matches the maximum flow measured at the S-1 weir at Water Road. The flow through the George Road channel, while providing a replacement habitat, matches in volume the diffuse groundwater flow migrating into Lark Seep. The minimum winter flows for both channels are recommended to be about 15 feet³/min, sufficient to provide a slight current. This value matches the measured minimum flow at weir S-1. By the ET calculation the minimum required is only 7.5 feet³/min. Therefore, the Lark Seep discharge to the G-1 channel may be greater than now measured. If so, the flow through the third pipe into the G-1 connector channel can be appropriately adjusted. A weir downstream of the channel junction will provide the needed measurement for balancing the flows.

The maximum summer flow into the G-1 connector channel could eventually rise to about 42 feet³/min, adding to the 10 feet³/min discharged from Lark Seep. This amount would replace all the groundwater flow intercepted by the G-1 channel. The connector channel underwater cross section needs only to be about two or three square feet to keep currents safely below scouring velocities (greater than 2-3 feet³/min). The use of the connector channel is only to convey additional water to G-1 Seep, if needed. It is not considered to be a habitat area as it may, at times, be dry. It may eventually be less expensive to continue the pipe to the G-1 channel rather remove weeds.

Also shown on Plate 6 is a small detention pond on the south side of the George Road channel. The north side of the channel is left accessible for maintenance. The pond aids in buffering the channel environment from changes in temperature, brief flow disruptions and, to some degree, water quality problems. This pond water depth also should be at least 5 feet deep. Ringing emergent vegetation will soon grow in and will aid excess nitrogen uptake and capture of heavy metals. The passage of water into the channel from the pond is across a sill cut 2 feet lower (about 2,176' msl) than the pond bank. Initially, anti-scouring cloth would be needed until cattails root. The flow will then be slowed and filtered by this vegetation. This design approach is commonly used for improvement of stormwater quality. A small, deeper pool area such as this has proved to be a very important habitat for the tui chub in the West Shop channel. The fact that the shore areas will be vegetated with cattail and perhaps other emergent plant species will serve to filter water in a manner similar to other inflow areas into the existing Lark Seep system.

The three piped discharges have predicted maximums of 42 (G-1 connector) and 25 feet³/min (George and East Shop). The line lengths from pond 9 to the channels is from 4,500 feet to the

G-1 connector to 5,300 feet to the East Shop channel. Depending upon the water surface elevation of pond 9, the hydraulic head is about 10 to 12 feet (slope gradient 0.002 to 0.0028). We have not attempted a detailed engineering design of the piping, valves and related equipment. However, the quantity required is believed deliverable by 12 inch diameter pipe, possible without pumping. As a moderate water temperature is important to fish health, the pipes should be buried with a soil cover of least three feet.

HEALTH CONCERNS

We have discussed the use of effluent water from pond 9 to augment groundwater flows to the Lark Seep system with Mr. Ted Saari of the Lohantan Region of the California Water Quality Control Board (Victorville office) to determine if there would be any problems associated with using the pond effluent for tui chub habitat restoration purposes. Mr. Saari referred us to Mr. Armand Quintana of the Environmental Management Branch of the California Department of Health Services (Ontario office). It was Mr. Quintana's opinion that there would be no problems associated with diverting secondary treated effluent water from an evaporation pond to the tui chub habitat. He noted that reclaimed wastewater is now used for marsh restoration in many parts of California. He was concerned about public access and the distance to residential areas. We assured him that Lark Seep was within a fenced, controlled area and that it was at least one mile from any residences.

TASK 4. PROPOSED MONITORING SYSTEM

MONITORING WELL LEVELS

As the various facility ponds are lined, the water moving to Lark Seep will undoubtedly decrease in volume. We believe the first indication of decreased water supply to the tui chub habitats will be a decline in ground water level.

To detect any changes in ground water levels we recommend that the following wells be monitored bimonthly once the pond sealing program begins: wells "MW-1", "MW-2", "MW-3", "J", "H", "I" and one well each from the "B" and "C" clusters.

MONITORING WATER FLOWS

As the facility ponds are sealed beginning in 1992, it is expected that two main changes in ground water conditions will occur. First, there should be a decrease in water levels in the monitoring wells north of the facility ponds. Second, there should be a decrease in water flow to Lark Seep. In order to monitor these changes we proposed a bimonthly monitoring system that will involved reading water flow into the Lark Seep as well as measuring levels of the wells.

Water flow rates in the various channels were monitored over a two-year period by a series of weirs installed on the East and West Shop channels and at two locations on the G-1 channel (Feldmeth, et al., 1989). Results of this study indicated that water flow in the East Shop channel remained constant at about 25 feet³/min year-round. Water flow over the two weirs on the G-1 channel showed a seasonal range with discharge being highest in the winter months and lowest in the summer. The weir located at the head of the G-1 channel immediately northwest of the large cattail marsh at Lark Seep, showed a discharge that ranged from a low of about 10 feet³/min in July to a high of about 30 feet³/min in December. The weir located further to the west at Pole Line Road showed a similar seasonal range of about 20 feet³/min in July to about 40 feet³/min in December. High rates of evapotranspiration from marsh plants and the open water of the channels and the lagoon during the summer months appear substantially to affect flow rates downstream (north and west) of Lark Seep. By contrast, the flow at the south end of the East Shop channel remained constant. We thus recommend that monitoring of the water flow to the marsh system be near the culvert where the East Shop channel passes under Water Road. Changes in water discharge rates at this point will not be affected by season and will indicate when the actual volume of water coming from the facility ponds decreases. We recommend that a new concrete weir be installed and that discharge rates also be measured bi-monthly. A location about 60 feet north of the culvert allows room for the pipe discharge system should it become needed. The weir than can be used to adjust the discharge

Because the G-1 channel provides some habitat for tui chubs, it also will be important to monitor flow rates in this channel. We recommend that a second concrete weir be installed west of the junction with the George Road connector channel and that monitoring also be bimonthly. A location at Pole Line Road allows checking of any decreases in the captured groundwater flow and, again, if a pipe discharge system is installed this location provides the flow information for

G-1 Seep needed for adjustment of the George Road Connector channel pipe discharge.

WATER QUALITY MONITORING

The two water quality parameters that are most important to the Mohave tui chub population at the NWC are temperature and dissolved oxygen. The critical thermal maximum for Mohave tui chub is 34 C and the critical low oxygen level is about 1.0 ppm (McClanahan, et al., 1986). We have observed that once water temperatures drop below about 15 C at Lark Seep, activity of the tui chub decreases to a low level (Feldmeth, et al., 1984). McClanahan, et al.(1986) found that swimming performance for this species drops off considerably in temperatures below 15 C.

WATER TEMPERATURE

The seasonal temperature range for the Lark Seep system shows that the optimal habitats in the East Shop channel range from about 15 C during the winter to a high of about 22 C in mid-summer. By contrast, in shallower downstream habitats of the G-1 channel, water temperatures dropped below 15 C by October 1 and did not rise above 15 C until mid-April. Thus it appears that the deeper, relatively warmer habitats of the East Shop channel allow chubs to be active almost year round. The cooler habitats of the lagoon and the G-1 channel drop to temperatures as low as 1 C during winter cold spells (Feldmeth, et al., 1984). In these cool, shallow channels less active tui chub become vulnerable to predation, especially by birds.

With the implementation of the City's wastewater reclamation program, reduction in water flows to the Lark Seep system may allow water temperatures to decrease to lower levels in the East Shop channel due to a longer retention time. The water that flows out of the ground at the south end of this channel maintains ground water temperatures at present because there is sufficient flow along the length of the East Shop channel. Reduction of this flow may allow more loss of heat to the cooler air during the fall and winter months. Burying the water delivery pipes throughout the distance from pond 9 to the channels will provide a usefully warmer environment. We thus recommend that bimonthly temperature readings be made both in the East Shop channel and in the G-1 channel once the pond sealing program begins.

DISSOLVED OXYGEN

Day-time dissolved oxygen levels for the Lark Seep system range from lows of about 2 ppm in the cattail-choked portions of the East Shop channel during mid-summer to highs of about 12 ppm in the G-1 channel in mid-winter. (Feldmeth, et al., 1984). In a 24-hour dissolved oxygen study conducted in 1983, however, we found that oxygen levels dropped as low as 1.1 ppm at 0550 hrs in the East Shop channel (McClanahan, et al., 1986). The high use of oxygen by cattails at night added to the lack of photosynthesis during the dark hours, makes the possibility of oxygen stress a reality. We thus also recommend bimonthly measurements of dissolved oxygen in the East Shop channel and the G-1 channel once the pond sealing program begins.

ADJUSTMENTS

As water levels flowing underground to Lark Seep decrease, effluent water pumped or fed by gravity flow from pond 9 will move by way of a buried pipe system to Lark Seep. Although there probably will be some decrease in temperature in the East Shop channel as water is piped in, dissolved oxygen and TDS levels should continue to provide optimal habitat conditions for the endangered Mohave tui chub.

- - - - -

REFERENCES

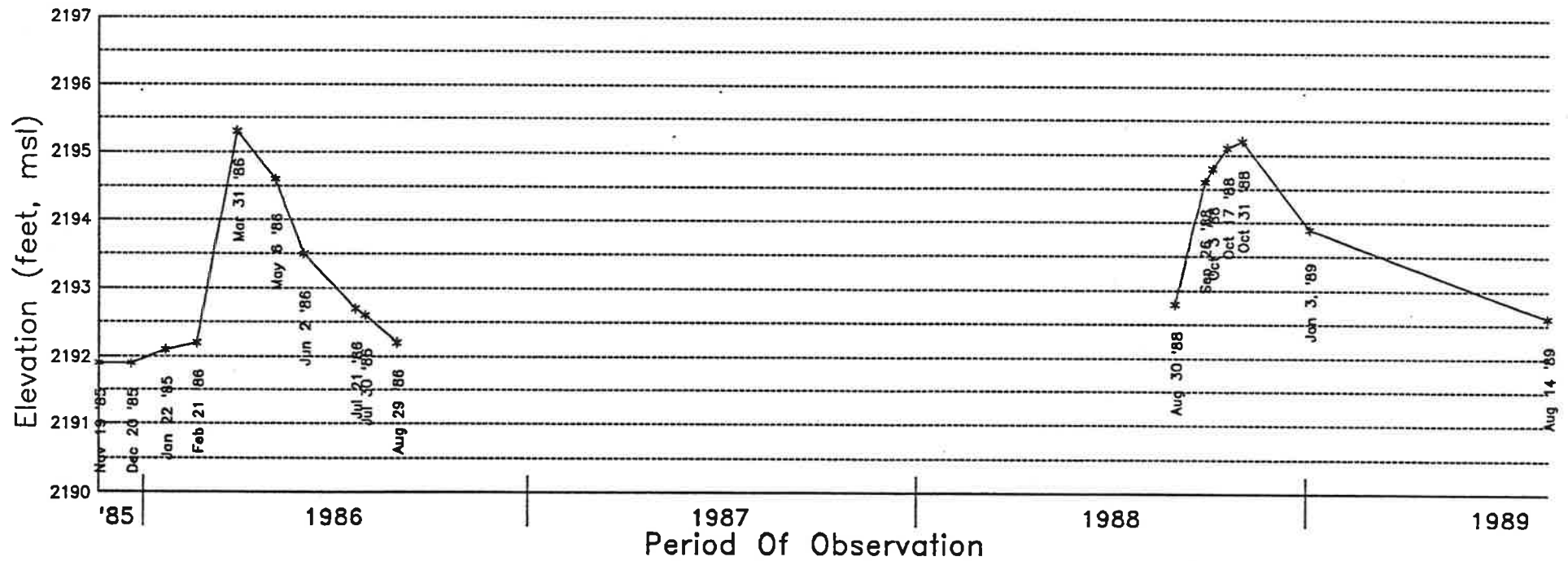
- Bechtel Environmental, Inc. 1989. Ridgecrest Domestic Wastewater Treatment Plant Groundwater Extraction Project, Scoping Draft and Project Description. Report of City of Ridgecrest.
- Bechtel Environmental, Inc. 1991. Environmental Assessment-Environmental Impact Report. City of Ridgecrest Wastewater Reclamation Project.
- Bilhorn, T.W., C.R. Feldmeth. 1985. Water Quality and Hydrology Studies at Soda Springs, San Bernardino County, CA. Report of U.S. Department of Interior, Bureau of Land Management. 55 pp.
- Federal Interagency Committee for Wetland Delineation. 1989. Federal Manual for Identifying and Delineating Jurisdictional Wetlands. U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S.D.A. Soil Conservation Service.
- Feldmeth, C.R., D.L. Soltz, L.C. McClanahan, B.A. Prigge, T.W. Bilhorn, J. Irwin, P. Brown-Berry and J. Jones. 1984. A Natural Resources Survey of the Lark Seep System with Special Emphasis on the Endangered Mohave tui chub. Report of the China Lake Naval Weapons Center. 89 pp.
- Feldmeth, C.R., R.F. Clements, D. Moore and T.W. Bilhorn. 1989. Field Monitoring of Mohave Tui Chub Habitats at China Lake Naval Weapons Center during the City of Ridgecrest's Wastewater Dewatering Program. Report of China Lake Naval Weapons Center. 69 pp.
- Havelka, M. and J. Bittman. 1980. Research on the Mohave Chub (Gila bicolor mohavensis) at the Desert Research Station from September 1979 to June 1980. 11 pp.
- McClanahan, L.L., C.R. Feldmeth, J. Jones and D.L. Soltz. 1986 Energetics, Salinity and Temperature Tolerances in the Mohave Tui Chub, Gila bicolor mohavensis. Copeia (1):45-52.
- Taylor, T.L. 1982. Population Size and Growth of Mohave Tui Chubs at Fort Soda, California. Report for Bureau of Land Management (CA-930-CT1-4). 5 pp plus tables and figures.

APPENDIX

PLATES

WATER TABLE ELEVATIONS WELL A (14L1)

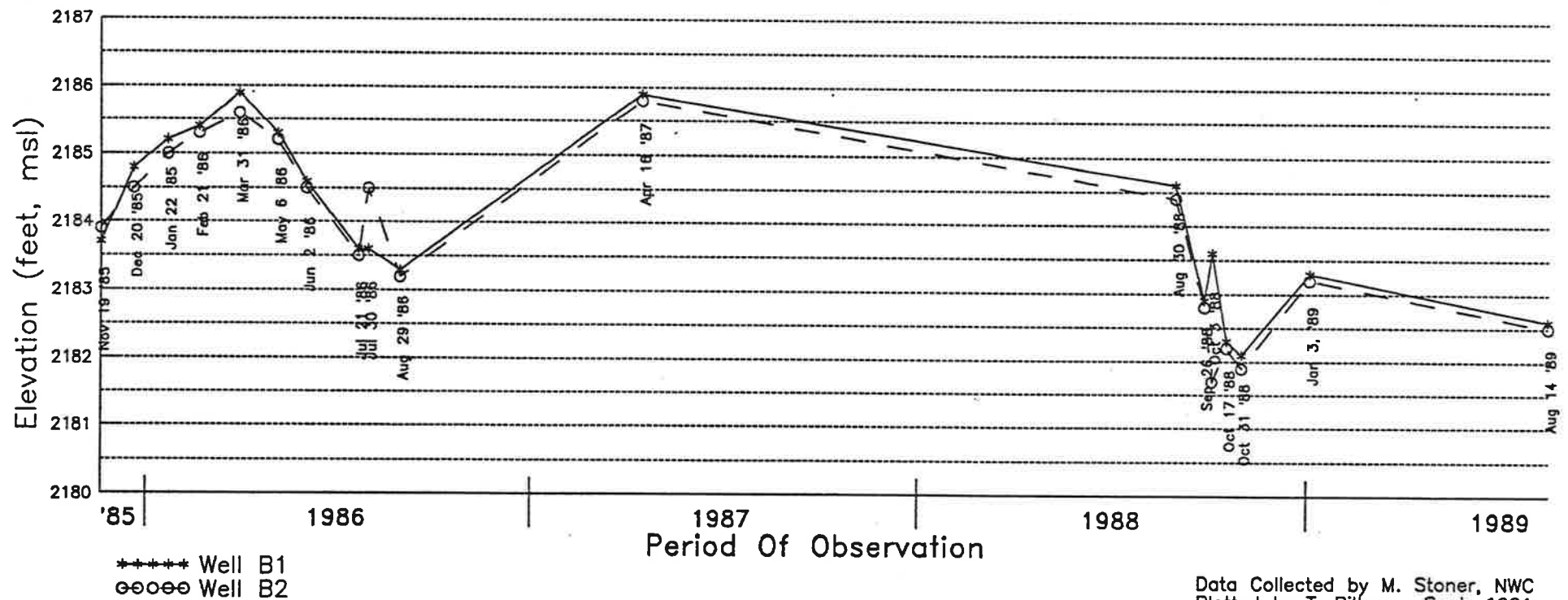
Hydrologic Study Lark & G1 Seeps, China Lake NWC



Data Collected by M. Stoner, NWC
Plotted by T. Bilhorn Sept. 1991

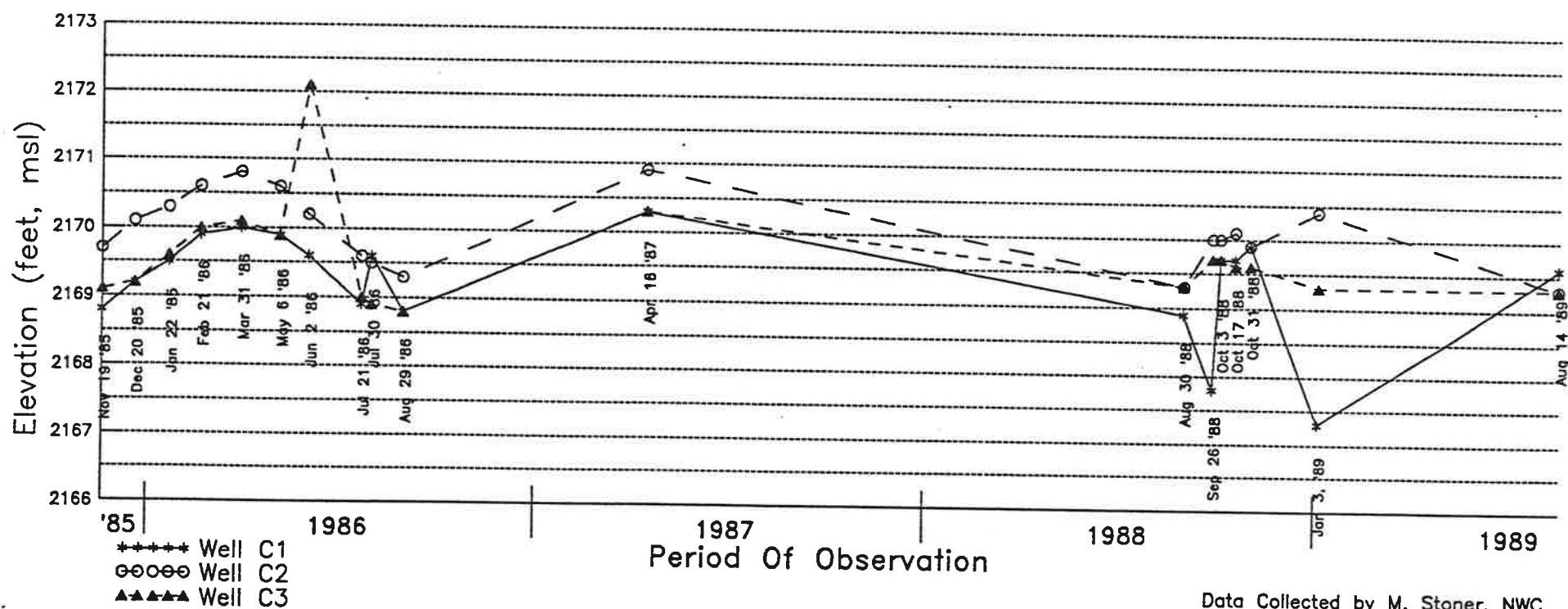
WATER TABLE ELEVATIONS WELLS B1, B2 (14B2, 14B1)

Hydrologic Study Lark & G1 Seeps, China Lake NWC



WATER TABLE ELEVATIONS WELLS C1 (11J2), C2 (11J1), C3 (11J3)

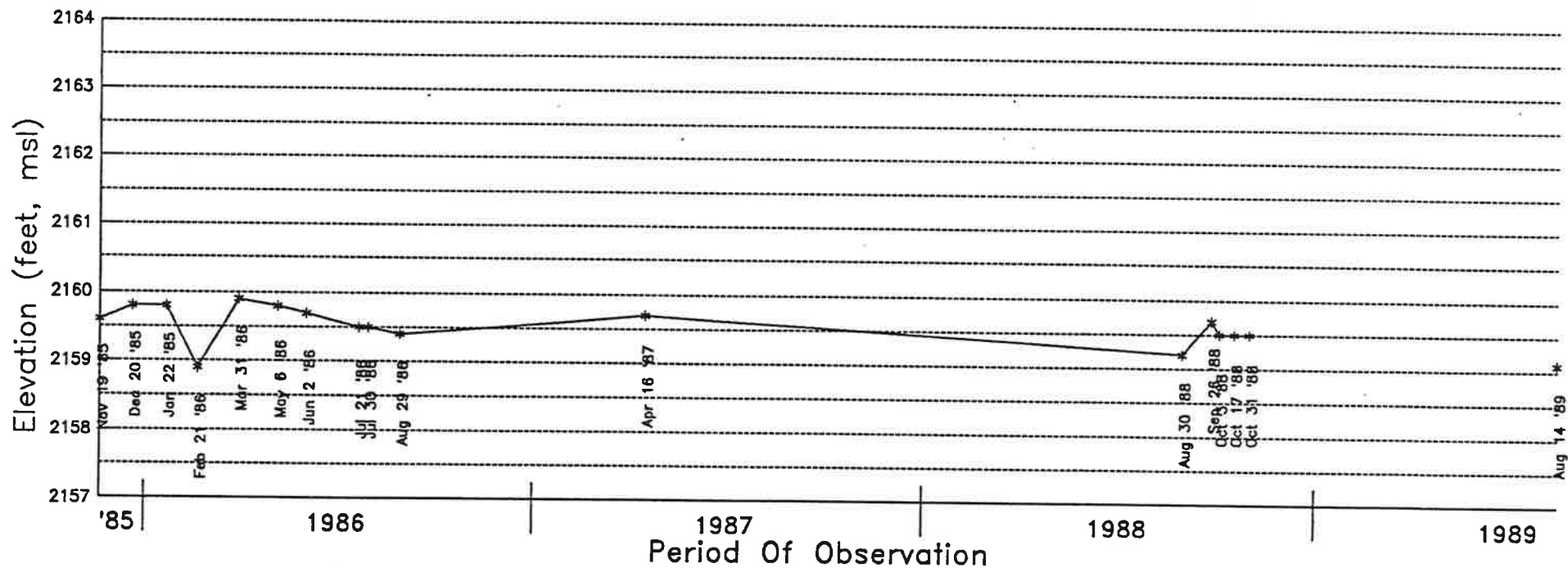
Hydrologic Study Lark & G1 Seeps, China Lake NWC



Data Collected by M. Stoner, NWC
Plotted by T. Bilhorn Sept. 1991

WATER TABLE ELEVATIONS WELL D (12F1)

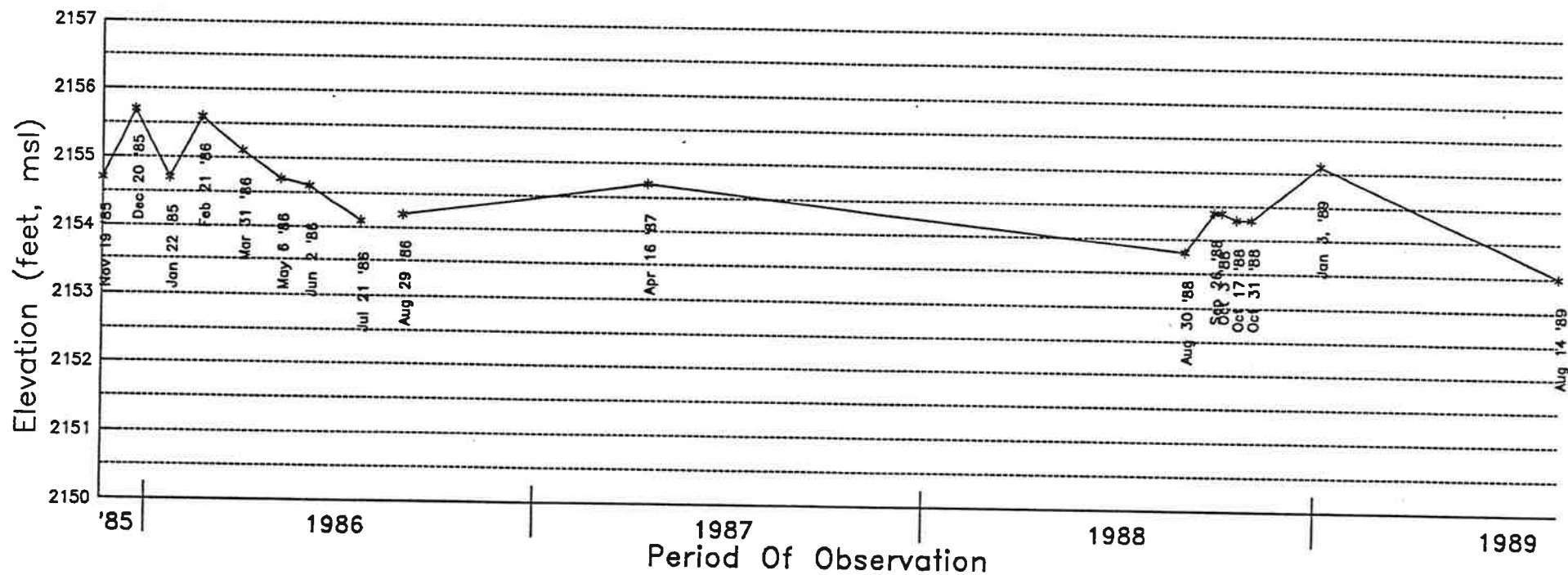
Hydrologic Study Lark & G1 Seeps, China Lake NWC



Data Collected by M. Stoner, NWC
Plotted by T. Bilhorn Sept. 1991

WATER TABLE ELEVATIONS WELL E (1P2)

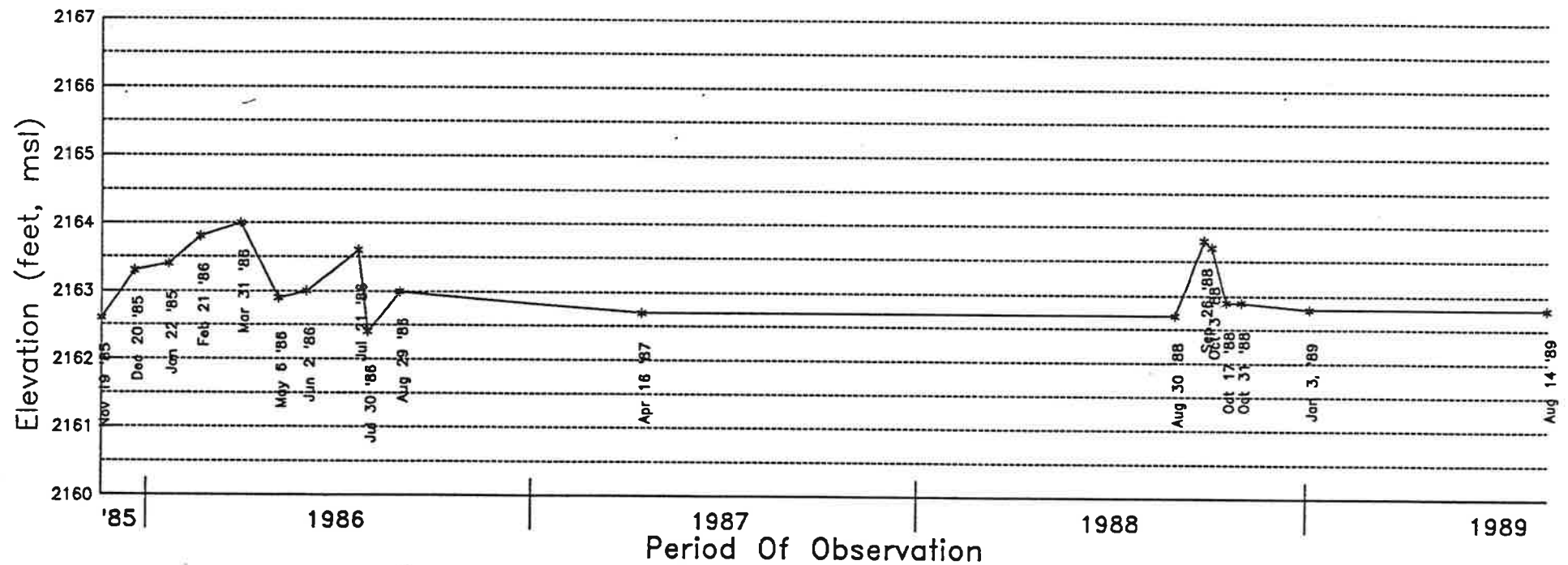
Hydrologic Study Lark & G1 Seeps, China Lake NWC



Data Collected by M. Stoner, NWC
Plotted by T. Bilhorn Sept. 1991

WATER TABLE ELEVATIONS WELL G1 (12G1)

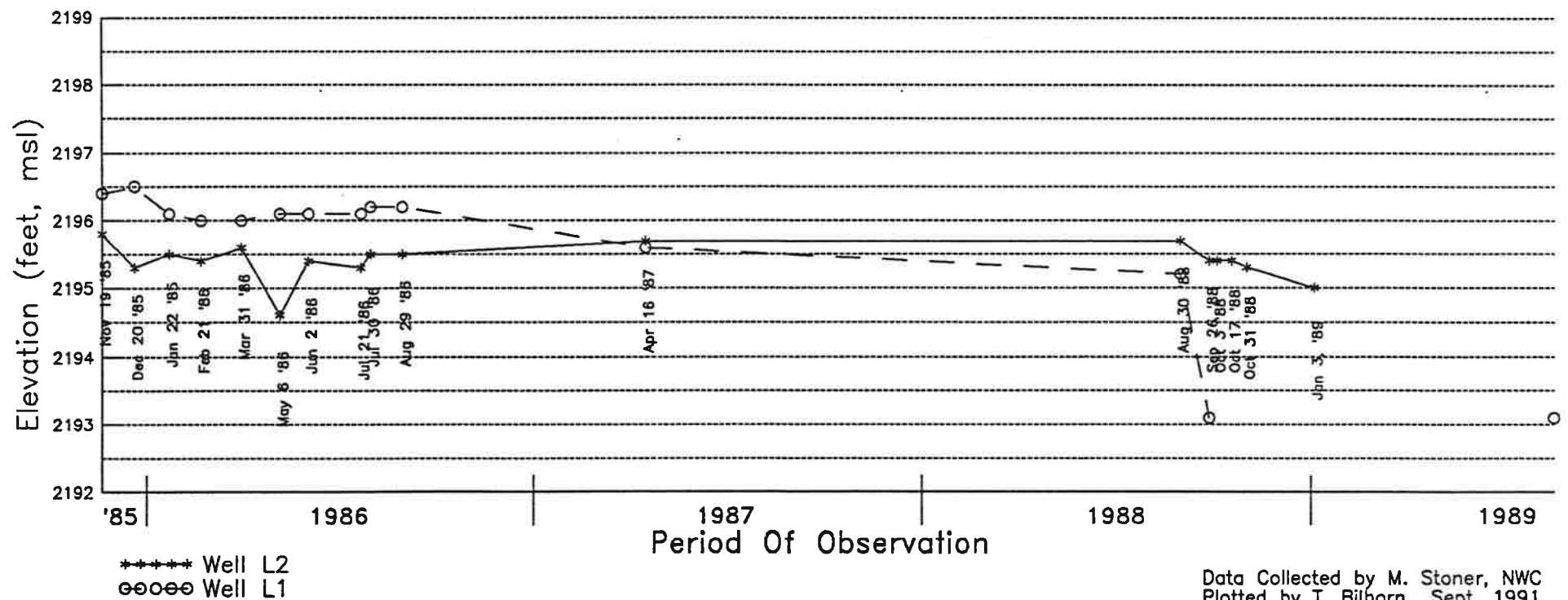
Hydrologic Study Lark & G1 Seeps, China Lake NWC



Data Collected by M. Stoner, NWC
Plotted by T. Bilhorn Sept. 1991

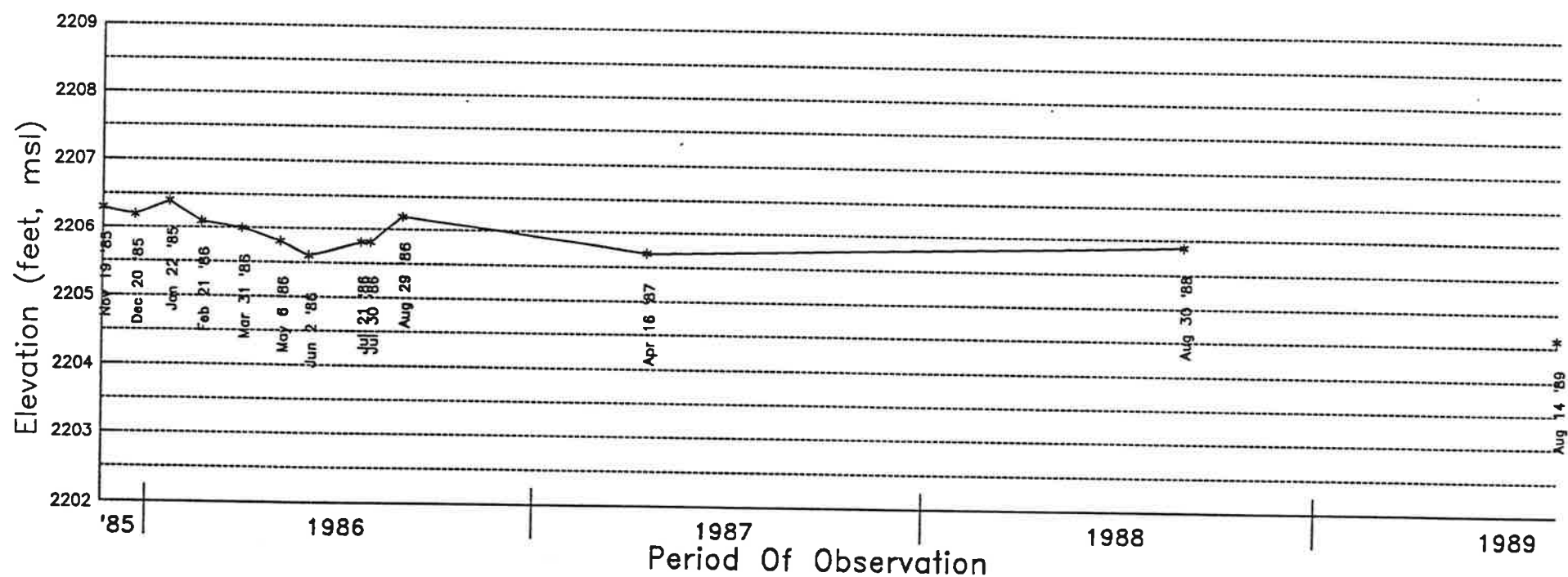
WATER TABLE ELEVATIONS WELLS L1 (23C2), L2 (23C1)

Hydrologic Study Lark & G1 Seeps, China Lake NWC



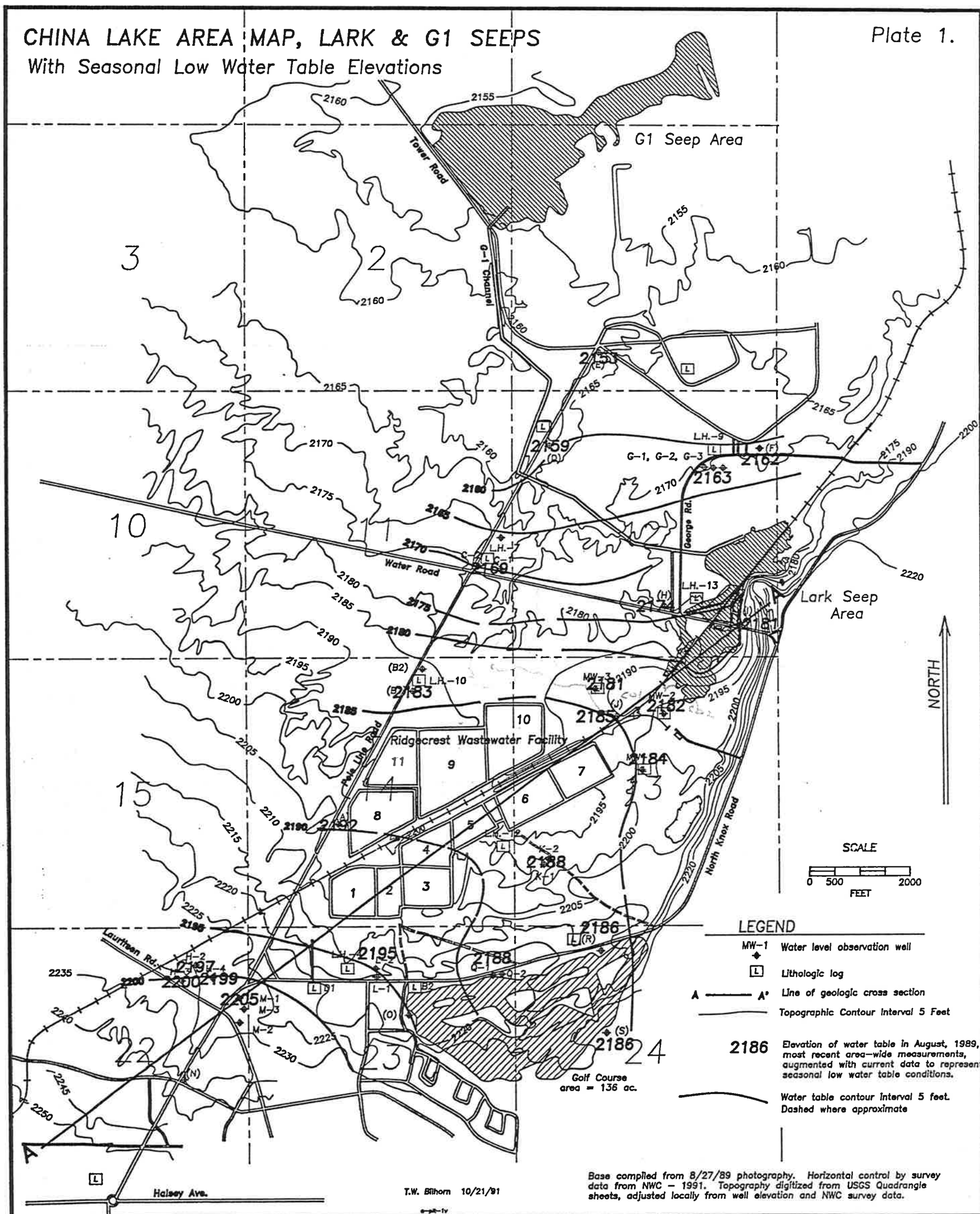
WATER TABLE ELEVATIONS WELL M1 (22H1)

Hydrologic Study Lark & G1 Seeps, China Lake NWC



Data Collected by M. Stoner, NWC
Plotted by T. Bilhorn Sept. 1991

Plate 1.

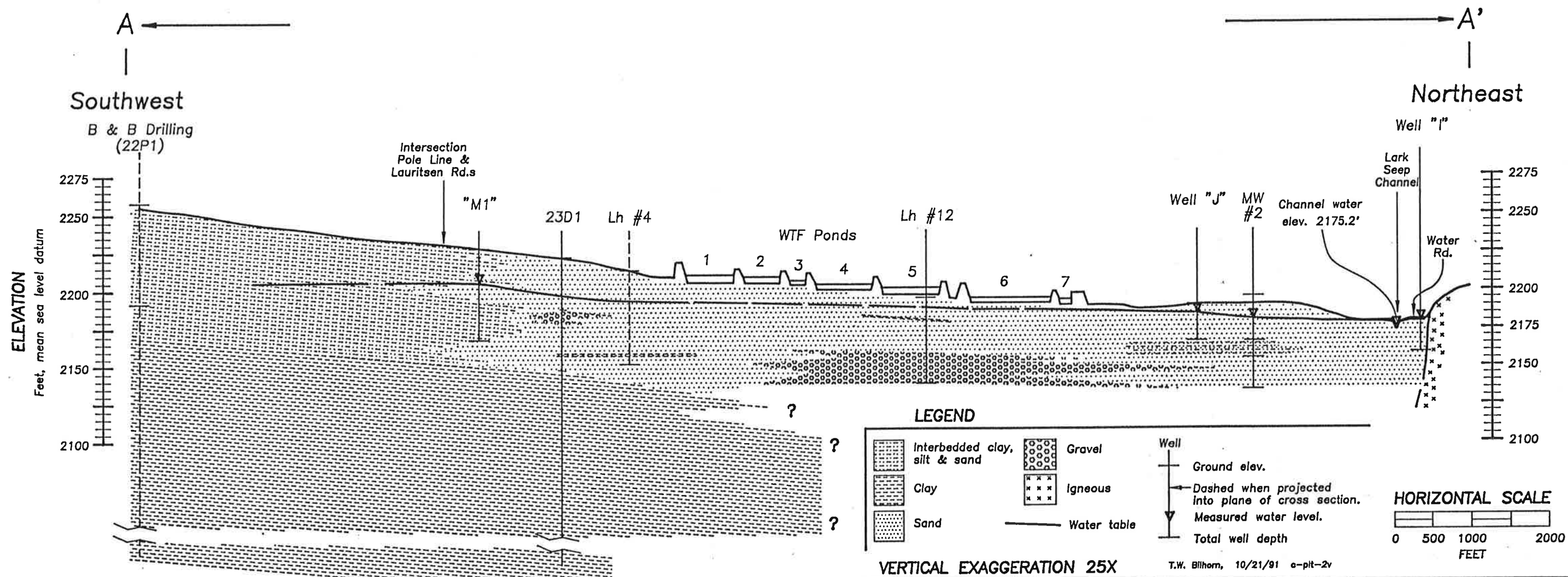


Base compiled from 8/27/89 photography. Horizontal control by survey data from NWC - 1991. Topography digitized from USGS Quadrangle sheets, adjusted locally from well elevation and NWC survey data.

GEOLOGIC CROSS SECTION – RIDGECREST WTF PONDS TO LARK SEEP

Plate 2

Showing Top of Water Table at Seasonal Low Level

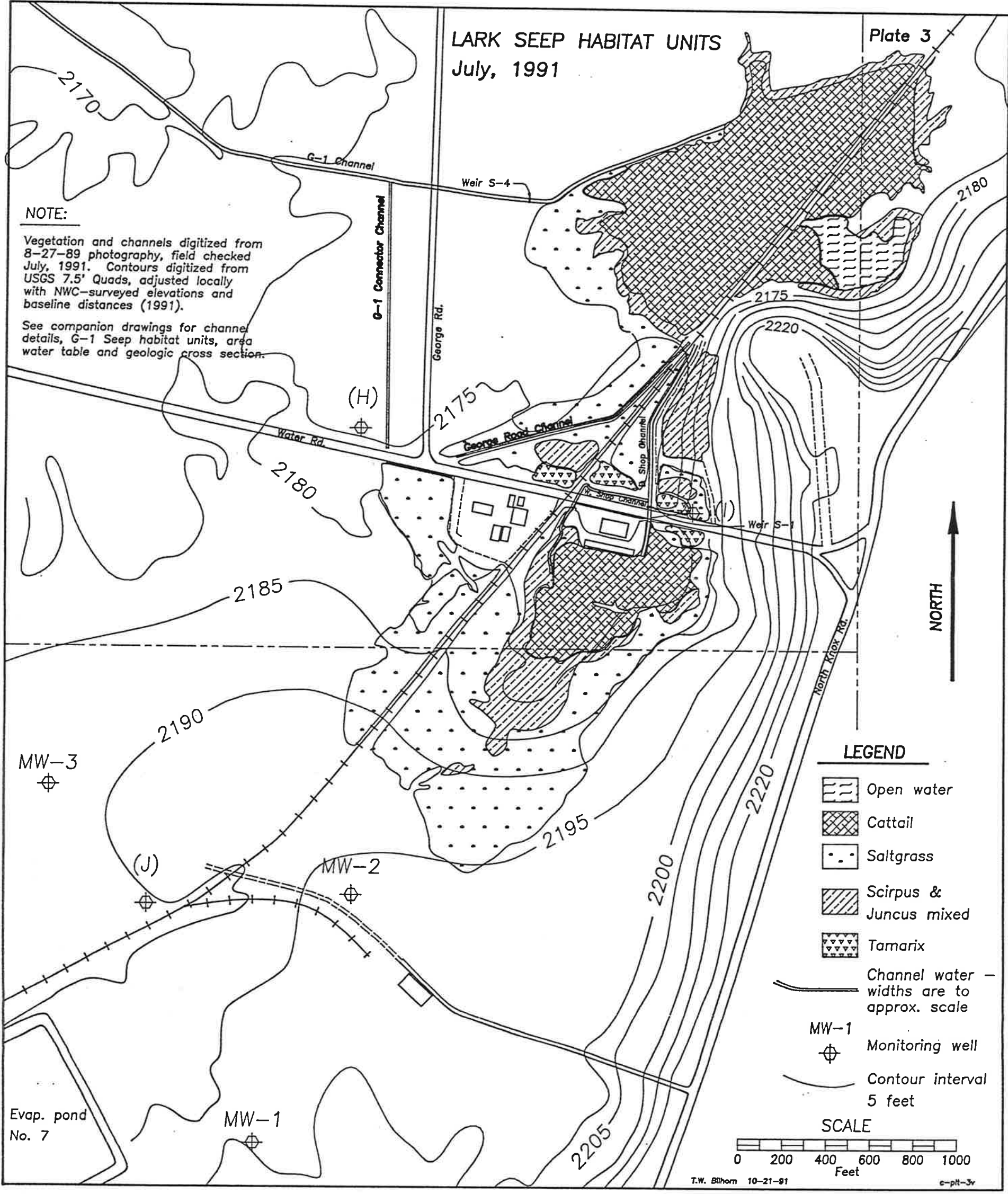


LARK SEEP HABITAT UNITS
July, 1991

Plate 3

NOTE:

Vegetation and channels digitized from 8-27-89 photography, field checked July, 1991. Contours digitized from USGS 7.5' Quads, adjusted locally with NWC-surveyed elevations and baseline distances (1991).
See companion drawings for channel details, G-1 Seep habitat units, area water table and geologic cross section.



LEGEND

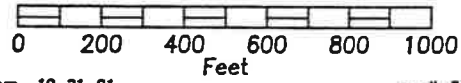
- Open water
- Cattail
- Saltgrass
- Scirpus & Juncus mixed
- Tamarix

Channel water - widths are to approx. scale

MW-1
Monitoring well

Contour interval
5 feet

SCALE



T.W. Blithorn 10-21-91

c-plt-3v

LARK SEEP CHANNEL AND LAGOON SYSTEM
Existing System - July, 1991

Plate 4.

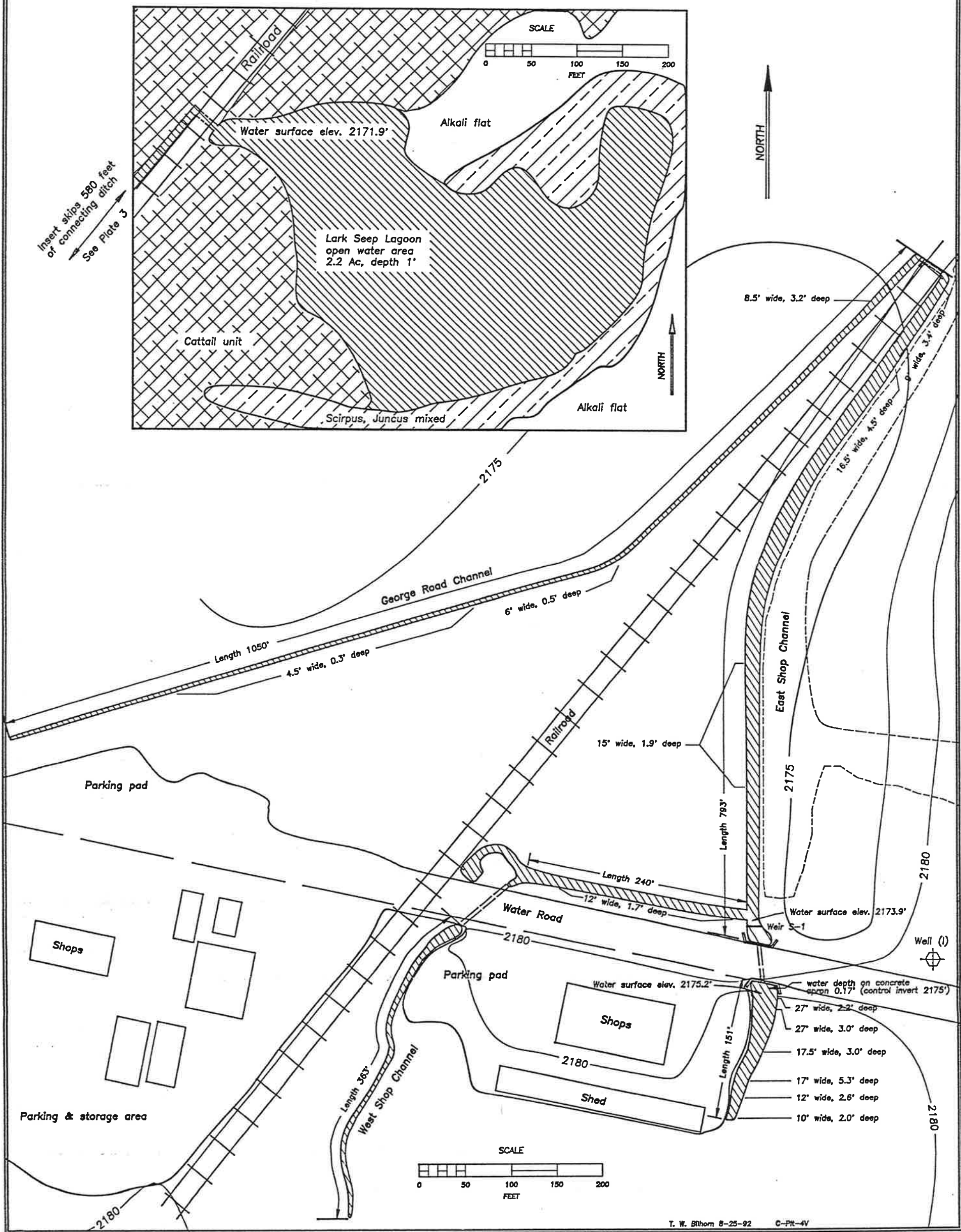
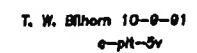


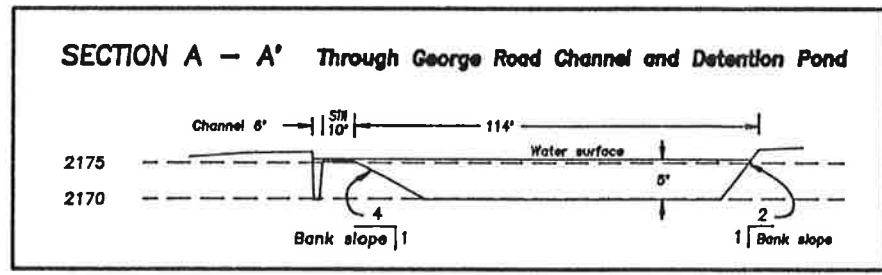
Plate 5



PROPOSED WATER DELIVERY SYSTEM TO MAINTAIN HABITAT AT LARK AND G-1 SEEPS

G-1 Connector Channel

George Rd.



Channel dimensions shown as of July, 1991. Maintenance efforts are to deepen, not widen and clear culvert obstructions at north end.

Max. summer discharge 42 CFM.
Min. winter discharge 0 - 16 CFM.

George Road Channel
Length 1050'

Detention Pond
Max. summer discharge 25 CFM
Min. winter discharge 15 CFM

Connecting sill approx. 100'
See inset

15' wide, 1.9' deep

East Shop Channel

Length 783'

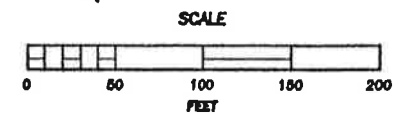
Water surface elev. 2173.9'

Permanent weir

Max. summer discharge 25 CFM
Min. winter discharge 15 CFM

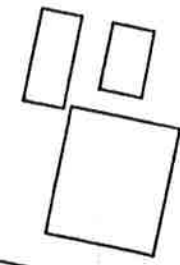
Pipe discharge into concrete lined stilling box

Buried pipe from WTF Pond 9



Parking & storage area

Shops



Water Road

2180

Parking pad

Shops

2180

Shed

Buried pipe from WTF pond 9