The City of CLOVIS

Water Master Plan Update • Phase One •

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PHASE I - WATER MASTER PLAN UPDATE

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EXECUTIVE SUMMARY

This report was prepared to support the 1994 Clovis General Plan, and the development plans therein. The primary purpose for the report is to examine the feasibility of continued growth in the greater Clovis area from a water resource stand point. This includes a review of existing and proposed demands for water and availability of supplies to meet those demands. Water supplies considered include both surface and groundwater. Currently all municipal demands are met with pumped groundwater. The study area corresponds directly to the General Plan area.

Groundwater

A number of factors influence the potential to develop groundwater for public supply in the study area. These factors include subsurface geologic conditions, depth to water and water-level trends, aquifer characteristics, recharge, and groundwater quality. Subsurface geologic conditions below the water level are important in terms of well yields and conditions above the water level are important when considering potential recharge operations.

The findings of the report with respect to groundwater may be summarized as follows:

- The aquifer is thickest under the southwest portion of the City, generally south of Herndon and West of Clovis Ave.

- To the north and east of Clovis, the aquifer thins substantially and bedrock becomes shallow with a resulting reduction in water production capacity.

- Planned growth areas are less favorable for groundwater development than in the existing City of Clovis.

- Existing groundwater pumping levels exceed recharge rates, resulting in continued lowering of groundwater levels in most parts of the area.

- For the past 10 years pumping amounts within the city have continued to increase (to over 16,000 Acre-Feet in 1994), while intentional recharge has averaged 5,000 Acre-Feet/Year.

- Surface and subsurface geologic conditions favorable for intentional recharge are limited.

- The areas most favorable for intentional recharge activities are along Dry Creek and other stream channels.

- Continued sole reliance on the existing supply system of recharge and groundwater pumping for water supply for future urbanizing lands is hampered due to geologic constraints.

- Groundwater quality varies widely over the study area. See the attached map titled "Groundwater Constraints."

A number of constituents were identified in the study to be present at problem levels or to possibly be a concern in the future, including DBCP, EDB, Nitrate, Iron, Manganese, Arsenic, and Radon. The areas where each of these have been identified, are outlined on the "Groundwater Constraints" map. At the present time the City utilizes wellhead treatment for DBCP removal for the water produced from five wells. Arsenic and Radon do not currently exceed drinking water standards, but if proposed standards are adopted, these could create problems for utilizing groundwater.

Surface Water

Within the study area there are lands included in the Fresno Irrigation District, "annexed" lands to the FID, Garfield Water District and International Water District. These agencies have surface water entitlements from either or both of the San Joaquin River and the Kings River. The Kings River supply is the predominant source accounting for over ninety percent of total available supplies. Kings River water is not allowed to be taken outside of the Kings River Water Association boundaries (which corresponds to the Enterprise Canal) which may cause problems with supply of water to lands in the northeast portion of the study area.

Surface water deliveries to the study area have approximated the surface water supplies available for the past ten years. During this same time, groundwater overdraft has occurred, suggesting that *increased utilization of surface water supplies will be imperative as development occurs to avoid worsening the overdraft condition.*

The findings with regard to surface water may be summarized as follows:

- There is potentially an adequate supply of surface water to meet the growth proposed in the General Plan if proper measures are taken to develop the supply and insure its full utilization.

- The capability to intentionally recharge large quantities of water in the study area is limited. For full utilization of surface supplies, direct delivery will be required.

- Surface water may be utilized for irrigation and intentional recharge without treatment. Surface water used for human consumption must undergo treatment.

Future Water Demands & Water Supply Elements

Based upon the data collected, factors for water use were developed for each land use. These numbers represent the average water use associated with specific land uses, such as commercial, low density residential and others. Adjustments were made to correct for variations and the resulting factors were checked against historic water production and land use records. As a final check, the results were compared with per capita use values available from other entities.

With the water use factors developed based upon existing use, future land use designations were used to calculate the estimated water supply needs for development of the different planned village areas. The results calculated provide a clear indication as to future water needs in specific areas.

After evaluating the water needs, and the potential supply, water budgets were completed for the existing city and study area. The budgets are useful in examining the various factors that influence water use and supply. The budgets were also used to check the results of determining the groundwater overdraft from water level charges alone.

An essential part of planning is understanding the alternative elements that may be used to satisfy both existing and future water supply demands. Some of the general elements addressed include; recharge, wells, surface water treatment, use of untreated surface water, use of reclaimed water, water banking, and conservation. Each of the elements was reviewed for their practical application within the area, with unit costs prepared for each element.

Alternatives and Recommendations

Following extensive review and evaluation, three major alternatives were formed. In addition the needs of the individual planned villages were examined. The findings of the study are summarized in the three alternatives as follows:

- **Alternative 1** - is a status quo alternative based upon continued reliance upon groundwater. This alternative would require the development of extensive recharge facilities (an estimated 1,000 - 3,000 acres depending upon subsurface geologic conditions) and retain the uncertainty involving groundwater quality issues.

- **Alternative 2** - is a large scale move to surface water treatment, which would be centered on the construction of a large water treatment facility. This alternative would provide the greatest protection against groundwater uncertainty but replace it with a high dependance upon surface water. This would be the most costly alternative, requiring major modifications to the distribution system, in addition to construction of a large treatment facility that is more difficult to phase with growth.

- **Recommended - Alternative 3** - The final alternative is a conjunctive use strategy where multiple elements are utilized to provide a secure long term supply. It includes utilizing both groundwater and treated surface water to insure a secure drought resistant water supply with the flexibility to utilize surface and groundwater supplies in a cost and operationally efficient manner. In addition this alternative is conducive to phased development that is a critical to both community approval and existing operational constraints.

The estimated capital costs for the facilities associated with the three alternatives are summarized in the table below.

Table S - 1

Summary of Capital Costs for Three Alternatives
(In millions of 1995 Dollars)

	Alternative 1	Alternative 2	Alternative 3
Artificial Recharge	126	0	34
Wells with Wellhead Treatment	23	6	6
Wells without Wellhead Treatment	15	0	4
Water Treatment Plants	0	80	35
Untreated Surface Water Use	0	0	2
Pipes, Booster Pumps, & Tanks	0	15	0
Total Capital Cost	**164**	**101**	**81**

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1 - INTRODUCTION

The City of Clovis is a community of approximately 60,000 people located in the San Joaquin Valley, adjacent and to the east of the City of Fresno. The two cities represent the greater metropolitan area within Fresno County.

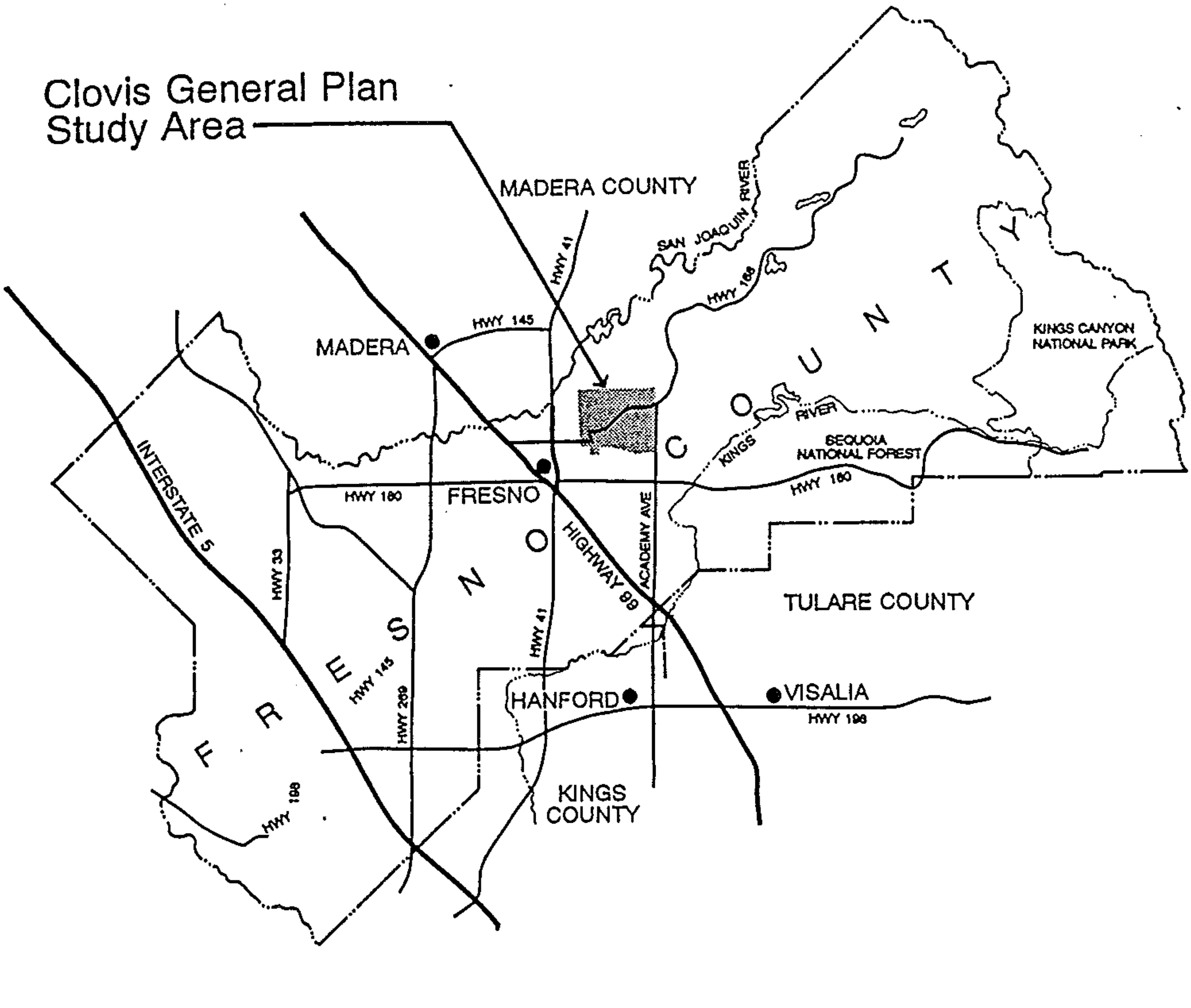
The Clovis area first began to develop early in the 1800's. At the beginning of the second half of the century, the countryside around the present city became prime grazing land for herds of sheep and cattle. Eventually, homesteads and their fences spelled an end to the open range era and before long, grain was cultivated and harvested.

The development of a major lumber mill and finishing plant was the result of the construction of a flume from Shaver Lake to the mill site in Clovis. The sawmill provided work for local residents and dominated political and social life in the community for years. As the flume and canal companies disbanded and the lumber industry changed, the people in the Clovis area returned to their historic agriculture centered economic base. The City of Clovis was incorporated as a general law city in 1912. The community remained essentially an agricultural center until just after World War II, at which time the population was still less than 2,000 people. Located within the Fresno Irrigation District, the City has been a focal point and urban center for the many small and large farms producing citrus, fruits, and nuts in the eastern part of the County. A map showing the City's regional location within the County is enclosed as Figure 1-1.

The City has strived to maintain its small town atmosphere and historic roots. Downtown Clovis is much as it once was, and historic Clovis is still centered where the Southern Pacific Railroad tracks cross State Highway 168. The current City limits encompass approximately 8,000 acres from Willow Avenue on the west to Temperance Avenue on the east, and from Nees Avenue on the north to the Gould Canal on the south.

The City has recently undertaken work that culminated in the adoption of a new General Plan. This plan, adopted April 26, 1993, provides the blueprint for future development of the local area through the year 2030. The stated purpose of the plan is:

> "It encompasses what the City is now, and what it intends to be, and provides the overall framework of how to achieve this future condition. Estimates are made about future population, household types and employment base, so that plans for land use, circulation, and facilities can be made to meet future needs. The General Plan represents an agreement on the fundamental values and a vision that is shared by the residents and the business community of Clovis and



THE PLANNING CENTER

NOT TO SCALE

FIGURE 1-1

> the surrounding area of interest. Its purpose is to provide decision makers and staff to the City of Clovis with direction for confronting present issues as an aid in coordinating planning issues with other governmental agencies, and for navigating the future."

Reproduced herein as Figure 1-2, is the adopted land use plan from the Clovis General Plan. This map will provide the basic guidelines for work performed for the Water Master Plan Update.

Purpose

The intent of this study is to evaluate the reliability of existing sources of water supply, identify future water demands within the study area, and provide a plan to meet the water supply needs for the City through the year 2030.

Historical Work

There has been considerable interest and work related to the water resources of the area. Important studies during the past two decades include:

(a) The Northeast Fresno Groundwater Study prepared by the Fresno County Public Works Department (July, 1976)
(b) 208 Water Management Plan prepared by the County of Fresno (June, 1979) which focused on protection of groundwater quality and short term water supplies, particularly in the northwest area
(c) A Water Resources Management Plan for the Fresno-Clovis Urban and Northeast Fresno County (June, 1986) funded by an EPA grant under Section 205(j) of the Clean Water Act
(d) A Surface Water Feasibility Study prepared by James M. Montgomery Engineers (1989)
(e) The Fresno/Clovis Water Resources Management Plan (FWRMP) prepared by CH_2M Hill. (1992-1994)

This later report was undertaken in three phases with many of the local water purveyors involved in the first two phases. The City of Fresno has initiated the third phase (implementation) independently. The third phase has been renamed The Fresno Metropolitan Water Resources Management Plan and the City of Fresno has stated their intent to adopt and implement many of the physical facilities and programs identified in the FWRMP. In the course of our work, we have maintained an open dialogue with the City of Fresno so that common issues would not be excluded with regard to resources or solutions.

Problem Assessment

The City has relied on untreated, largely non-disinfected groundwater as its sole source of potable water. Pesticide contamination was discovered in some City wells in the late 1970's. At the present time five of the twenty-six City wells have been fitted with granular activated carbon (GAC) water treatment facilities and four other wells are used only as standby units because of groundwater quality problems. Contaminants include 1, 2-dibromo-3-chloropropane (DBCP) and ethylene dibromide (EDB) and nitrate. Naturally occurring contaminants such as iron and manganese are also present in some areas.

DBCP and EDB are primarily due to former pesticide application to the surrounding farmland. Nitrates can also become elevated due to farm practices. Iron and manganese are present in the alluvium and in some cases the groundwater. On a more limited areal scale, commercial and industrial solvents, particularly volatile organic compounds may enter the aquifer. This introduction is usually through poor storage and handling practices, careless or improper disposal, and leaking underground tanks. However, these constituents have not impacted city wells to date.

Water quality regulations have become more rigorous in past years. If the present trend continues, water quality regulations may require some form of wellhead treatment at every public well in the City. Such treatment may consist of disinfection, corrosion control, and/or removal of radionuclides and organic chemicals. Many of the well sites are not sized, located, or configured to easily accommodate wellhead treatment.

The City's water distribution system was constructed based on dispersed wells and a local distribution network of relatively small water mains. The loss of some wells and spatial distribution of the remainder has created local areas of low pressure during peak demand periods, and has concentrated pumping activities to smaller isolated areas. In addition, many of the City's wells were historically located in the southwest, in a part of the study area where groundwater conditions are generally favorable. Growth areas have since been to the north and east, where groundwater conditions are not as good.

These problems have manifested themselves in a relatively short period of time, triggered by changes in water quality regulations, as well as significant growth on the periphery of the City.

Study Objectives

The principal objectives of this study are to develop a Water Master Plan that will guide the City of Clovis to:

- Improve the reliability of the existing water supply system.
- Develop additional safe, and dependable water supplies to meet future needs.
- Implement the Water Master Plan in an economic manner.

Study Area

As stated earlier, the Master Plan area will coincide with the limits of the General Plan. The General Plan specifically addresses growth to three urban villages and associated growth to existing City boundaries. However, there is a significant area zoned agricultural and rural residential east of the Enterprise Canal. These areas will be evaluated, but to a lesser extent than the urban area or the urban villages. At this time, the City does not provide services to the existing rural residential properties. This study will identify demands associated with the land use designation but makes no assumption on water service to the agricultural and rural residential properties.

Plates 1 and 2 show the current City boundaries and the limit of the study area while Plate 3 shows the different entities having jurisdiction in the study area.

2 - LAND USE

Introduction

Review of the City's General Plan suggests that the community desires to maintain its small town atmosphere as development occurs. An excerpt from the land use element, at the heart of the General Plan, states:

> "The goals, policies, and action programs of the land use are intended to support and reinforce the current quality of life in the community as a community of families in a small town atmosphere. The Land Use Element promotes the achievement of goals by establishing clear direction for future land use...The key element of land use policy is the Land Use Plan Map, which depicts the location of the permitted type and densities/intensity of all land uses within the project area."

Reference is made to Figure 1-2, which is a reproduction of the Land Use Plan Map adopted in the General Plan.

Setting

The General Plan area encompasses approximately 47,600 acres. The study area is generally bounded by Copper Avenue to the north, Academy Avenue to the east, Gould Canal to the south, and Willow Avenue to the west. The City of Clovis is the only urban center within the study area and it is located in the southwestern quadrant. The City limits presently encompass approximately 8,000 acres. Irrigated agriculture extends from the City boundaries to the north and east, both within an organized irrigation district supplied with surface water as well as another area that has no formal organization. Interspersed within the agricultural lands are areas of rural residential development on 2 to 5 acre parcels. Approximately 68 percent of the total project area is currently developed to urban, rural residential or agricultural uses with the remainder classified as idle/pasture. Low density residential land use dominates in the urban area accounting for 37 percent of the acreage. Rural residential land use outside the urban area is also of significant acreage accounting for approximately 17 percent of the total area. As shown on Plate 4, agriculture is by far the most dominate use in the area, accounting for half of the developed property.

It is the vision that commercial development will be concentrated in the urban area of downtown Clovis, mainly along the Clovis Avenue Corridor, including both Old Town, and the Shaw Avenue Corridor.

More intense development is planned for the northwest and to the southeast within the Fresno Irrigation District. In these areas, the village concept has been advanced. An urban village concept is planned to consist of approximately 160 acre neighborhoods established around a 10 acre village center. These villages are known as the Northwest Urban Center, Northeast Urban Center, and the Southeast Urban Center, as shown in Plate 5. Further to the east, it is envisioned that rural residential land will predominate.

Figure 2-1 shows the land use breakdown for the study area both under existing conditions and as planned by the general plan for ultimate buildout.

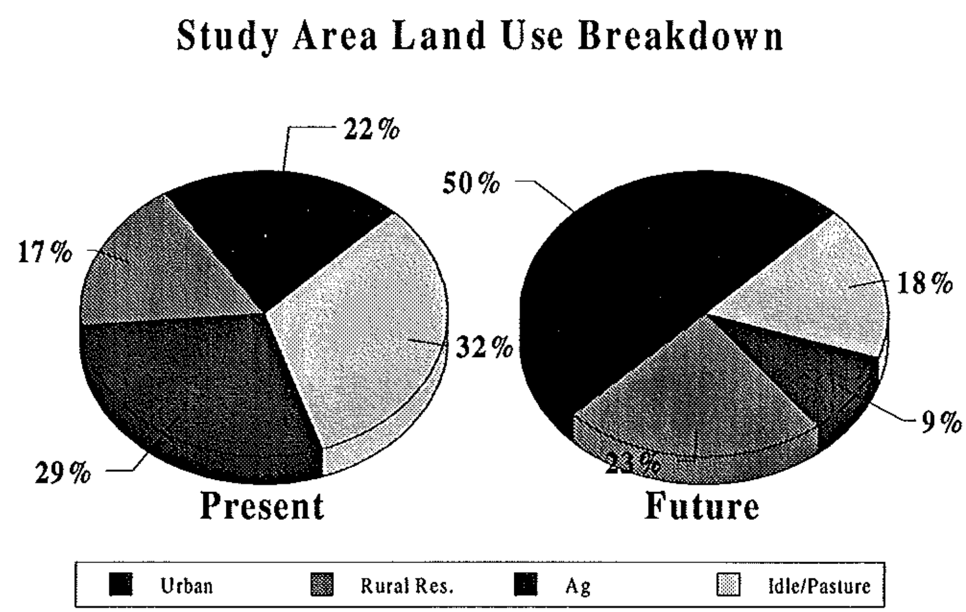


Figure 2-1 Land Use Within the Study Area

Villages

Northwest Urban Center

The Northwest Urban Center is located in the northwest corner of the project area, adjacent to the northern City limits and covering the unincorporated lands within the County of Fresno. The Northwest Urban Center extends south from Copper Avenue, along the old railroad right-of-way transit corridor to Nees Avenue, easterly along Nees Avenue to Clovis Avenue, and northerly from Clovis Avenue along the Dry Creek Canal to Sunnyside Avenue, then back to Copper Avenue. The area contains approximately 3,356 acres. Existing land uses consists mostly of agricultural lands. There are some rural residential lands, and a scattering of very low density residential uses. The Northwestern Urban Center is planned to include major regional and industrial mixed-use, employment-generating centers, and two transit centers along the old Southern Pacific Railroad transit corridor. Development potential is planned to be preserved through the designation of 802 acres for agricultural uses adjacent to and east of the Enterprise Canal. Residential land uses range from rural and very low to high with the majority designated for low and medium density. A 160-acre school campus and park sites were planned to be reserved with access to a trail system proposed along the Dry Creek and Enterprise Canals. The school complex was recently completed and a considerable amount of development has already begun in this area.

Northeast Urban Center

The Northeast Urban Center Specific Plan is the largest in acreage, approximately 6,522 acres. Located in the northeastern sector of the study area, the Friant-Kern Canal and Dog Creek form the eastern boundary, Herndon Avenue delineates the far southern edge with the planned outer beltway (Copper Avenue alignment) as the northern border. Existing land uses are predominantly open rangeland with scattered rural residential and agricultural pockets. Northern portions of the site are within the flood plain of the Dry Creek Reservoir.

This urban center is planned to provide a mix of residential, industrial, agricultural, mixed use, and open space uses, compatible with the adjacent Dry Creek Reservoir and the planned agricultural areas to the east. The Northeast Urban Center contains a large portion of planned agricultural and very low density residential land uses to try and retain the rural character of the area.

Southeast Urban Center

The Gould Canal represents the southerly boundary of the Southeasterly Urban Center. Locan Avenue serves as the western boundary and Shaw and McCall Avenues the northern and eastern boundaries, respectively. This is the smallest of the planned villages, at approximately 2,500 acres. Existing uses consist mostly of agriculture with a scattering of rural residential properties. The concept of this village envisions seven urban villages, each concentrated around a Mixed Use Village Center. Residential uses are comprised primarily of rural residential, very low and low density designations with lower densities along the southern perimeter and adjacent to agricultural designated land. A 160-acre education campus is planned to serve as the focal point of the Southeast Urban Center.

Immediately to the north of the southeast village, is a special study area that is to be reviewed for development potential with a specific plan study . The area is bounded by Shaw, Leonard, Bullard, and Highland. In the General Plan this area was designated for agricultural use, but further study has revealed conditions that may render agriculture uneconomical as a long term use.

Population Trends

The City of Clovis prepares population forecasts for its jurisdiction. In doing so, the City of Clovis also works with Fresno City staff to compile estimates of future growth. The California State Department of Finance also estimates future population within the City. Shown in Figure 2-2 is the historic population figures and projections into the future. Past estimates of growth have historically underestimated future population growth within the City. This overall trend has been experienced in other Valley towns, where growth has exceeded that in other parts of the State.

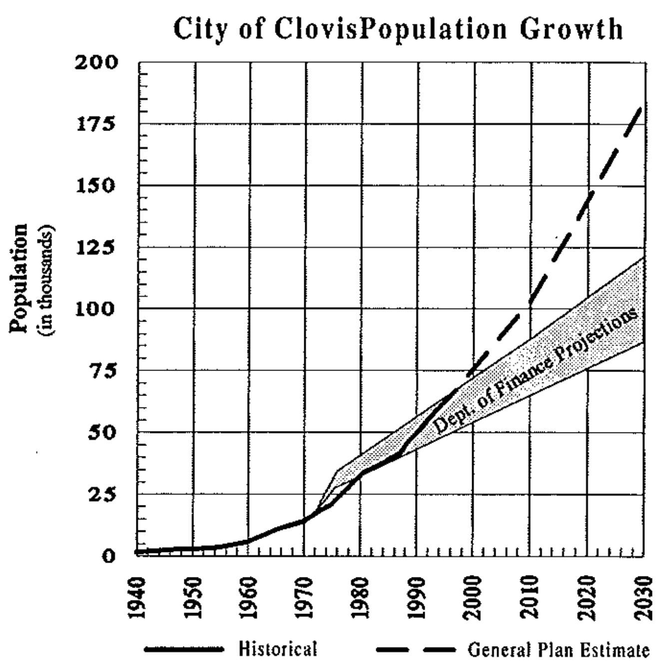


Figure 2-2. Clovis Population Growth.

Based upon estimates in the recently adopted General Plan, a total of 62,435 housing units are projected to be built, corresponding to a population of approximately 183,000 people based on average target densities and proposed land use distribution within the mixed use areas. It is also estimated that build-out of the General Plan would take place in approximately the year 2030 based on (a) continuing stable economic conditions (b) state job growth, and (c) an increasingly important role of the San Joaquin Valley region to the State economy.

Agriculture

As stated before, Clovis was founded and initiated growth due to the lumber industry and logging in the late 1800's. Following the logging era, the predominant land use in the Clovis area has been agriculture with operations ranging from small farms to large scale agricultural operations. Generally the smaller farms are located closer to the City limits and the rural residential areas. The larger agricultural operations are generally located in the unincorporated County portion of the study area in lands designated for agricultural use. Recently there has also been some conversion of the typical pasture lands to more highly profitable tree crops, specifically citrus and nuts.

It is intended that the General Plan will provide for the continuation of commercial agriculture as long as the areas are not sub-divided into smaller parcels. Generally, the majority of the agricultural lands exist within the Fresno Irrigation District (FID), the FID Annexed areas, and in the Garfield and International Water Districts (see Plate 3).

The FID encompasses approximately 383 square miles (245,232 acres). Within the 47,600 acre study area, 25,800 acres are within the FID. Of this total 3,000 acres are not contiguous and are located in the annexed portion of the District. The International Water District covers approximately 700 acres and is wholly within the study area. Lastly, the Garfield Water District, encompasses 810 acres of which 50 percent is in the study area. Historically, the lands within each of these districts are cultivated to agriculture (with the exception of land in the vicinity of the City of Clovis). Crops grown commercially have been categorized into various groups consisting mainly of:

Alfalfa and Pasture	Figs
Almonds	Mediterranean Orchard
Cotton	Vineyard
Deciduous Orchard	Miscellaneous Field Crops

Almost 40 percent of the agricultural lands are cultivated to permanent crops. Total acreage within the study area amounts to 47,600 acres. Total lands within the study area that are under cultivation are estimated at 16,000 acres. With development, the agricultural lands are expected to be reduced to less than 8,000 acres. As development of land occurs, it is expected that the land adjacent to the City center will be urbanized first, thus converting the agricultural lands to an urban use.

All lands within the Garfield and International Water Districts rely on and have the ability to utilize surface water. Within the FID, this is not the case. There are some lands within the district on service and some that are not. It is estimated that in 1994 over 10,000 acres of urban and agricultural lands did not take water service. A map of these parcels is included as Plate 6. These properties are served by groundwater pumping only. The remainder, or water service lands, are served by pumping from ditches or by gravity flow. A portion of the lands classified as on water service do not actually take delivery of District irrigation water, particularly in areas surrounding Clovis. Some parcels have historically never diverted water. Other parcels prefer pumping shallow groundwater, and some on drip irrigation generally prefer groundwater, due to scheduling and filtering considerations.

Service to rural residential land is based primarily on a parcel's proximity to FID distribution facilities which were in existence prior to creating the smaller parcels. Approximately one-half of the existing rural residential zoned lands are classified as on FID water service, although only a portion actually take water deliveries. The FID irrigation system is shown on Plate 7.

3 - EXISTING WATER SYSTEM

General

The Clovis water supply system is reliant upon water pumped from the aquifer beneath the city. Wells are spaced at intervals across the City and are connected to a distribution system that has been sized to allow the supply to be injected at multiple points throughout the system. The network consists primarily of 12-inch mains on a half mile grid with extensive looping. The wells are controlled by a telemetry system that controls pump operations. In addition each well is equipped with independent switches that will control the pumps based upon local pressure in the case of remote computer failure. Storage is provided by three facilities. The oldest is a 65,000 gallon elevated tank located near downtown Clovis. The second is a 500,000 gallon elevated tank just a mile west of the first. The last and most recent addition is a 2 million gallon facility located near Armstrong & Tollhouse.

In addition to operating its own water system, the City has also been operating the Tarpey system for several years. The two systems are connected, but separated by valves that normally remain closed. The Tarpey wells are located within a mile of each other along the Gould Canal in the Southern portion of the City.

Supply

Currently, there are twenty-seven wells operating in the City system with five operating in the Tarpey system. The production of the existing wells varies from approximately 400 gpm to approximately 2,200 gpm. Total annual production for Clovis averages 14,000 acre-feet while that for the Tarpey system is 2,000 acre-feet. Figure 3-1 shows the annual water production for both systems from 1990 to 1994.

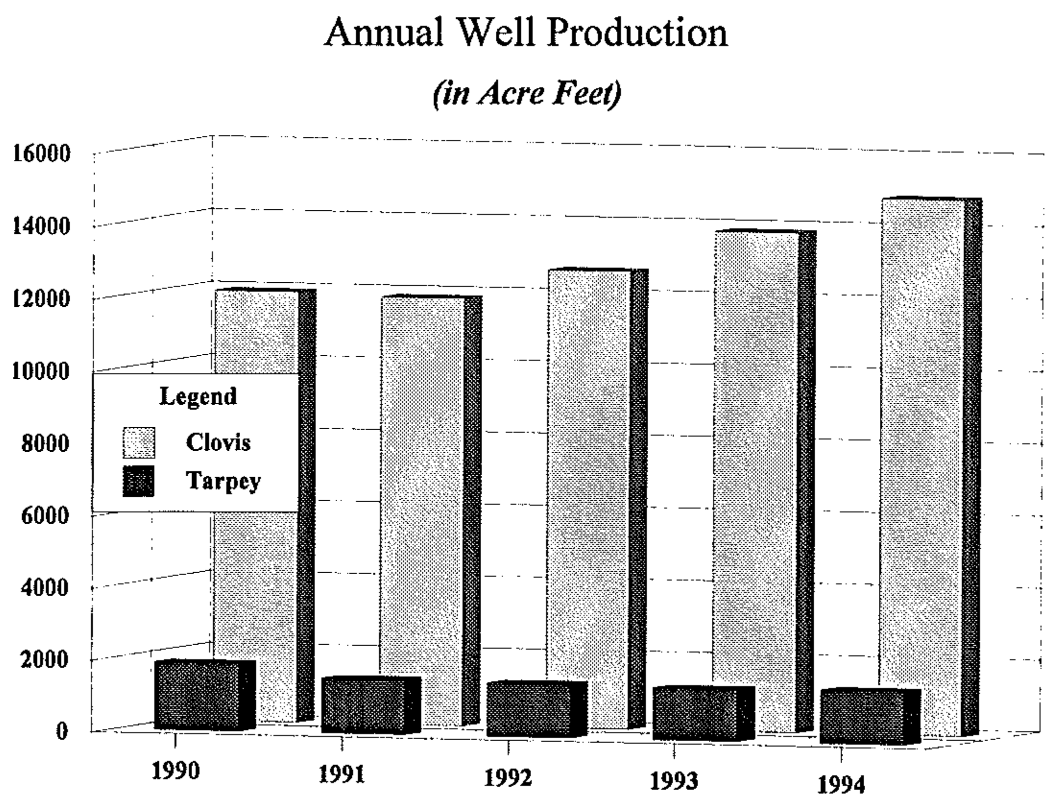
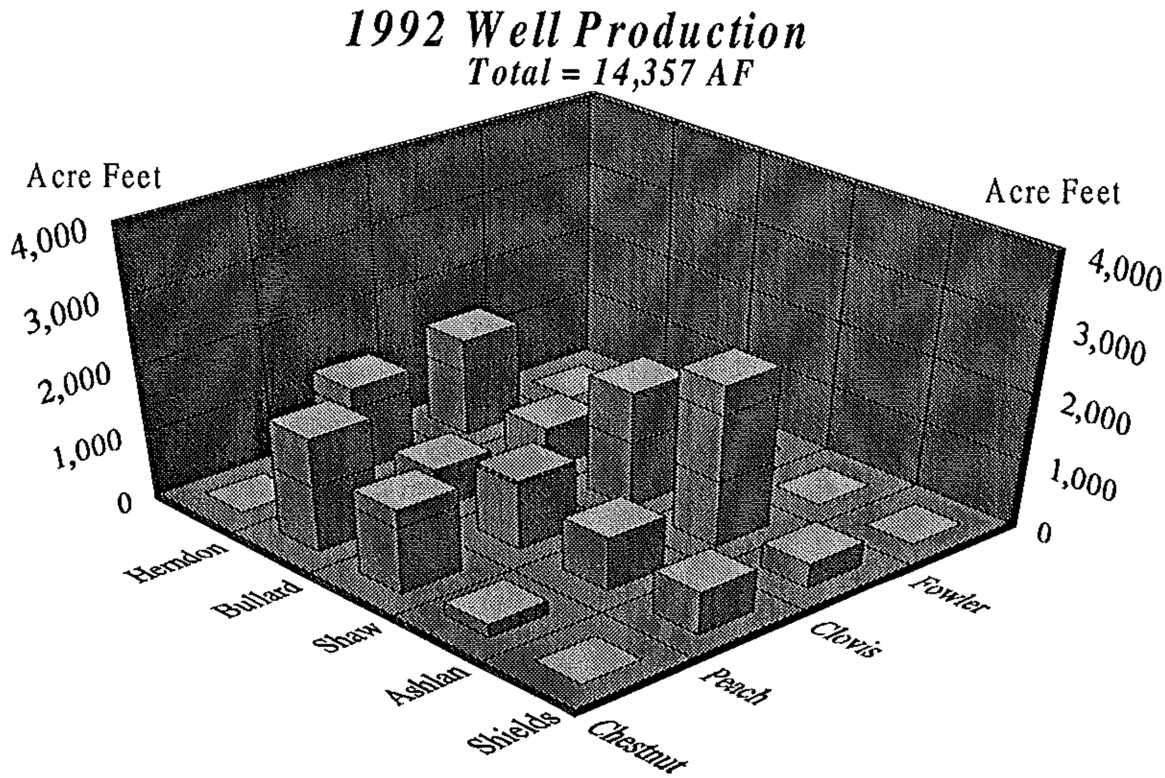


Figure 3-1 Annual Production for Clovis and Tarpey Wells

Existing wells are not evenly distributed across the service area, but rather generally located in the western half of the City as shown on Plate 8. In general the Southwest quarter of Clovis is served by older wells, and the newest wells have been in the north, while the Eastern portion of Clovis is served primarily by two high capacity wells, both equipped with treatment facilities. The northern portion of Clovis (north of Herndon Ave) which has experienced the highest growth in recent years has shifted the production characteristics of the city system dramatically. The 1991 City Water Master Plan showed one existing well in this area and recommended the installation of 8 more. Presently the City operates 7 wells within the area with one more planned. Production from the wells in this area as a percentage of total city production increased from 23 percent in 1992 to 44 percent in 1993. For the first seven months of 1994 it continued to increase to 49 percent. Figure 3-2 shows the distribution of production for 1992 and 1993 from the City's wells.

It should be noted that well numbers 1, 13, 16, and 20 are on standby due to water quality problems, and have not been used for production purposes for at least two years.



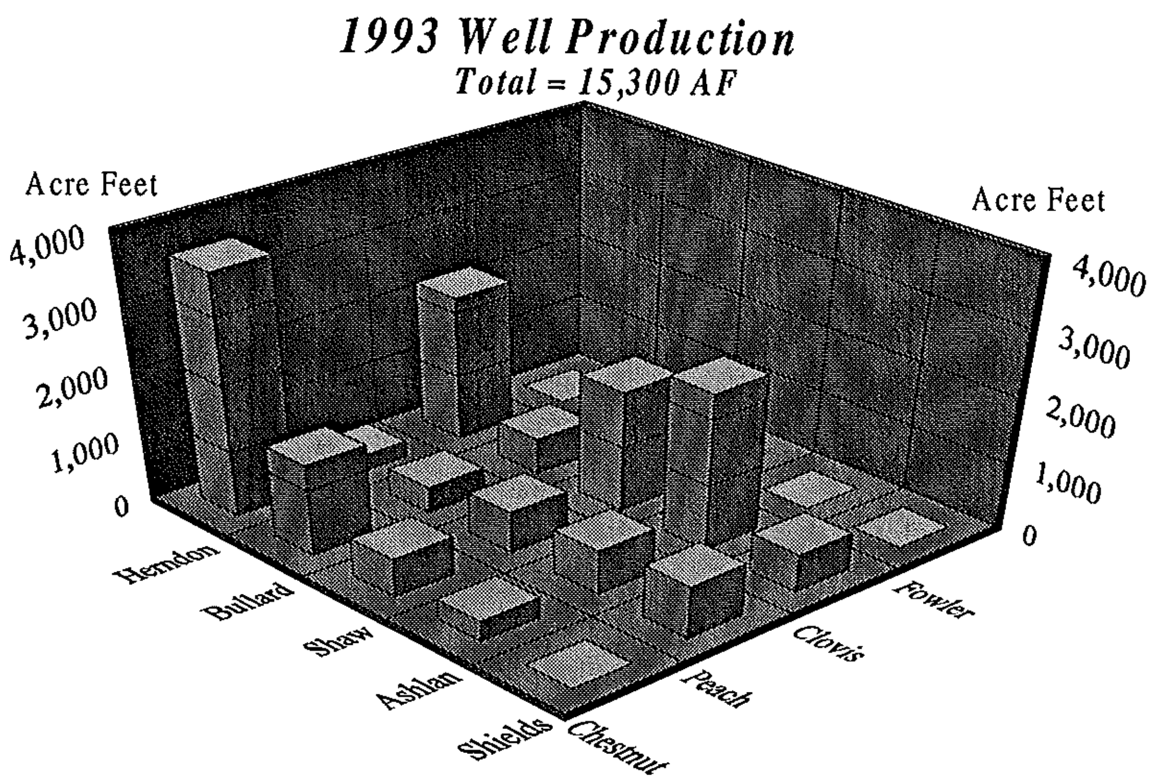


Figure 3-2. Well Production Comparison Between 1992 and 1993.

4 - WATER DEMANDS

General

This chapter develops water demand projections based upon the land use scenario of the recently adopted General Plan. The chapter focuses on urban, rural residential, and agricultural consumptive demands in the study area. Agricultural water demand accounts for water used to irrigate crops; rural residential water demand accounts for municipal uses outside the urban area; urban water demand accounts for all other water uses, including municipal, domestic and industrial. None of the water demands can be viewed in isolation as they are inversely related. As urban growth displaces irrigated farm land, the water demands will change. From a water resources perspective, this displacement raises the question of whether an acre of irrigated farm land uses more water than an acre of urban land use. The answer to this question is not straightforward, as it depends on the irrigated crop, source of water supply, the type of land use, whether stormwaters are retained on site and lastly, whether wastewater flows are recharged in the local area. Figure 4-1 shows the existing urban water demands.

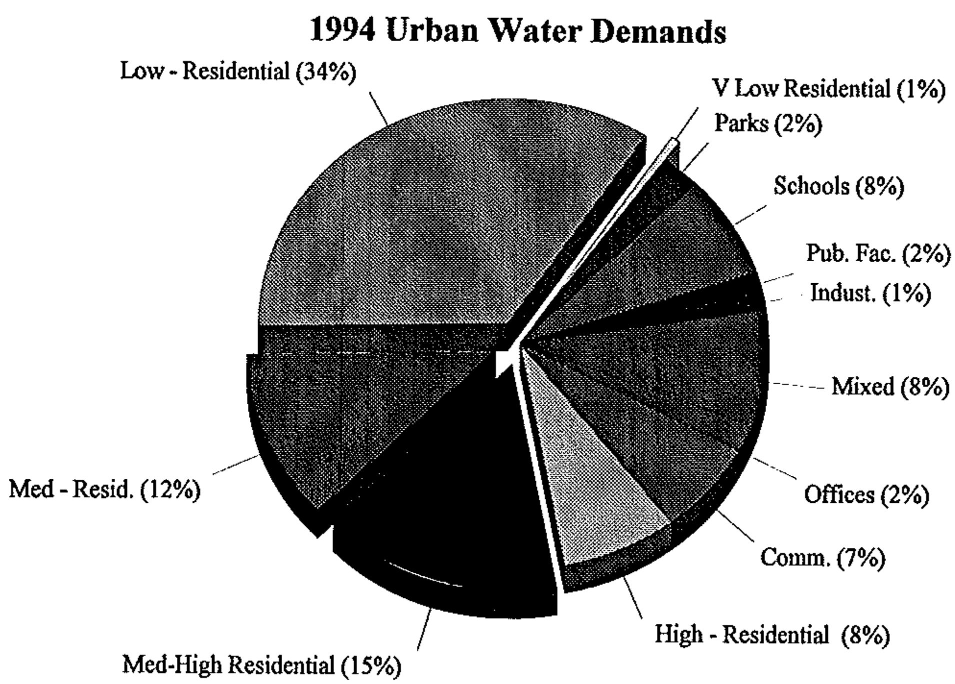


Figure 4-1. Existing Urban Water Demands by Land Use Designation.

Of specific interest to water supply, are two areas of lands within the study area. Namely those lands within the Fresno Irrigation District (FID), Garfield and International Water Districts, and those lands that are outside of these districts. Lands specifically not within a water district rely solely on groundwater for their water supply. Much of the conversion and urbanization of the area is planned to occur within the FID service area.

Figure 4-2 shows the estimated water demand for the proposed urban areas within the study area at ultimate buildout.

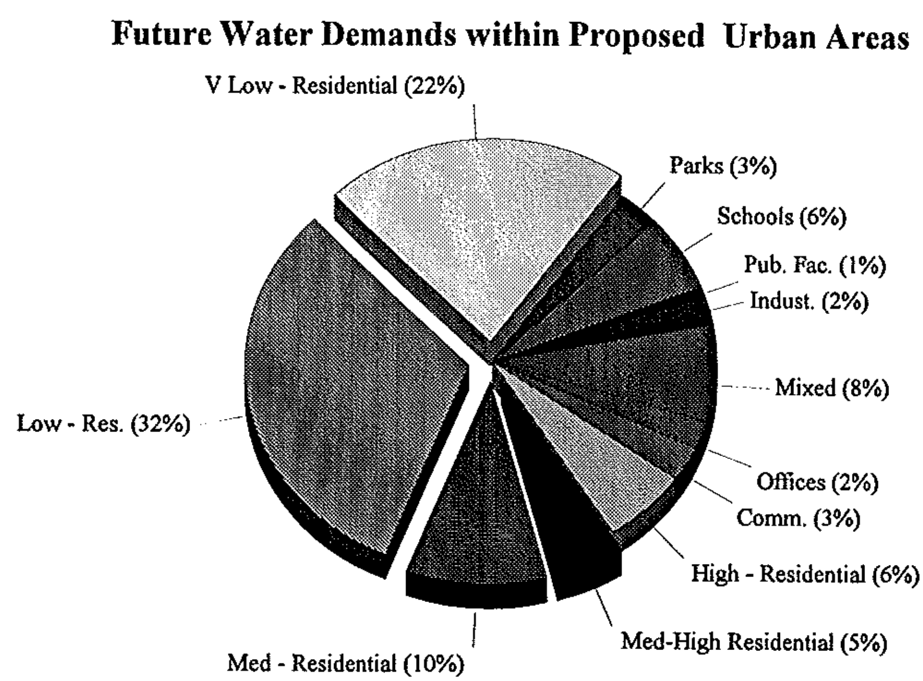


Figure 4-2. Estimated Water Demand by Land Use Within Proposed Urban Areas Under Buildout Conditions.

Estimating Future Water Demands

The ***land use base approach*** was applied to estimate water demands for the lands within the study area. This approach includes five steps:

1) Define appropriate land use categories such as single family residential, multi-residential, commercial and industrial, agricultural,

2) Determine water demand expressed in acre feet per acre for each type of land use,

3) Consider the impacts of present and future water conservation programs,

4) Estimate future land use patterns in terms of acres of each type of land use, and

5) Multiply the water demand per acre times the number of acres of each land use category.

Acres for each type of housing categorized in the following section are gross acres. This incorporates streets and sidewalks within the acreage figures.

The land use base approach differs significantly from population based estimates. Population estimates are multiplied by average per capita water use values to arrive at annual demand projections. The land use approach recognizes that water use is based on land use patterns (as well as population) and is considered to better account for changing demographic patterns such as trends toward higher density housing and larger number of persons per household. Also, because this approach identifies general areas of future growth, it facilitates planning and engineering decisions regarding infrastructure. In addition, it accounts for the conversion of water demand from agricultural to urban land use. Although this study uses the land use base approach to estimate demand, population estimates were also developed to estimate water use per capita; thus serving as a check of the land use based water demand.

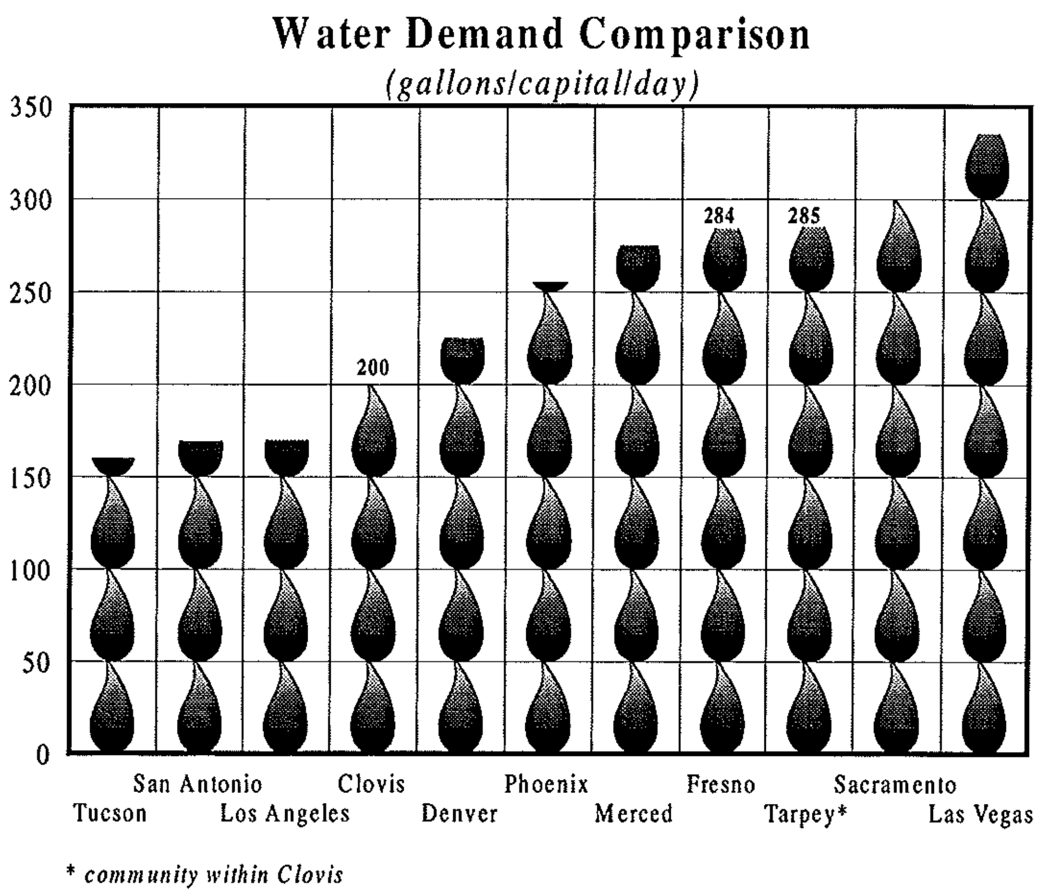
Land Use Based Demands

Water Purveyors

Within the study area there are three suppliers of municipal water. The principle purveyors are the City of Clovis, the City of Clovis for the Tarpey System, County Service Area 10, and County Water District No. 42 (see Plate 3). Both the County service area and the County Water District deliver water to what is termed in this report rural residential lands and will be discussed later in this section. Only the City of Clovis provides water to fulfill urban demands.

According to the Fresno/Clovis Metropolitan Water Resources Management Plan dated January 1992, average water use in The City of Fresno is approximately 214 gallons per capita per day while the City of Clovis uses approximately 190 gallons per capita per day. These figures represent the total annual water production divided by population. Analyzing recent data from Clovis reveals that use within the City limits for the last four years approximates 200 gallons per capita per day while the Tarpey system uses approximately 285 per capita per day. Department of Water Resources Bulletin 166-4 dated August 1994 lists per capita use for Fresno and Clovis to be 284 and 217 gallons per capita day respectively. A comparison of per capita water use with other western cities is included in Figure 4-3. A major difference for the lower Clovis per capita consumption versus Fresno and Tarpey, is that the City of Clovis meters all of its water customers. Other potential reasons for the difference could be industrial and commercial uses that more common in Fresno. For comparison, recent data reviewed from County Service Area 10, and the County Water District No. 42, which represent rural residential use suggest per capita use of 809 and 1,300 gallons per capita per day, respectively. Due to these values, it is very apparent that the rural residential demands are based largely upon landscape requirements and as such are treated separately in this report.

Figure 4-3. Clovis Water Demand Comparison with Other Cities.



Urban Land Use Categories

Twelve different categories of water use were defined for this analysis with respect to the urban area. Five represented residential uses, four commercial and industrial, and three other uses. These uses refer to the General Plan and are identified in the following categories:

Single-family Residential, Very Low, 0.6 to 2.0 Units Per acre. This category represents residences with extensive landscaped areas.

Single-family Residential, Low 2.1 to 4.0 Units Per Acre. The traditional subdivision type housing is represented by this category.

Single-family Residential, Medium 4.1 to 7.0 dwelling Units Per Acre. This category represents denser residential development.

Multi-family Residential, Medium-High 7 to 15 Units Per Acre. This area of multi-family housing is represented by duplexes, multi-family apartments, townhomes and small lot, detached homes.

Multi-family Residential, High 15 to 25 Units Per Acre. A broad spectrum of multi family housing is represented by this category, including multiplexes, apartment buildings, and condominiums.

Commercial. All types of service oriented businesses are included in this category. Commercial retail consists of shops, service stations and restaurants.

Office. This category includes professional offices, medical facilities, and corporate headquarters.

Mixed use. This category includes a complimentary mix of retail, professional office, industrial, business park, medical facilities, and higher density residential uses.

Industrial. This category includes all industrial users.

Public facility. Public facilities include government buildings, corporate and maintenance yards, churches, and meeting halls.

Schools. Includes all schools - generally with extensive lawn areas.

Parks and recreation facilities. Parks, irrigated open spaces and golf courses are included in this category.

The following land use categories have been defined for analysis with respect to lands outside the urban area.

Rural Residential

The Rural Residential category has been used by the County in the unincorporated areas of the project area allowing for residential development. Most of these properties are self-sufficient from a water supply standpoint, with a well and septic system. However, there are two districts that provide water to lands of this classification; namely, County Service Area 10, and County Water District No. 42. These two districts serve about one percent of the acres developed to this land use. The following description describes properties in this category:

Rural Residential, 0.5 Units Per Acre. This designation allows a density of up to one residential dwelling unit per two acres. Historically, this has been encouraged by County planning and much of the rural residential development has been realized outside of the irrigation district area between the Enterprise and the Friant-Kern Canal. Many areas within this designation have underlying zoning which requires a minimum of 5 acres per dwelling unit. This category allows very low density residential uses and small scale agricultural operations. Rural residential uses may be dispersed uniformly across the land or be situated to leave more acreage for orchards, pastures, or other agricultural or open space activities.

Agricultural

The agricultural category encompasses those lands that have been cultivated for the purpose of providing food and fiber. This designation will include large scale enterprises as well as small hobby farms consisting of permanent as well as open field crops. Grazing, pasture and animal husbandry activities are also included. The following is the general plan designation:

Agricultural, one unit per 20 acres. This category represents agricultural uses in the developing area. Agricultural use in and around the villages has been encouraged. The agricultural category has been established in the General Plan to help conserve productive agricultural lands within the study area. One dwelling unit per 20 acres is the maximum density permitted.

Water Demand By Land Use

Urban

Estimates of urban water demands expressed in terms of acre feet of water usage per acre for each type of land use in the urban area are summarized in Table 4-1. As indicated in this Table, water use values derived for the City of Clovis were compared with those utilized in the Fresno/Clovis Water Resources Management Plan (FWRMP). In the FWRMP, estimates were made about types of land use and generalized breakdowns of indoor use versus outside use. This approach had been utilized in identifying and estimating demands for the City of Fresno and is a good approximation of water use for that city. However, in the analysis for the City of Clovis, utilizing the water demands from the FWRMP report resulted in an average annual water demand that was significantly higher than indicated by the production records from City wells and not indicative of future water use. Therefore, an attempt was made to identify, evaluate, and use specific data related to each of the land use categories.

Metered records from select individual accounts of all urban categories were reviewed to estimate water demand figures based upon acreage. Land use demands used for this analysis have been determined based upon using the existing water use from metered accounts from the City of Clovis. It should be noted that average demand values derived from Clovis data are significantly lower than that recommended for use by the FWRMP report. The trends in the reductions are throughout all categories, with the most significant deviation in the medium single family residential land use.

Table 4-1.

Estimated Urban Water Demand by Land Use
For City of Clovis w/o Tarpey
Based on Existing Urban Land Use

	Residential				
	V. Low	**Low**	**Medium**	**Med High**	**High**
Total Acres	40	2,776	1,355	783	245
FWRMP #	3.0	3.1	2.9	5.1	5.1
FWRMP - AF	124	8,606	3,930	2,271	1,250
% of Total *	0.6%	38.8%	17.7%	10.2%	5.6%
Proposed #	3.1	2.1	1.5	3.4	5.1
Design - AF	124	5,830	2,033	2,662	1,250
% of Total **	0.7%	34.6%	12.0%	15.8%	7.4%
	Commercial		**Industrial**	**Government**	
	Com/Offc	**Mixed**	**Industrial**	**Pub Fac.**	**Schls/parks**
Total Acres	820	640	242	188	818
FWRMP #	2.4	2.4	2.8	2.8	2.8-3.1
FWRMP - AF	1,894	1,280	678	526	1,621
% of Total *	8.6%	5.8%	3.1%	2.4%	7.3%
Proposed #	1.8	2.2	1.0	1.4	2.8
Design - AF	1,476	1,408	242	263	1,582
% of Total **	8.8%	8.3%	1.4%	1.6%	9.4%

\# Yearly Water Demand Numbers (Acre-Feet / Acre)
* % of total using FWRMP Numbers
** % of total using Proposed Numbers (based on selected actual billings)

Rural Residential

A review of records for both the County Services Area and the County Water District, indicate an average water demand of 1.5 acre-feet per acre results. In general, these areas control stormwater on-site and have septic systems which percolate water used within the home back into the ground. Accounting for this incidental recharge, it is estimated that the ***net water demand*** or ***consumptive use*** is approximately 0.8 AF/ac.

Agricultural

The agricultural water demand was estimated for current conditions using 1994 cropping data. Under normal conditions, the current agricultural consumptive use is estimated to be 41,000 AF/Y for lands within the organized Districts within the study area. Current demands were estimated using the AgWater model with crop coefficients used by the Kings River Conservation District. If effective precipitation is taken into account, the estimated consumptive use of applied water is calculated to be 36,500 AF/Y.

Additional water supplies are needed so that available moisture is kept in the root zone. Water in excess of the crop requirements is recharged to the groundwater aquifer as deep percolation and can be recovered through pumping.

Results

Using the aforementioned criteria, water demands were estimated for each of the categories at the present and at buildout. Included as Figures 4-4 and 4-5 are two charts that summarize these estimates. (See Appendix A for actual data) For ease of comparison purposes, the water demands were broken into three geographical areas. These three areas are as follows:

- Within FID - Those lands lying to the west of the Enterprise Canal (including the original Clovis urban area that is excluded from FID).
- Other District - These lands consist of property within the International, Garfield Water Districts and the annexed lands to the FID.
- Outside Districts - These lands are not included in any organized district.

The reason for this breakdown is to make comparison of water supplies easier in later chapters.

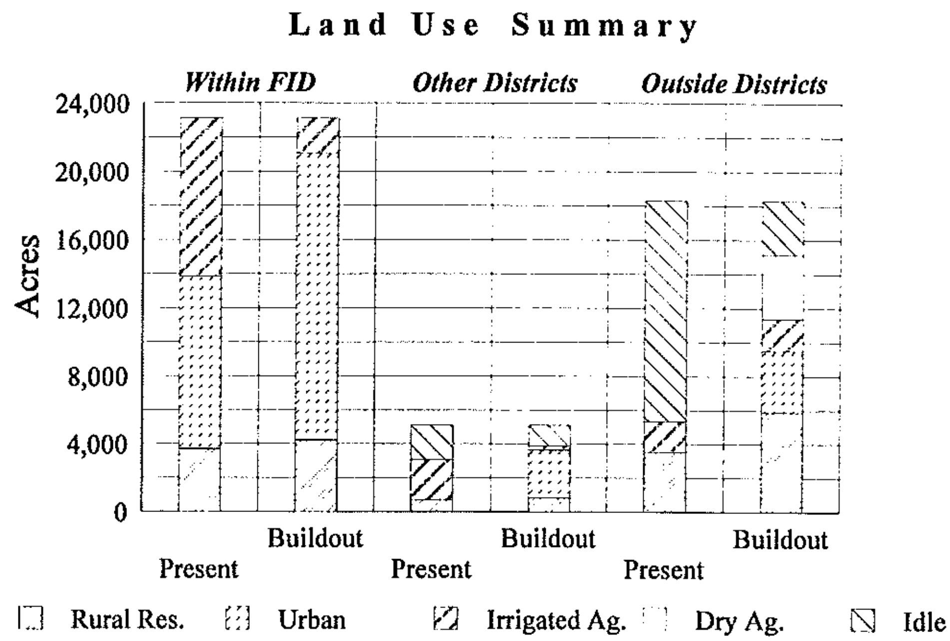


Figure 4-4. Land use comparison between present and buildout.

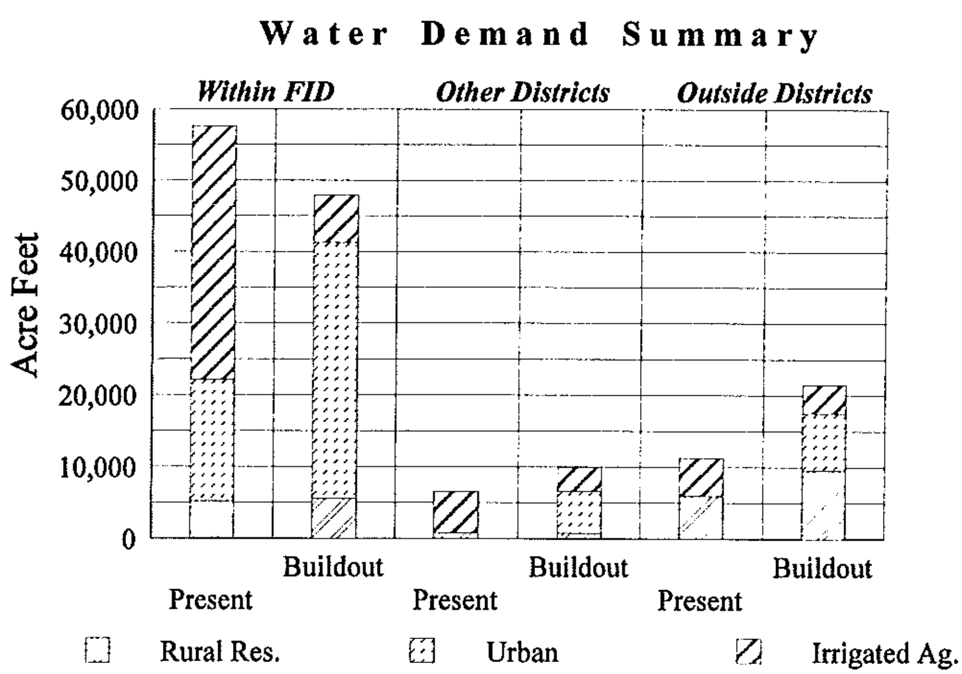


Figure 4-5. Water demand comparisons between present and buildout.

5 - SURFACE WATER SUPPLY

Precipitation

The climate for the study area is characterized by a mild spring and fall, hot dry summers and cool winters. Due to the City's location near the foothills of the Sierra Nevada, the temperature and precipitation vary slightly from the valley floor. The weather station closest to the study area is located at the Fresno Air Terminal. Table 5-1 indicates the average monthly temperatures, together with the maximum and minimum temperatures for the period of record. Also included is the average monthly precipitation at the station. As indicated, the area has a very temperate climate.

Annual rainfall within the area typically varies from six inches in dry years to over 21 inches received in 1983. The average annual precipitation for the area is approximately ten inches. Some of this water is ponded locally and percolates to the groundwater. However, due to the topography, soils and timing of precipitation events, some of the rainfall exceeds the transmission ability of the soils. Once saturation is exceeded, the water collects and is concentrated to local streams which drain towards the southwest.

Rainfall and Stormwater Management

Through the cooperation of the cities of Clovis and Fresno, Fresno Metropolitan Flood Control District (FMFCD) and FID, a concerted effort is being made to capture and recharge as much storm runoff as possible in the region. Dry Creek Reservoir is the single most prominent facility that handles stormwater flows. Located northwest of the City of Clovis, the reservoir encompasses approximately 2,000 acres and reduces the flood potential of Big Dry Creek. Plate 9 shows the location of the prominent flood control facilities within the study area.

Local Streams

Several foothill streams contribute to the area's water supply. Four streams with significant flows are Big Dry Creek, Dog Creek, Redbank Creek, and Fancher Creek. Fancher Creek is located just to the east of the study area. The flows from these foothill watersheds vary considerably between wet and dry years. These flows contribute to winter irrigations and groundwater recharge, with some significant amounts captured by the Fresno Irrigation District canal system.

Table 5-1
Average Daily Temperatures (°F) and Precipitation (in.)

	Fresno Air Terminal		
Month	**Maximum**	**Minimum**	**Precipitation**
January	54.3	37.4	1.82
February	61.4	40.9	1.66
March	66.5	43.8	1.73
April	74.4	47.8	0.94
May	82.6	53.4	0.36
June	91.3	59.7	0.11
July	98.6	64.9	0.01
August	96.7	63.3	0.01
September	89.9	58.3	0.18
October	79.2	50.8	0.55
November	66.0	42.4	1.00
December	54.8	37.7	1.54
Average Annual Total			9.90

Record for Temperature: 1888 through 1993
Record for Precipitation: 1878 through 1993

Historical flow data is not available for the four main foothill streams, making accurate monthly flow estimates impossible. The lack of detailed data on these streams does not appreciably affect water management decisions as the flows tend to come during winter and occur over short time periods.

Historic Operation

Historically, storm runoff from drainages east of the study area has been intercepted by the FID canal system up to the capacity of the canal system to safely convey the flow. Storm flows are generally picked up by the FID system in the Gould Canal and are directed to the San Joaquin River. FID staff reports that, to the extent possible without endangering the canal system, groundwater recharge of storm flows within the FID service area is maximized. During heavy individual storm events, relatively high peak flows may be discharged to the San Joaquin River via FID canals or natural drainages. From a long term average perspective, however, the volume of these storm spills is minor.

Flood control dams and detention basins have been constructed on the major upslope streams (Dry, Dog, Redbank, Fancher, Alluvial Drain and Pup Creeks). In addition to the flood control benefits provided by these structures, they allow a higher percentage of the storm flows to be safely handled by the canal system and increase the opportunity for groundwater recharge. This further decreases the amount of water lost from the area.

Urban runoff is generally directed to detention basins. Stored water is pumped from these basins to canals as required to maintain flood protection storage in the basins. Prior to construction of the flood control basins, floodwaters flooded large undeveloped areas. These areas now drain to the flood control basins, with discharge facilities to canals and then to the San Joaquin River. As urbanization proceeds, pervious areas (dry lands and fields) are partially replaced with impervious areas (streets, parking lots, and houses). FMFCD has increased the level of maintenance on the flood control basins with the intention of enhancing the recharge rate in the basins. This will at least partially offset the effect of the increased impervious areas and reduced deep percolation of precipitation in the newly urbanized areas.

Types of Surface Water

Within the study area there are lands included in the Fresno Irrigation District, annexed lands to the Fresno Irrigation District, Garfield Water District and International Water District. Included as Table 5-2 is a listing of the types and amounts of water supply for each agency.

Table 5-2
Entities in Study Area with Surface Water Supplies

Entity	Source	Use	Contract Number	Contract Amount (AF/yr)
Fresno Irrigation District	Kings River Bureau - Class II	Ag.	14-06-200-1122A	452,000* 75,000
Fresno Irrigation District Annexed Lands	Bureau - Class II	Ag.		
International Water District	Bureau - Class I	Ag.	14-06-200-585A	1,200
Garfield Water District**	Bureau - Class I	Ag.	14-06-200-9421	3,500

* Historical average annual entitlement. ** 50 percent of District is within the study area.

Kings River

The Kings River is the primary water source for the Fresno Irrigation District. FID is one of the 28 agencies that comprise the Kings River Water Association (KRWA). KRWA acts as trustee for all member agencies and holds water rights licenses for all of the Kings River and storage rights licenses on Kings River reservoirs (Table 5-3). The Watermaster for the KRWA administers the diversion of Kings River water granted under the licenses.

The allocation of the water available under the Kings River licenses is covered by a Water Right Indenture dated May 3, 1927, and amended and supplemented on June 1, 1949 and September 3, 1963. The allocation of water among the KRWA member agencies is determined by applying a schedule for each month to the natural flow of the Kings River as it would occur without reservoir storage above the historic Piedra gaging station. The calculated natural flow is often referred to as Pre-project Piedra. The allocation of water to each agency by this schedule is termed entitlement. Included in the Appendix is the monthly diversion schedule for the month of March for the Fresno Irrigation District.

Fresno Irrigation District holds "low flow" rights to the Kings River. While the District is entitled to water at nearly all flows, the percentage of total flow FID may divert is higher at relatively low Kings River flows. Therefore, for a given percent water year, FID receives a greater entitlement if the snow pack melts slowly than if the runoff occurs rapidly.

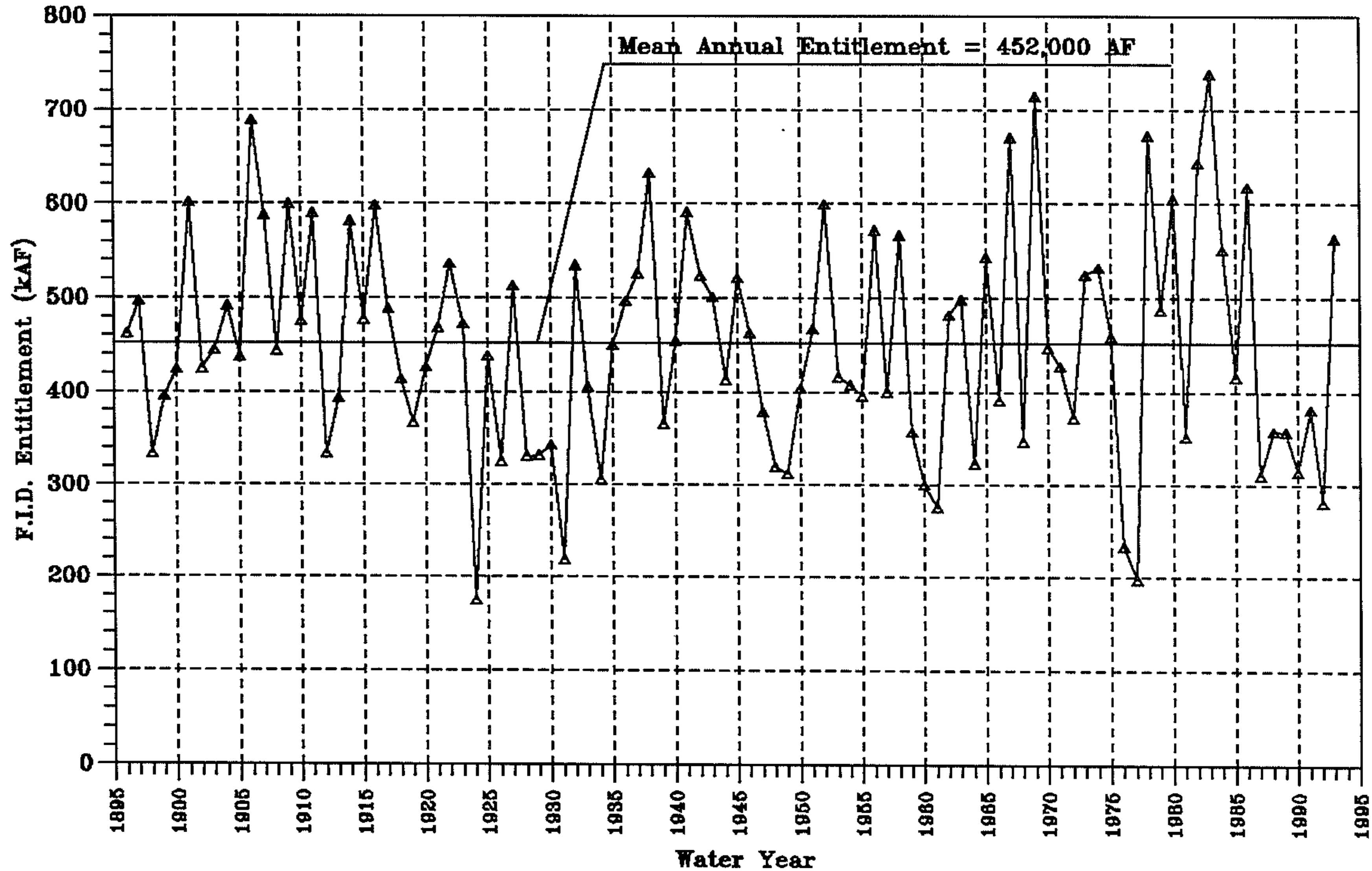
Fresno Irrigation District has received an average annual entitlement from the Kings River of approximately 452,000 AF (Figure 5-1). The median entitlement, the minimum amount received in half the years, is 445,000 AF (Figure 5-2). An annual entitlement of 300,000 AF has occurred or been exceeded in 94 percent of the years of record.

The District's annual entitlement can vary widely for similar type water years. The widest scatter has occurred in water years with 60 percent to 70 percent of the historical mean. In this range annual entitlements have varied from 305,000 AF to 420,000 AF. This wide range of entitlement is due to the variability in precipitation and snowmelt.

Table 5-3
Kings River Water and Storage Licenses

KINGS RIVER WATER RIGHTS LICENSES:		
License No.	Direct Diversion (CFS)	Beneficial Use (AF/Y)
11517	613	569,600
11521	1,096	(included above)
11518	5,000	2,565,000
11519	3,059	(included above)
TOTAL	9,768	

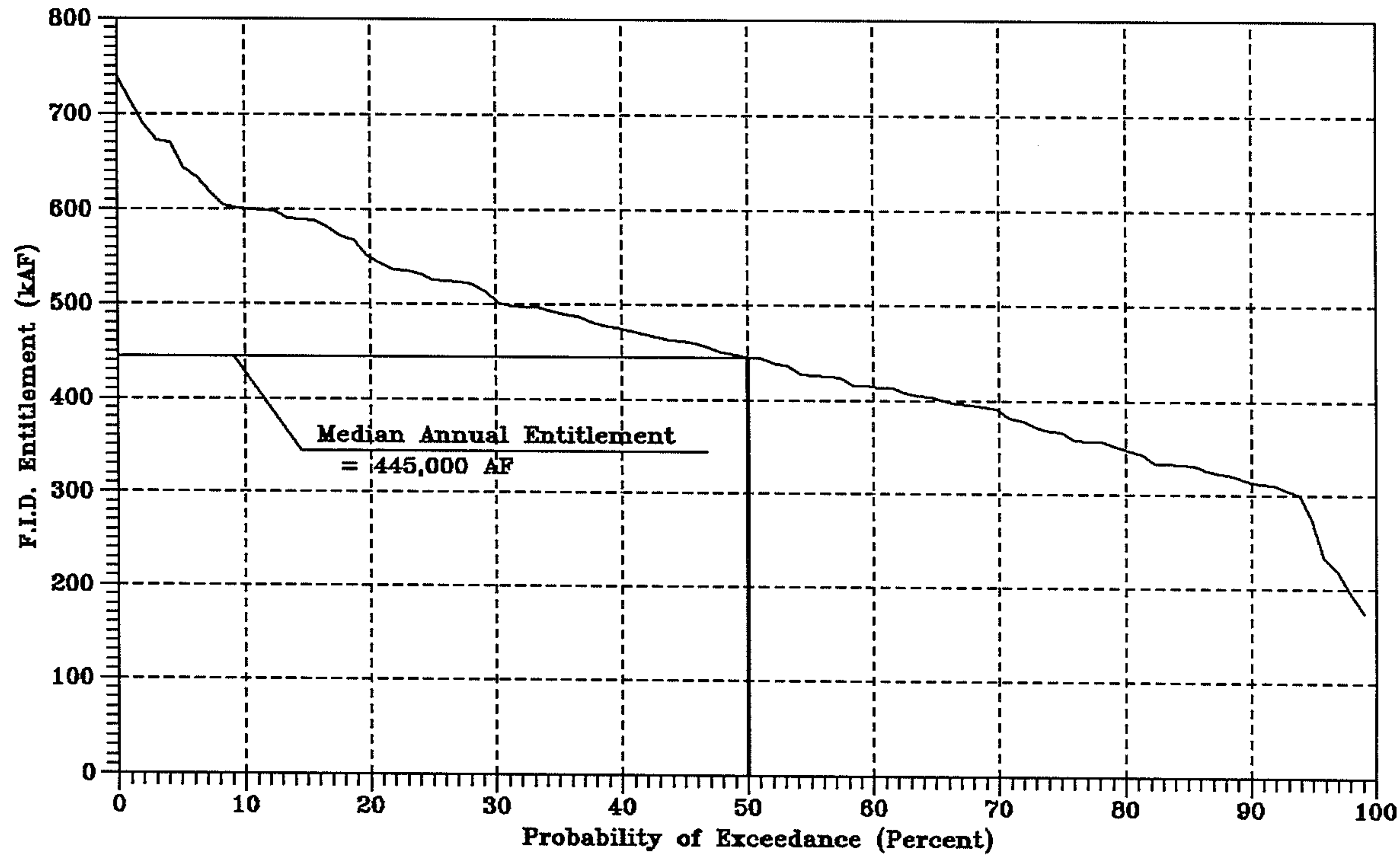
KINGS RIVER STORAGE LICENSES:		
License No.	Reservoir	Storage Right (AF)
11522	Courtright	102,500
11520	Wishon	128,000
11517	Tulare Lake	188,000
11521	Tulare Lake	796,000
11518	Pine Flat	600,000
11519	Pine Flat	355,200
TOTAL		2,169,700



CLOVIS WATER MASTER PLAN UPDATE

FIGURE 5-1

Historic FID Entitlement



Based on records from 1895 to 1991

CLOVIS WATER MASTER PLAN UPDATE

FIGURE 5-2

FID Entitlement Probability Curve

Friant Division - Central Valley Project

The Friant Division of the Central Valley Project extends from near Chowchilla on the north to Kern County in the south. Friant Dam, constructed on the San Joaquin River, controls the natural runoff of the San Joaquin River and redirects the water to the Madera and Friant-Kern canals for use in the areas previously described.

By the time construction began on Friant Dam in 1939, the watershed already was well developed. Located on the main stream on the San Joaquin River about 25 miles northeast of Fresno, Friant Dam (Millerton Reservoir) is the principal storage facility on the Friant Division of the CVP. The dam was completed to the point that it could regulate the River's flow in 1944 and was finished in 1947. Small diversions began into the Madera Canal in 1944 and the Friant-Kern Canal in 1949. However, full operation of Friant Dam did not occur until 1951, when the Delta-Mendota Canal was completed. Until this canal was built, water was released from Friant Dam for the exchange contractors downstream. The exchange contractors are the San Joaquin River water rights holders who exchanged their use of natural river runoff for a substitute supply from the Delta-Mendota Canal.

The plan of the United States for the San Joaquin River has been to acquire the water rights by purchase or providing a substitute water supply. Total water supplies were estimated to be 2,150,000 acre-feet; 800,000 acre-feet has been designated as Class I supply. Class I water is that supply which can be considered dependable in practically every year with deficiencies only in occasional very dry years. Class I deficiencies have been experienced in nine of the last 28 years. Class II water is that water in excess of Class I and accordingly is much less dependable as to its quantity and time of occurrence.

Provost & Pritchard has developed a model which predicts allocation of Class I and Class II water based upon precipitation. The estimated CVP supply closely matches the actual allotments for the period since 1966 (Table 5-4). The minimum Class I supply was 25 percent in 1977. The Class II allotment has averaged 45 percent since 1966, and has been 100 percent in seven of the last 29 years. Class II supplies have been 0 percent in ten of the last 29 years, including seven of the last eight years.

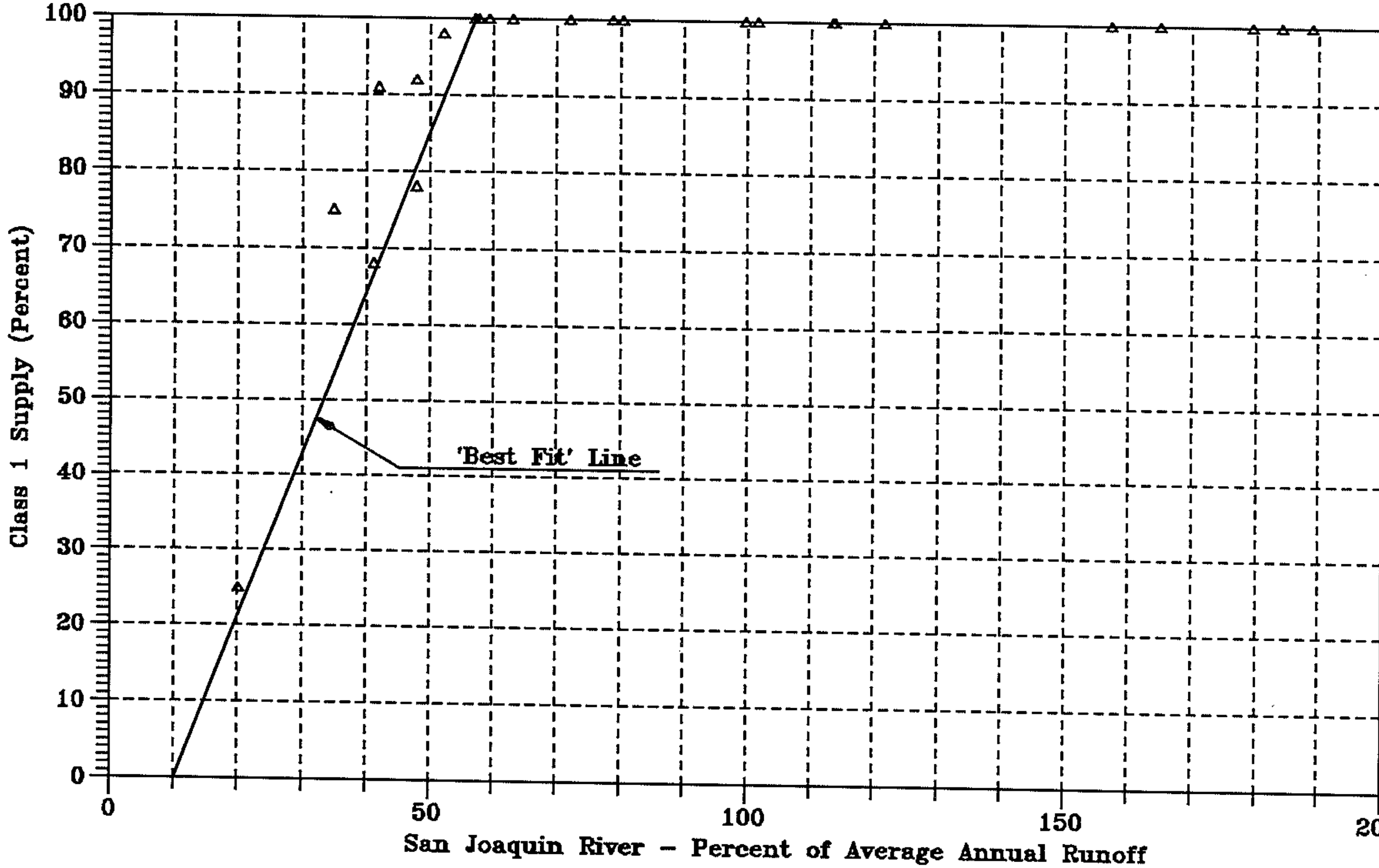
To analyze the availability of the CVP supply, the Class I and II allotments were estimated for the entire period of record on the San Joaquin River. The existing CVP data was compared to San Joaquin River flow data and linear relationships were developed to predict CVP supplies. The Class I allotment most closely correlates to the total annual runoff (Figure 5-3), while the Class II supply fits best with the March through September runoff (Figure 5-4).

A third source of Friant Division CVP water is Section 215 water, which is surplus flood flow on the San Joaquin River. The water is only useable when Millerton Reservoir is in flood release. Because the Kings and San Joaquin Rivers have similar average annual

Table 5-4
Actual and Predicted Friant Division - CVP Water Supplies

	CLASS I		CLASS II	
USBR Water Year	Actual	Predicted[a]	Actual	Predicted[a]
1966	100%	100%	23%	24%
1967	100	100	100	100
1968	92	88	0	0
1969	100	100	100	100
1970	100	100	29	30
1971	100	100	35	34
1972	100	100	4	3
1973	100	100	77	73
1974	100	100	82	77
1975	100	100	60	65
1976	75	58	0	0
1977	25	24	0	0
1978	100	100	100	100
1979	100	100	63	60
1980	100	100	100	100
1981	100	100	22	14
1982	100	100	100	100
1983	100	100	100	100
1984	100	100	50	50
1985	100	100	14	17
1986	100	100	100	100
1987	91	75	0	0
1988	78	89	0	0
1989	98	99	0	0
1990	68	73	0	0
1991	100	100	0	23
1992	83	81	0	0
1993	100	100	90	100
1994	80	83	0	0
AVERAGE	93%	92%	45%	45%

a pre-model developed by Provost & Pritchard

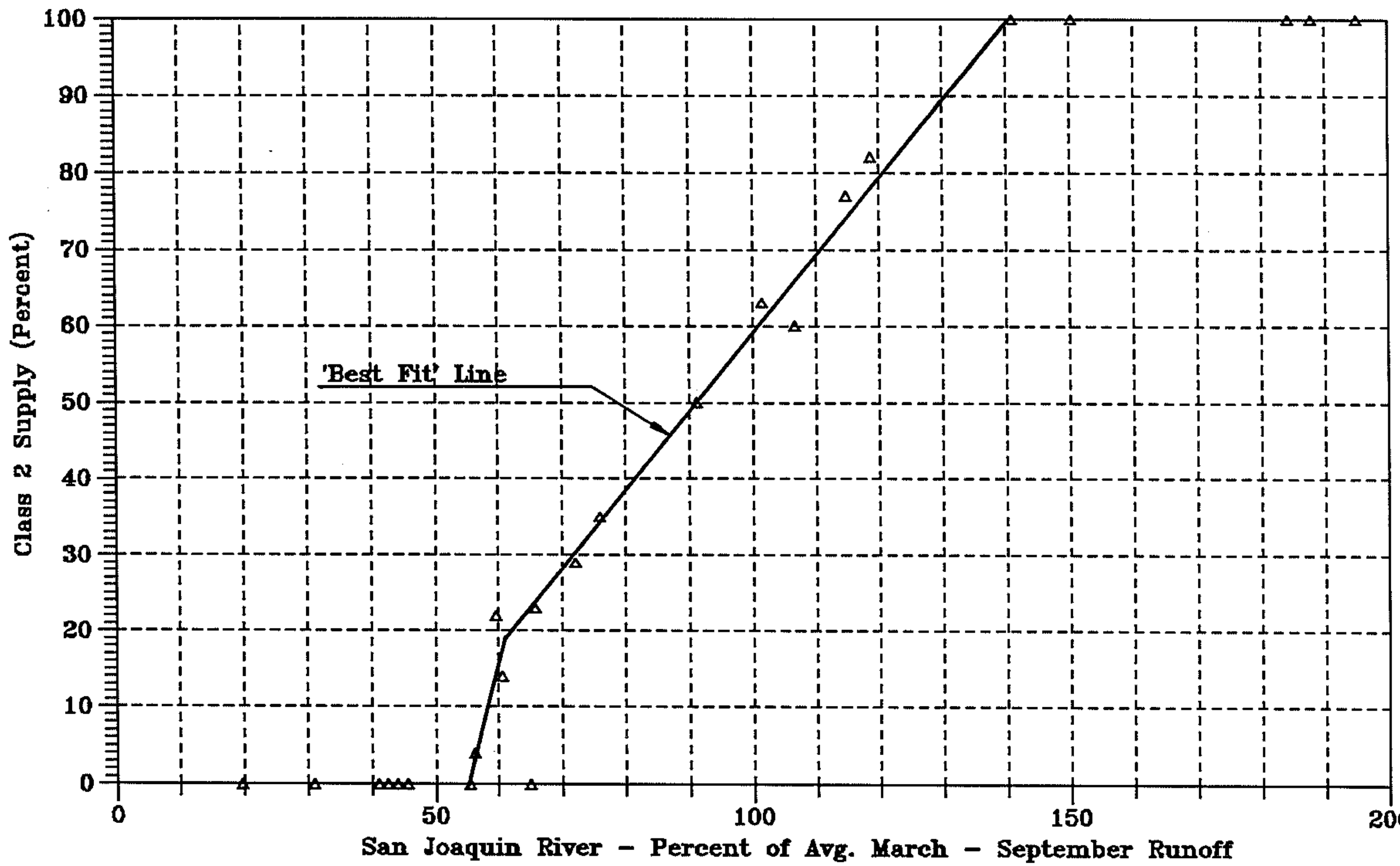


Based on records from 1966 to 1991

CLOVIS WATER MASTER PLAN UPDATE

FIGURE 5-3

Friant Division CVP
Class 1 Water Supply



Based on records from 1966 to 1991

CLOVIS WATER MASTER PLAN UPDATE

FIGURE 5-4

Friant Division CVP
Class 2 Water Supply

runoff totals, while Millerton Reservoir has only half the storage capacity of Pine Flat, the San Joaquin River tends to experience more frequent flood flows than the Kings River. Therefore, Section 215 water may occasionally be available. During the period of 1895 to 1991, the Kings River has experienced annual flood losses averaging approximately 200,000 AF/y. Annual flood releases from Friant Dam on the San Joaquin River are estimated to approximate 465,000 AF/y.

The FID has a contract with the United States Bureau of Reclamation (Bureau) for 75,000 AF of Class II water from the Friant Division of the Central Valley Project (CVP). The contract, was executed on July 20, 1964 and has a 30-year term expiring on February 28, 1995.

The International Water District also has a Bureau contract for Friant Division CVP water. The Contract is for agricultural water use with a maximum of 1,200 acre-feet of water. The contract is for a Class I water supply.

The Garfield Water District has a Bureau contract for 3,500 acre-feet of Class I water. Again, this contract is for a supply of agricultural water only.

Each of the districts are currently renegotiating their contracts with the Bureau. It is understood that with the renewal, both the FID and the IWD will have the ability to deliver water for municipal & industrial (M&I) use within their respective districts. Due to the passage of the Central Valley Project Improvement Act (CVPIA) in 1992, interim contracts with a maximum initial length of 3 years with subsequent 2 year renewals are being executed. Long term renewals will only be approved after the environmental documents related to the Act are approved.

One of the initial objectives of this study was to ascertain the ability of the City to obtain a contract for a firm water supply for the Bureau of Reclamation. The feasibility of obtaining such a contract is discussed in a letter from Gary Sawyers which is contained in Appendix B. Mr. Sawyers is a respected attorney who specializes in California water law.

Water Transfer Under Federal Law

The CVPIA of 1992 provides that Bureau water may be purchased and transferred. Transfers can take the form of either short or long-term contracts. In order for a transfer to take place, lands would have to be fallowed to allow for the water to be delivered for the new use. This relationship could be made through an agreement or outright purchase of the property.

It is possible that land could be located within an irrigation district that has a Class I water supply contract from the Friant Division. This land could be purchased and the water transferred to the City. Conveyance of the water through Federal facilities is not affected. However, some arrangement would need to be in place to utilize FID facilities to convey the water to the City.

Groundwater Banking

Groundwater banking is the recharge of water to the groundwater basin for storage and the subsequent extraction of a portion of that water for delivery. Groundwater banking is useful for making an existing surface water supply more reliable in dry years so that there are no shortages from droughts. Groundwater banking can also create a new water supply by using water for recharge that would otherwise flow to the ocean. To make the same amount of water available for future use, it takes substantially more recharge area (ponds) and substantially more water needed in groundwater storage to create a new water supply compared to the area and storage requirements for firming up an existing surface water supply.

The Fresno Irrigation District has adopted a policy wherein they support groundwater banking within their District provided that three acre-feet must be recharged for two acre-feet extracted. To discuss this policy, common interests, and other matters related to surface water supplies, a meeting was held with representatives of FID and The City of Clovis. Specifically related to banking programs FID maintains the purpose of banking arrangements is to mitigate the negative impacts to groundwater levels by the exportation of water. It was also agreed that Clovis and more specifically the study area is on the edge of the aquifer and that the thinning of the deposits create more problems to the City than to much of FID. As such, water level changes will be more drastically felt by the City. This being the case, mitigation efforts undertaken within the study area should be proposed so that water levels stabilize. If this is the case, then mitigation may not be appropriate.

It was explained by FID that banking arrangements presently underway for their annexed lands have resulted in a water cost of approximately $40/AF in 1994 or for an agricultural supply. In addition, it was noted that water supplies included in a banking program need not necessarily be the City of Clovis's and that FID would be willing to contract with the City on a banking agreement.

Estimated Surface Water Supplies

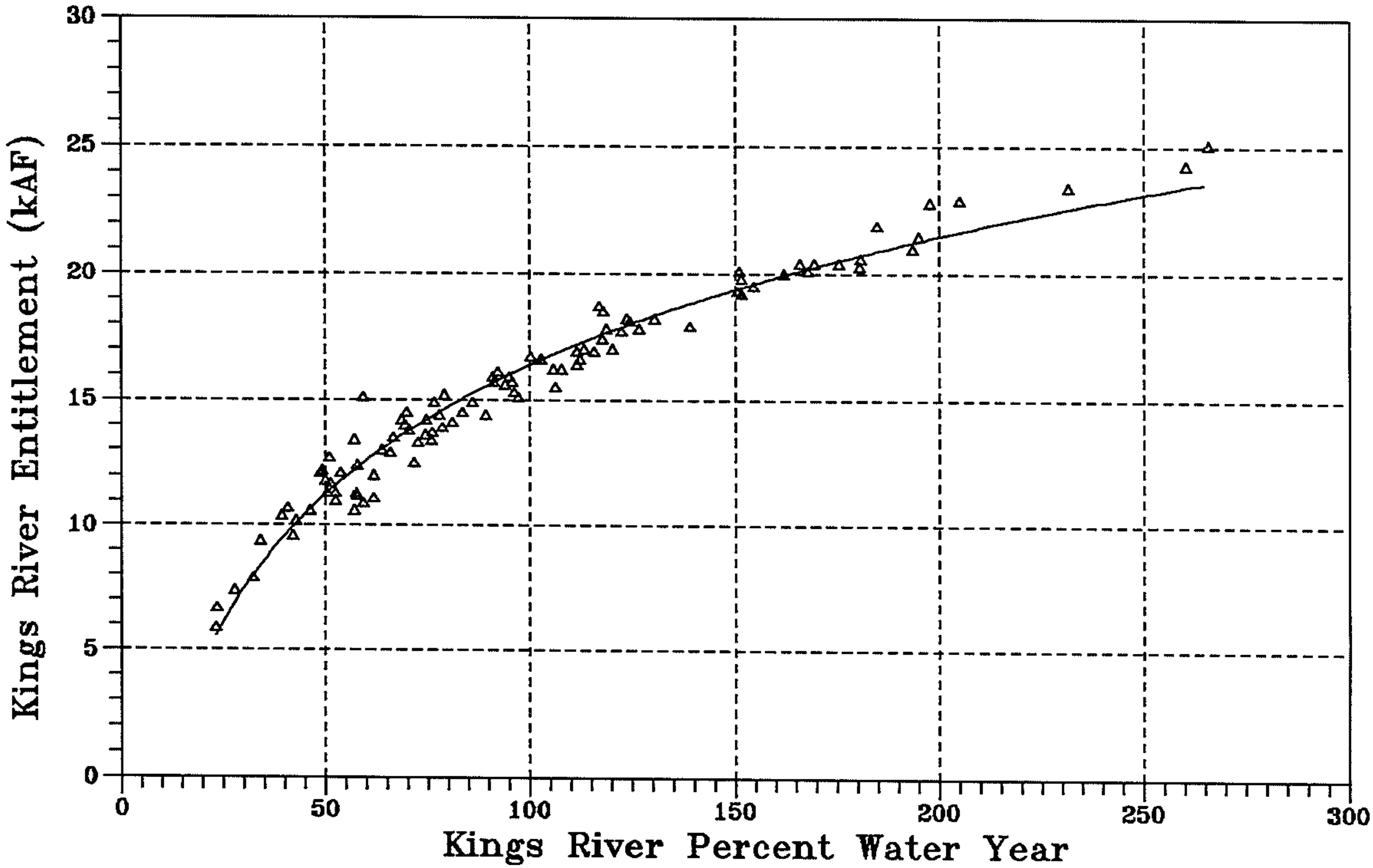
Present

Based upon the preceding sections an estimate can be made on quantities of water available to the City. The City of Clovis is presently located entirely within the Fresno Irrigation District, except for the City center which is excluded from the District. Existing agreements between the City and Fresno Irrigation District authorize the City, on behalf of the landowners of the urbanized area to receive and manage the water associated with the acreage of the urbanized lands. Presently, this accounts for about 3.5 percent of FID lands. At present, based upon the area of the City in the FID, surface water entitlement for a normal year is estimated at 15,900 acre-feet. As stated before, the City's actual Kings River entitlement is based upon hydrologic factors. Included as Figure 5-5 is a graph showing entitlement versus water year. In addition, a portion of the Class II water supply is also available which results in approximately 1,100 AF on average, utilizing historical data. More detailed discussion will commence in the next paragraph on this subject. The worst year on record was 1923. If 1923 conditions were experienced this year, the resultant water supply to the City would total approximately 6,000 AF.

A document important in addressing surface water available to the City is an agreement between the City of Clovis and FID dated August 7, 1972. This contract commits the FID to deliver water based upon the urbanized acreage of the City within the FID. Of note in the contract are the following phrases under part 6:

> 6. "Water Made Available to City. ...During each water year beginning with March 1, 1973, the District will make available to the City...that portion of the total water diverted by the District from the surface water supply available to it for such water year, as the acreage of Included Area,...bears to the acreage of the total area in the District..."
>
> "No water which has been received by the District either as Class I or Class II water under its contract with the United States..... or which has been stored by the District in the Pine Flat Reservoir under the District's contracts with the United States providing for such storage...shall be made available to the City."

It is understood that total supplies to the City as a percent of the total FID lands related to the aforementioned volumes are correct. When the City/FID contract was executed, the Bureau maintained that FID had no ability to deliver municipal water and, therefore, FID made up the difference with Kings River entitlement water supplies. The other provision of storage, if enforced, would mean that the City's Kings River surface water entitlement is "run of the river". As is shown in Figure 5-6, runoff usually starts in March with peak flows in May and little or no flow past August. The total available

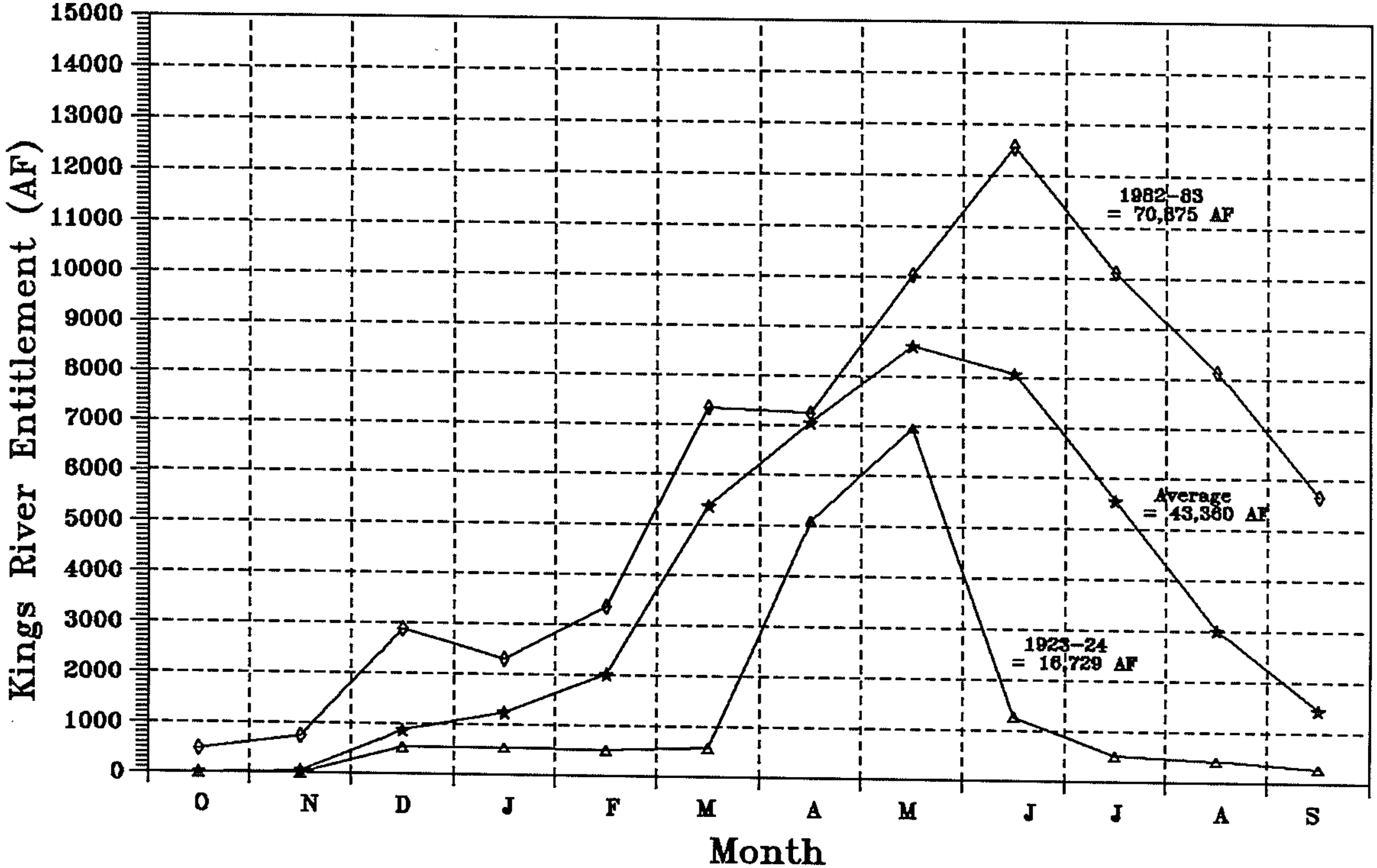


Based upon historical record,
water years 1895-96 to 1992-93.

CLOVIS WATER MASTER PLAN UPDATE

FIGURE 5-5

City of Clovis' FID
Kings River Entitlement
for City of Clovis Area



Based upon 22,800 Acres (Complete buildout & Tarpey Village).
Does not include FID exclusion of FID annexed lands.

CLOVIS WATER MASTER PLAN UPDATE

FIGURE 5-6

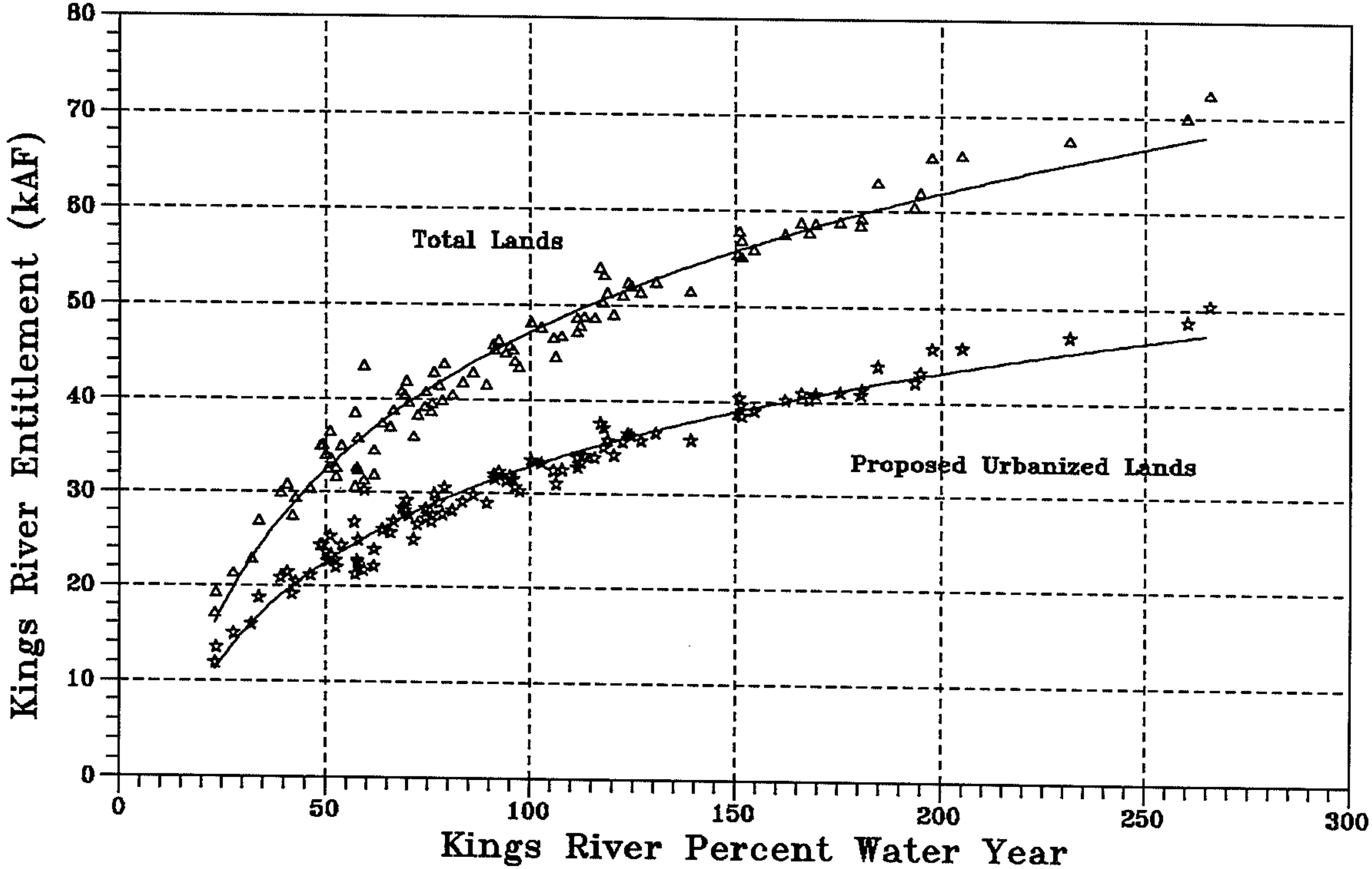
Study Area
FID Monthly Distribution
of Kings River Entitlement

supply previously shown in Figure 5-5 is still valid, however, to achieve full utilization of this supply would require greater use in the months of snowmelt.

Future (Buildout 2030)

Looking at ultimate buildout, water supplies may be available from both the FID, the Garfield and International Water Districts. The FID annexed lands are similarly within this area, but do not have a firm surface supply. It is understood when the lands were annexed to FID that they would receive water once the needs of the FID were met. In practice, surface water supplies have been allocated to these lands on an annual basis. Total acreage of the study area within the Fresno Irrigation District approximates 23,300 acres or 9.5 percent of the total District lands. Figure 5-7 presents the estimated Fresno I.D. Kings River entitlement water supply available to both the study area and the planned urbanized lands. This supply is by far the largest and most important surface water source to the area

In addition to Kings River water supplies, as mentioned earlier, supplies are also available from the Friant Division of the CVP. Fifty percent of the Garfield Water District (GWD) and all of the International Water District (IWD) are within the planned urbanized areas. Full contract amounts for these districts' land within the study area would total 2,950 acre feet. Potential Class II water supplies are more difficult to determine due to timing of events. To this end they were quantified based upon the urbanized lands within FID for the last twenty years of record. These quantities are shown in Figure 5-8. In addition to Class II supplies, Kings River and Class I water supplies are also shown.



Based upon historical record, water years 1895-96 to 1992-93.

CLOVIS WATER MASTER PLAN UPDATE

FIGURE 5-7

Kings River Entitlement for within Study Area

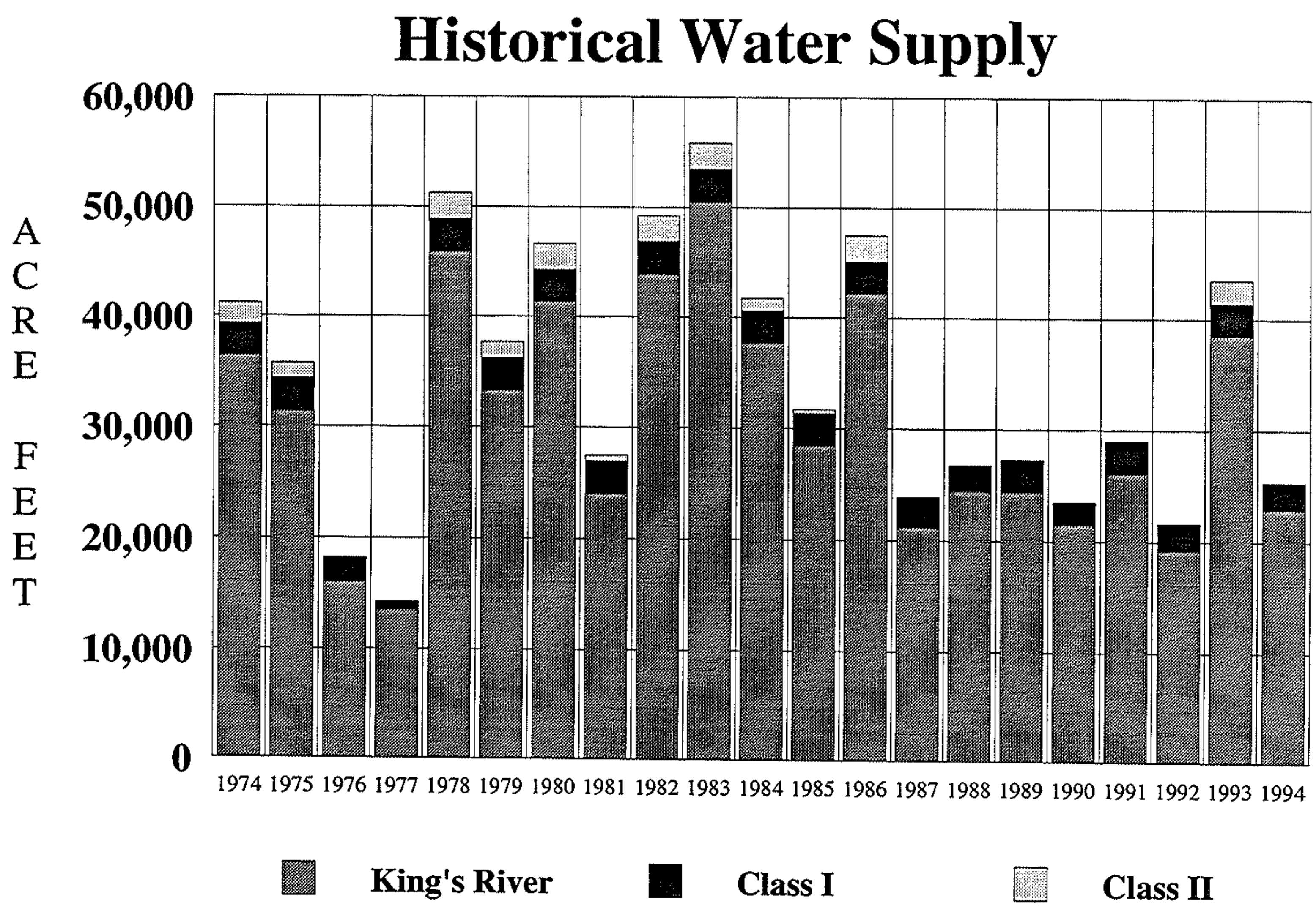


Figure 5-8 Potential water supply for planned urbanized lands within Study Area for period 1974 ~ 1994.

Historical Deliveries

Included in Table 5-5 is a listing of the historical deliveries made to recharge facilities within the City. The Clovis recharge basin located near the southern border of the City has received the largest amounts of water for recharge. In recent years a significant amount of recharge has been done by running water down Big Dry Creek. The remainder of recharge takes place in flood control basins and creeks flowing through the area (see Plate 9). The most productive flood control basin has been Basin 7C, located at Alluvial and Clovis Avenue and every attempt should be made to expand the duration of use of this basin as well as explore other potential sites in the vicinity.

Table 5-5
Historical Deliveries for Recharge

	Clovis Basin	Flood Control Basins*	Sub Total (AF)	Recharge thru Creeks**	Total (AF)
1974	3,179		3,179		3,179
1975	5,021		5,021		5,021
1976	3,540		3,540		3,540
1977	2,845		2,845		2,845
1978	6,397		6,397		6,397
1979	6,952		6,952		6,952
1980	6,751		6,751		6,751
1981	4,930		4,930		4,930
1982	4,521	1,606	6,127	1,318	7,445
1983	3,927	884	4,811	1,664	6,475
1984	3,427	1,491	4,918	1,438	6,356
1985	2,419	260	2,679	844	3,523
1986	3,146	1,252	4,398	1,381	5,779
1987	1,601	782	2,383	119	2,502
1988	1,490	1,130	2,620	516	3,136
1989	3,961	1,261	5,222	344	5,566
1990	2,156	886	3,042	2,009	5,051
1991	3,278	1,694	4,972	3,158	8,130
1992	3,208	1,583	4,791	3,604	8,395
1993	1,879	2,275	4,154	4,640	8,794
1994	1,409	1,865	3,274	2,214	5,488
Avg.	3,621	1,305	4,429	1,788	5,536

* *Basins Include:*

Basin S
Basin CL
2-D Clovis Ave
3-D Hoblitt
3-F LaVerne
4-E Pup Creek
5-B/5-C Sierra
5-F Vartikian
6-D Hughes
7-C

** *Creeks Include:*

Big Dry Creek
Redbanks Creek
Dog Creek

source of data: FID Delivery to Recharge Basin Monthly Report

Within the project area, historical water deliveries made by the various districts in the study area are as shown in Table 5-6. From review of the data, it is apparent that historical surface deliveries have approximated the water supply available to the area.

Table 5-6

Historical Surface Water Deliveries within Study Area

	FID	Annex	Garfield*	Int'nal	Total
1983	52,752	54	2,896	1,905	56,159
1984	65,872	58	2,668	1,301	68,565
1985	58,478	38	3,220	1,164	61,290
1986	60,503	33	3,024	1,444	63,492
1987	41,688	13	3,226	930	44,244
1988	39,877	76	2,484	1,035	42,230
1989	39,154	16	3,154	1,240	41,987
1990	25,373	149	2,988	1,146	28,162
1991	30,430	150	2,610	1,172	33,057
1992	30,678	1,130	3,376	851	34,347
1993	47,281	576	n/a***	n/a	
Average	44,735**	208	2,695	1,108	47,353

* 50% of Garfield W.D. within Study Area
** Average 10.3% of FID entitlement
*** n/a - not available at time of printing

Water Quality

The surface water sources of the San Joaquin and Kings Rivers are generally of excellent quality. There is limited quality data available for Big Dry Creek, Dog, Redbank, and Fancher Creeks. The general mineral composition of the surface water sources is shown in Table 5-7. It could be expected that during rainfall events and with the continued development in the lower foothill areas, the local streams would become more turbid than either of the other surface sources.

In order for surface waters to be utilized by the City, water needs to be delivered via the existing creek drainages or either FID's Enterprise or Gould Canals. No water quality analysis are known to have been taken in either canal at prospective city delivery points. Caution should be exercised should the City desire to utilize surface water for delivery to satisfy municipal and industrial demands.

A thorough examination of potential contamination activities or sources that may affect the water supply conveyance facility should be made. The purpose of the evaluation is to identify risks associated with providing the raw water supply through this means and potential activities that can be taken to lessen any risk.

Table 5-7

Surface Water Inorganic Chemical Analysis

Source	pH	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO3)	Boron (B)	Alkalinity (HCO3)	TDS
Kings River	6.9	4.8	0.7	2.0	1.1	2.4	1.1	-	0.6	-	1.8	44
San Joaquin River*	7.0	3.5	0.4	5.4	1.0	5.2	7.9	-	0.4	-	6.5	46
Big Dry Creek	7.1	5.3	0.0	2.7	1.0	3.4	1.5	0.2	0.5	0.08	1.8	48

* Analysis at milepost 34.92 in Friant-Kern Canal

Summary

In summary, surface supplies are available to a large part of the study area. It is important they be utilized as the land use changes from irrigated agriculture to urban uses. The most significant water supplies are within the Fresno Irrigation District, and the Kings River entitlement consists of over 90 percent of total surface supplies. Kings River water is not allowed outside the Kings River Water Association boundaries which may cause some problems with the supply of water to the Northeast Village. Full utilization of Bureau water supplies augmented with water transfer and/or groundwater banking will most likely be required to provide a dependable water supply to this village.

Historical surface water deliveries to the study area have approximated the water supply available to the area. During the same period of time overdraft has occurred, suggesting that full utilization of the surface water supplies will be imperative as development occurs to avoid exacerbating the overdraft condition.

The surface water supplies are of excellent chemical quality. More turbid water could be expected from the stream group than other surface sources relegating them to an alternate water source during times when turbidity is excessive. If surface supplies are considered for treatment, identification and evaluation of risks of contamination should be thoroughly addressed.

6 - GROUNDWATER

Introduction

Previous studies of regional groundwater conditions in the Clovis area that provide information useful for this report include Page and LeBlanc (1969), John Carollo Engineers and Harshbarger & Associates (1969), County of Fresno, et al (1979 and 1986), and Kenneth D. Schmidt and Associates (1991).

As part of previous evaluations of groundwater conditions in the service area, records had been obtained and evaluated through 1991. As part of this evaluation, records on regional groundwater conditions through 1994 were obtained and used. Historical information on City of Clovis wells, water-levels, production, pump tests, chemical quality, and intentional recharge practices were also obtained.

Drilling of wells and test holes in the area north and east of Clovis during the past decade has indicated that well yields in part of the area are not as favorable as in much of the rest of the urban area to the south and southwest. There are problems that have been encountered in some locations including shallow bedrock and substantial thicknesses of clay strata. In addition, the area northeast of the Enterprise Canal is outside of the Fresno Irrigation District (FID), and canal water and/or distribution facilities for this water are not available. Concerns were expressed about the long-term adequacy of groundwater for urban development in parts of this area in the Northeast Fresno Groundwater Study (County of Fresno, 1972) and the 208 Water Management Plan (County of Fresno et al, 1979).

Primarily because of urban development in recent years, a number of test holes and public-supply wells have been drilled, particularly in the area north of Shaw Avenue. These have provided a substantial amount of new information, particularly on subsurface geology, groundwater production capability, and groundwater quality. The rest of this discussion is organized in the following order: subsurface geologic conditions, water levels, pumpage, aquifer characteristics, intentional recharge, and groundwater quality.

Soils

The soils in the northern part of the study area are predominantly loamy soils. These soils identified as the San Joaquin, Ramona, and Holland soil series are underlain by hardpan. The surface soils are brown to reddish-brown, and the sub-soils are generally reddish-brown or yellowish-red sandy clay loam or clay loam. They have low to moderately low permeabilities, while their water holding capacities range from low to high. The soil is poorly drained and forms areas of gently sloping terrain to nearly level land surface. In its virgin condition, the San Joaquin sandy loam was treeless, except for a scattering of growth along streams; the only vegetation consisted of grasses and wild oats. For support of irrigated agriculture, the soil requires intensive management and can be used for a variety of crops including figs, olives, vineyards, deciduous fruits, and citrus. Irrigated agriculture may require breaking up the hardpan by blasting or ripping. Ripping is the most common method, as it improves the internal drainage and deepens the soil.

Soils that are more centered in the City of Clovis urban area consist of Madera Sandy Loams. The Madera series consists of well drained soils that have a dense fine textured subsoil, and are moderately deep with hardpan at depth. There are many areas where the hardpan occurs at a depth greater than 6 feet. The largest continuous body of this soil lies upon the sloping plains northwest and eastward from the vicinity of the City of Fresno. It occurs on terraces and in other areas of old alluvium, such as older and high alluvial fans. An excerpt from the 1912 soil survey states:

> "Prior to the construction of the present dike systems, a number of foothill streams, including Fancher, Redbank, and Dry Creek, overflowed or discharged their water on areas of this type."

The surface soil of the Madera and Fresno sands are medium to rather course in texture, grayish brown or light to brown in color. They have a low organic matter content. This type of soil occupies the gently sloping or undulating, valley plains, occurring as low, broad alluvial fans or delta-like areas. Channels and depressions have been either wholly or partially obliterated by blowing in of sand and a number of the smaller circular depressions seemed to have been caused by the same process. In its natural condition, the Fresno sand is of very loose structure and when water is applied for the first time the soil undergoes considerable settling, with the result that the surface often sinks a foot or more in patches a few to several feet in diameter. Owing to the method of deposition, these soils generally occur as elongated bodies with a general northeasterly to southwesterly trend in the valley plains. The soils merge gradually into adjacent soil types, and it is commonly difficult to define specific soil boundary lines. These soil types are free from alkali and drainage conditions are always good and sometimes excessive. Plate 10 displays a generalized soil map for the study area.

Subsurface Geologic Conditions

Page and LeBlanc (1969) provided the regional subsurface geologic framework for the Fresno-Clovis area as of that time. Information from drillers logs, electric logs, and geologic logs can be used to provide more detail on subsurface geologic conditions in specific parts of the area. Prior to the 1969 investigation of the urban area by John Carollo Engineers and Harshbarger and Associates, no electric logs were known to be available for water wells in the area. The drillers' logs were available, and wells at that time were generally shallow (usually less than 300 feet deep).

Commencing in the late 1970's, a number of geologic and electric logs were obtained from test holes that were drilled in the City of Clovis and adjacent areas in the City of Fresno. In addition, it has become standard practice in the past decade to have electric logs for new public-supply wells in the Fresno-Clovis urban area.

Plate 11 shows the locations of test holes and wells in and near the urban area for which electric logs and geologic logs are available. Presently available data now extend to a depth of about 500 to 600 feet throughout much of the Clovis urban area. However, little data is available outside of the urban area. Drillers' logs are available for the rural area, but most wells are less than 200 feet deep.

The alluvial deposits in the area have been subdivided into several types, based primarily on the predominant particle size and interpretation of the electric logs. One unit comprises deposits primarily coarser than sand, usually cobbles, gravel, and sometimes boulders. Deposits of this type tend to have the highest resistivities on the electric logs and are generally the most permeable of the deposits, except when inter-mixed with clay. Electrical resistivity, in areas where the groundwater salinity is low, is primarily a function of the permeability of the subsurface deposits. A second type comprises deposits that are primarily sand in texture. Deposits of this type tend to have the next highest resistivities on the electric logs, and are also generally highly permeable. These two coarse-grained strata comprise the major water-producing deposits of the Clovis area. A third type comprises deposits that are primarily clay. Deposits of this type tend to have the lowest resistivities on the electric logs and generally have the lowest permeability of all the deposits. If these strata are sufficiently thick, then they may act as a confining bed, to separate groundwater in the overlying and underlying coarse-grained deposits. The fourth type comprises fine-grained deposits of an intermediate texture between sand and clay. Included in this type are silt, sandy clay, clayey sand, and silty clay deposits. These deposits generally have resistivities intermediate between sand and clay. Deposits of this type are believed to have a low to moderate permeability, can contribute some water to wells, and probably do not act as significant confining beds. All of the alluvial deposits vary in thickness and extent, and sometimes individual units cannot be correlated for great distances laterally. However, there is overwhelming evidence that the course-grained water-producing strata are well connected hydraulically.

Shallow Bedrock

Shallow bedrock is a constraint to development of groundwater in part of the Herndon-Shepherd Plan Area (bounded by Herndon, Willow, Shepard, and Dewolf), and in the area northeast of Clovis. Shallow bedrock northeast of Fresno was mapped as part of the 208 program (County of Fresno, 1979, Figure 7). Contours of thickness of alluvium or depth to the top of the bedrock were developed based on drillers logs that were available as of 1978. Fifty-foot thickness contours were shown, from 50 to 200 feet. This map showed that the depth to bedrock gradually decreased to the northeast toward the Friant-Kern Canal. However, an area of shallow bedrock, less than 100 feet deep, was shown near Herndon Avenue, between Temperance and Leonard Avenues.

Since 1989, more than one dozen test wells have been drilled in the western part of the Herndon-Shepherd Area, generally North of Sierra and East of Minnewawa and a number of these encountered bedrock (metamorphic rock) above a depth of 500 feet. Several deep test holes or wells have been drilled in the East Clovis Area, but they have not encountered bedrock. Drillers' logs in the predominantly rural part of the study area were also collected as part of the evaluation. The depth to the top of the bedrock in the study area was plotted (see Plate 12). Depth to the top of the bedrock is generally greater than 600 feet in the southwest part of the Herndon-Shepherd Plan Area, and in most of the East Clovis Area south of Shaw Avenue. Within the Herndon-Shepherd Plan Area, the depth to the top of the bedrock increases gradually to the southwest. The depth to the top of the bedrock ranges from less than 100 feet near Dry Creek and Shepherd Avenue and near Herndon and Tollhouse Avenues, to more than 600 feet near Willow and Herndon Avenues.

Two relatively isolated areas of shallow bedrock are shown, including one along Tollhouse Road near Herndon Avenue, and another in the vicinity of Shepherd Avenue and Dry Creek. Plate 12 indicates that few wells east of the City and south of the Enterprise Canal have been drilled deep enough to encounter bedrock in the area west of Bethel Avenue. In addition, several bedrock depressions have been identified. One is the vicinity of Herndon Avenue and Dry Creek, where a number of wells have penetrated more than 300 feet of alluvium. Another is in the Quail Lake Area (Shaw Avenue and McCall Avenue), where several wells have penetrated more than 350 feet of alluvium. Deeper drilling is necessary in the area south of the Enterprise Canal, and between Temperance and Bethel Avenues, to further delineate areas of shallow bedrock in that area.

Alluvial Deposits

Evaluation of geologic logs, electric logs, and drillers' logs for test holes and wells in the area indicates that the uppermost several hundred feet of alluvium are normally more coarse-grained than the underlying deposits. These course-grained deposits are termed the older alluvium. The older alluvium was historically the main water producing formation in the study area. The underlying deposits are generally finer grained and are termed the continental deposits. They are generally less productive than the shallower deposits. At depth in part of the East Clovis Area, and in part of the North Fresno Growth Area, the continental deposits are usually blue, green, or gray in color, indicative of reducing conditions. The reduced groundwater is deficient in oxygen and conditions are favorable for reduction reactions (ie reduction of sulfate to sulfides). The presence of these reduced deposits beneath part of the East Clovis Area has important water quality implications on the potential development of groundwater for public supply. This is because high concentrations of iron, manganese, and hydrogen sulfide are sometimes associated with these deposits.

The reduced (blue-green) deposits were encountered below a depth of 300 feet at Test Well T13S/R21E- 22D, near Ashlan and Fowler Avenues, and at City Well No. 12, near

Clovis and Gettysburg Avenues. Below a depth of 440 feet at Test Well 22D, siltstone was predominant. Although not considered bedrock, the siltstone in this area is generally non-water producing and normally directly overlies the bedrock. The shallow bedrock, generally thin older alluvium (compared to farther southwest), relatively shallow reduced deposits, and/or siltstone in some parts of the Clovis Master plan area are constraints to the development of public-supply wells.

As part of the Fresno Water Resources Management Plan, a number of subsurface geologic area sections were developed (Kenneth D. Schmidt and Associates, 1991). One of these, (Section 'C-C) passed through Clovis, from Well No. 25 (Nees and Minnewawa Avenues) southeast to City Well No. 20 (Barstow and Armstrong Avenues), thence south to test hole T13S/R21E-22D (near Ashlan and Fowler Avenues). The northernmost four wells along this section are in the Herndon-Shepherd Plan Area, and the southern three are in or near the East Clovis area (see Plate 14). The three southernmost holes or wells ranged from 514 to 855 feet in depth. Five test holes or wells along this cross section encountered bedrock (metamorphic rocks), at depths ranging from about 360 to 440 feet. Depth to bedrock increases to the southeast along this section. Coarse-grained deposits of the older alluvium generally thicken to the southeast along this section. At City Well No. 25 these deposits are only about 110 feet thick, at Test Well 89-B, they are about 170 feet thick, and at City Well No. 16, they are about 250 feet thick. The under-lying continental deposits are predominantly fine-grained, although there are some relatively thin interbedded coarse-grained strata that are also present.

As part of this evaluation, a new subsurface geologic cross section was developed. This section (see plates 11 & 13) extends from the southwest to northeast. The southwest end of this section is near the City Corporation Yard (Well 4-AA), and the northeast end is near Tollhouse Road and Copper Avenue. The area of shallow bedrock near Tollhouse Road and Herndon Canal is shown, as is the thickening of the alluvium to the southwest. This section illustrates the transition from an area of limited groundwater production due to shallow bedrock to the northeast, to an area of more favorable groundwater production due to the presence of a thick section of highly permeable alluvium in the southwest.

In summary, subsurface geologic conditions are more favorable for groundwater development in the southwesterly part of the study area, and less favorable to the Northeast. Alluvial deposits conducive to development of large capacity wells thin to the Northeast. Besides shallow bedrock beneath the northeast part of the area, other constraints to development of public supply wells in East Clovis are a local siltstone unit which limits well production capacity and reduced (blue-green) deposits, which can be associated with groundwater quality problems. Deeper subsurface geologic conditions are poorly known beneath the eastern part of the study area due to a lack of deep test holes or wells.

Water Levels

Water level measurements were obtained from the City of Clovis and Fresno Irrigation District. Recent measurements for the former County of Fresno Northeast Network were obtained from the California Department of Water Resources (DWR). This network was originally established by the county to evaluate water level trends northeast of Fresno and Clovis, particularly in the rural residential area. Wells in this network were measured quarterly by the County of Fresno from 1974-1987 and semi-annually by DWR after 1990. Regional water-level elevation contour maps were previously prepared for the City of Fresno Water Resources Management Plan and Fresno Irrigation District Groundwater Management Plan for spring 1991. Therefore, for consistency this same period was used to prepare detailed depth to water and water level elevation contour maps for the Clovis Master Plan area.

Depth to Water

Plate 16 indicates that depth to water ranged from less than 30 feet beneath some easterly rural areas to more than 100 feet beneath the northwest portion of the study area in spring 1991. The shallowest water levels were generally in the vicinity of the Dry Creek Reservoir and east of McCall Avenue.

In most of the Clovis urban area, the depth to water was between 70 to 100 feet in Spring 1991. In general, depth to water is greater to the northwest beneath topographically higher areas. Water levels have fallen significantly in most of the area since about 1986, due to the drought and increased pumping.

Water-Level Elevations

Plate 17 shows water-level elevation contours and the direction of groundwater flow in spring 1991. The direction of groundwater flow and hydraulic gradient can be used to determine the rates and amounts of groundwater flow into and out of the urban area. They can also be used to evaluate changes in groundwater quality that can be expected in the future. Flowlines are constructed perpendicular to the water-level elevation contours and show the direction of groundwater flow. Flowlines are drawn so that the network lines approximate squares as much as possible (a flownet). An important assumption in the use of a flownet is that the groundwater will flow perpendicular to the water-level contours only in an isotropic, homogenous aquifer. If the permeability of the aquifer materials varies with direction, then the groundwater flow will generally follow the direction of highest permeability. Groundwater will still flow downgradient, but at some direction other than perpendicular to the water-level contours. Thus the flownet should be interpreted with care, and subsurface geologic conditions carefully considered. Subsurface geologic information in and near the Clovis urban area indicates that the highest horizontal permeability is often oriented in the northeast-southwest direction.

On the flownet, there are some locations where flowlines converge and effectively terminate. These are locations of groundwater discharge, which in this case are areas of concentrated pumping. Similarly, there are some places where flowlines diverge or originate, which are locations of groundwater recharge. Recharge to the groundwater in the Herndon-Shepherd Plan Area and the adjacent North Fresno Growth Area appears to be primarily from seepage of Dry Creek streamflow. A major source of recharge to the southwest part of the Clovis urban area is from intentional recharge at the Clovis Basin and the City of Fresno Leaky Acres facility (operated since 1970). Converging flowlines are apparent in much of the urban Clovis area due to pumping for municipal supply.

Water-Level Hydrographs

Water levels were measured by the County of Fresno in a number of wells in the Northeast Network on a quarterly basis from 1975 to early 1987. These measurements were normally for relatively shallow (100 to 200-feet deep) domestic wells, which tapped the older alluvium. Measurements in most of these wells generally showed a relative constancy in depth to water from about 1975 to 1986.

As part of this evaluation, water-level hydrographs were prepared for more than 40 wells with records extending back to at least the 1970's (see Plates 19-22). The period from 1974 to 1994 is a period when surface water deliveries were only slightly greater than the long-term average. Water levels fell during this period throughout most of the study area. In the area west of Fowler Avenue, water levels declined in most wells from 20 to 40 feet, or an average of one to two feet per year. The greatest declines were generally in the area between Shaw and Alluvial Avenues. There were also water-level declines of greater than 20 feet in rural parts of the Fresno Irrigation District that were not on canal water service. Northeast of the Enterprise Canal, the main area of water-level decline was southeast of Tollhouse Road, north of Shaw Avenue, between Highland and Del Rey Avenues.

Well Production and Aquifer Characteristics

Table 6-1 summarizes the most recent pump test data available for the City of Clovis wells. Pumping rates for individual City wells in recent years have ranged from about 400 gpm to almost 2,000 gpm. However, the pumping rates for most wells has ranged from about 600 to 1,500 gpm. The specific capacity is the pumping rate divided by the drawdown. The specific capacity values cited are based primarily on PG & E short-term pump tests, where the true static level was often not measured. Therefore, the values reported usually have a smaller drawdown and larger specific capacity than if the true static level had been measured and used for the calculations. Specific capacities for most City wells have ranged from about 30 to 100 gpm per foot of drawdown.

Table 6-2 summarizes the results of aquifer tests that have been conducted on City of Clovis wells developed within the past six years. In this case, specific capacity values were determined based on the true static water levels. Specific capacities ranged from 10 to 39 gpm per foot. Transmissivity is an indication of the capability of the aquifer to transmit water through a specific width of the aquifer. Aquifer transmissivity ranged from 13,000 to 88,000 gpd per foot, and averaged 53,000 gpd per foot. The transmissivity is lowest in the east part of the Herndon-Shepherd plan area and highest in the southwest part of Clovis west of Minnewawa.

Table 6-1

Summary of Recent Pump Test Data
For the City of Clovis Wells

Well	Date	Pumping Rate (gpm)	Static Level (feet)	Pumping Level (feet)	Drawdown (feet)	Specific Capacity (gpm per foot)
3	05/25/93	500	100.3	106.0	5.7	88
5	05/25/93	592	91.2	103.9	12.7	47
6	03/25/88	415	88.2	93.6	5.4	77
9	03/22/88	794	69.6	80.4	10.8	74
10	05/25/93	813	81.7	85.2	3.5	232
11	05/25/93	1,183	111.5	130.8	19.3	61
12	05/25/93	1,250	--	129.3	--	--
14	05/25/93	1,550	138.6	154.4	15.9	97
15A	06/01/93	1,968	108.7	164.0	55.3	32
17	04/05/88	1,675	98.4	107.1	8.7	193
19	06/13/90	538	80.3	87.4	7.1	76
20	04/19/89	348	166.0	186.0	20.0	17
21	11/05/90	1,160	101.6	160.2	58.6	20
23	06/01/93	440	126.0	153.3	27.3	16
24	06/01/93	1,486	120.0	145.0	25.0	59
25	06/01/93	1,303	132.3	156.6	24.3	54
26	06/01/93	1,848	--	--	--	--
27	06/01/93	1,492	141.9	174.0	32.1	47

Pump tests on these wells are from short-term PG & E tests, and static levels may be 5-minute recovery values, and not representative of true static conditions.

Table 6-2

Summary of Aquifer Tests
For City of Clovis Wells

Well No.	Perforated Interval (feet)	Date	Duration (hours)	Pumping Rate (gpm)	Static Level (feet)	Specific Capacity (gpm/ft)	Transmissivity (qpd/ft)
8-A	315-510	10/12/91	10	1,800	110.8	39	68,000
21	230-520	06/29/89	24	1,300	98.5	13	35,000
22	190-345	08/17/90	23	1,135	101.1	14	16,000
23	170-367	10/03/90	24	770	96.3	10	13,000
24	160-380	04/24/91		1,475	86.4	38	75,000
25	190-365	10/31/91	24	1,770	95.4	37	55,000
26	240-490	2/20/91	24	2,030	106.1	32	72,000
27	265-610	2/12/92	24	1,740	105.9	31	88,000

Specific Yield

Page and LeBlanc (1969) presented estimates of specific yield for the Fresno area. John Carollo Engineers and Harshbarger & Associates (1969) utilized an average specific yield of 0.13 for the older alluvium in the urban area. Average values for the under-lying continental deposits probably range from about 0.07 to 0.10, based on the predominant fine-grained texture of these deposits. Specific yield values can be used along with water level changes to estimate changes in groundwater storage.

The average water level-decline in forty-one wells from 1974 to 1994 was 1.5 feet per year. These wells represent an area of about 25,000 acres. The specific yield is the percentage of saturated aquifer materials which will freely drain water. Using an average specific yield of 12 percent, based on previous hydrogeologic studies in the area, the change in storage averaged about 4,500 acre-feet per year during that period. This is equal to almost half of the overdraft calculated for the entire Fresno Irrigation District.

Pumpage and Intentional Recharge

Pumpage by the City of Clovis increased from about 7,900 acre-feet per year in 1980 to 15,300 acre-feet in 1993. In 1993, the pumpage by the City of Clovis was about ten percent of the total pumpage for public supply in the entire Fresno-Clovis urban area. For the study area, the estimated average pumpage is about 32,000 acre-feet per year within the Fresno Irrigation District and 21,000 acre-feet per year outside of the District.

Recharge at the Clovis Basin west of Tarpey Village began in 1974 and in flood control basins and stream channels in or upgradient of the City in 1982. Intentional recharge in the City of Clovis during 1974-94 ranged from about 2,500 acre-feet in 1987 to 8,800 acre-feet per year in 1992 (see Table 5-5).

Groundwater Quality

There have been numerous investigations of groundwater quality in and near the Fresno-Clovis urban area, including Page and LeBlanc (1969), Kenneth D. Schmidt (1971), the County of Fresno (1979 and 1986), Engineering-Science, Inc. (1970), and Kenneth D. Schmidt and Associates (1991). Schmidt's report primarily involved the distribution of nitrate in groundwater. The first of these reports was regional and covered most of the valley portion of Fresno County. The last three of these reports dealt with the Fresno-Clovis metropolitan and upgradient Areas. Extensive groundwater quality investigations of the Fresno-Clovis urban area and adjacent lands were completed as part of the 208 Water Quality Management Program and 205(j) Water Quality Management Program. Whereas the 208 program studies focused on inorganic chemical constituents in groundwater, by the time that the 205(j) program studies were undertaken, the pesticide dibromodichloropropane (DBCP) had been found in groundwater in part of the urban area. The report on the results of the 205(j) program thus included a discussion of DBCP in groundwater beneath the Fresno Water Management Plan Area, including the Clovis urban area.

A number of groundwater quality studies have been conducted in the area northeast of the Fresno urban area (termed the "Northeast Area"). These include evaluations of the effect of irrigation on groundwater quality (Nightingale, 1972 and 1974, and Nightingale and Bianchi, 1974), regional groundwater quality in the Northeast Area (County of Fresno, 1976), and an evaluation of high nitrate areas in groundwater of the Northeast Area (Day and others, 1977).

Water from numerous large capacity wells in the Fresno-Clovis urban area has been sampled for analysis of inorganic chemical constituents for several decades. Although relatively few water samples were collected and analyzed prior to the early 1960's (when the DWR Fresno water quality study was performed), numerous samples have been collected and analyzed since that time. The results of chemical analyses, including trace organics, radon, and alpha activity, for samples collected in recent years from City wells were obtained from the City of Clovis. Additional data for private domestic wells were obtained from the County of Fresno Environmental Health Division. Also, the results of the samples in the adjacent parts of the City of Fresno, as presented in the FWRMP were utilized.

Inorganic Chemical Constituents

Areal Distribution

Four inorganic chemical constituents in groundwater in the area were selected for detailed discussion, based primarily on their importance to water use. Total dissolved solids (TDS) is an indication of the salinity of water, but was not mapped because contents in the groundwater study area are relatively low. Nitrate was selected because it has been one of the most important inorganic chemical constituents in groundwater of the urban area for decades. It is the only inorganic chemical constituent in the Primary Drinking Water Standards to have been found in amounts exceeding the maximum contaminant level (MCL) in water from some large-capacity wells in the Fresno/Clovis area. Manganese was selected because concentrations exceeding the recommended MCL are common in the groundwater east of Clovis, near Dry Creek, and near the Clovis Basin. Iron was selected because of its occurrence in the east Clovis area. The manganese and iron do not have health-based MCLs, however, their presence in water at excessive levels causes objectional characteristics, such as color and odor.

The discussion in this part of the report largely concerns public supply wells in the urban area and private domestic wells that have been sampled in the rural area. The quality of groundwater in a local area (i.e., near a source of contamination) may be different than shown by the results of supply well sampling. This is because the sampled supply may not be perforated shallow enough to reach the contamination and they may not be located in the contamination plume. Monitor wells are usually necessary to delineate plumes from point sources. The quality of water pumped from a well also depends on the design of the well, because there are usually significant vertical variations in groundwater quality. Thus the quality of water pumped from shallow wells often is not the same as that of water pumped from deep wells, even in the same vicinity.

Total Dissolved Solids

In 1989-91, TDS concentrations of less than 100 mg/l were present only beneath and down gradient of the Clovis Basin and Fresno's Leaky Acres. The relatively low salinity of groundwater in this part of the urban area is due to the intentional recharge of low salinity canal water for two decades. Although the low salinity groundwater is considered beneficial in most aspects, it has a higher corrosiveness than other groundwater in the urban area. TDS concentrations in groundwater beneath the northern half of the Fresno-Clovis urban area normally range from about 100 to 250 mg/l, well below the recommended MCL of 500 mg/l.

Nitrate

A drinking water limit has been established for decades for nitrate, as excessive concentrations in drinking water can cause methemoglobinemia (blue babies). Plate 23 shows nitrate concentrations in water from wells in the study area in recent years. Nitrate concentrations in groundwater in most of the Clovis urban area were less than the MCL of 45 mg/l. However, there is a large area where nitrate concentrations exceed the MCL, in the floodplain of Redbank and Fancher Creeks. This high nitrate area was discussed in detail in the 208 program report (County of Fresno, et al, 1979). In 1978, water samples were collected from many shallow domestic wells in this area. The area where nitrate concentrations exceeded 45 mg/l was well delineated and is shown on Plate 23. For the rest of the rural area, sampling results for recent years are not available for as many wells as in the large high nitrate area. Another smaller area of nitrate concentrations exceeding 45 mg/l in the groundwater was west of the Dry Creek Reservoir, primarily north of Shepherd Avenue and east of Peach Avenue.

Some of the lowest nitrate concentrations in groundwater were found near Leaky Acres. Nitrate contents in water from most of the wells downgradient of Clovis Basin and Leaky Acres were less than 5 mg/l in 1989-91. Nitrate concentrations of less than 15 mg/l were primarily near or downgradient of the recharge facilities and also along part of the Gould Canal, between Clovis and Temperance Avenues. This is also indicated to be an area of significant recharge, mainly from canal seepage.

Although high nitrate concentrations have caused several shallow public supply wells in the Fresno urban area to be closed, construction of deeper wells with adequate annular seals has been demonstrated to be effective in mitigating this problem. Such mitigation has been successfully practiced in this area for more than two decades.

Manganese

The recommended MCL for manganese in public water supplies is 0.05 mg/l. Historically, only a few public-supply wells in the Fresno-Clovis urban area have produced water exceeding the MCL for manganese. A former City of Fresno well (PS 83) near Fowler and Dakota Avenues was abandoned in the early 1970's because the manganese concentration exceeded the MCL. Manganese problems have become more noticeable with expansion of the urban area to the east and the drilling of deeper wells. Plate 24 shows areas where manganese concentrations in water from wells have exceeded 0.01 mg/l in recent years. Besides the results from public-supply wells, this figure also shows contours of manganese concentrations in the east Clovis area, based on sampling of many private domestic wells in 1990. Also, manganese analyses for water from private domestic wells in the rest of the study area were obtained from Fresno County Environmental Health and plotted. The largest known area of high manganese concentration is in east Clovis. The high manganese concentrations are found in water from wells in a westerly to southwesterly trending elongated zone, between Clovis and Highland Avenues, and south of Barstow Avenue. Two City of Clovis wells (No. 13 and No. 16) produced water with manganese concentrations ranging from 0.13 to 0.27 mg/l, exceeding the recommended MCL in 1990. Both of these wells have been out of service for years. In addition, water from City of Clovis Well No. 20 (near Barstow and Armstrong) had a manganese concentration of 0.04 mg/l, just below the MCL, in 1989. Test well T13S/R21E-22D, drilled near Ashlan and Fowler Avenues (one-half mile north of former Fresno City well PS 83), also encountered high manganese concentration in the shallow groundwater.

Test wells in the Herndon-Shepherd Plan area have indicated high manganese concentrations in shallow groundwater in part of that area, particularly near Dry Creek. A test well near the Clovis Basin (near Well 4-AA) indicated high manganese concentration in the shallow groundwater.

Iron

The recommended MCL for iron in public water supplies is 0.3 mg/l. Historically, few public-supply wells in the Fresno-Clovis urban area have produced water exceeding the MCL. Iron problems have also become more noticeable as the urban areas have extended to the east, and deeper wells have been drilled. City of Fresno Well No. 101, located east of the Fresno Air Terminal has iron concentrations exceeding the MCL and is periodically treated. Plate 24 shows areas where iron concentrations in the groundwater exceed the MCL. Besides data from public supply wells, this map also shows contours of iron concentrations in the east Clovis area, based on sampling of many private wells in 1990. Iron analyses of water from private domestic wells in the rest of the study area were obtained from Fresno County Environmental Health and plotted. Two areas in east Clovis with high iron concentrations in the groundwater have been delineated. The northeasterly of these is between Bullard and Ashlan, and Armstrong and Locan Avenues, and partly overlaps the area with high manganese concentrations. The southeasterly area is smaller, and is located south of Ashlan Avenue, between Temperance and Dewolf Avenues, and appears to be considerably smaller.

Arsenic

Although the present MCL for arsenic is 50 ppb, the EPA has discussed lowering the MCL to the range of 2 to 5 ppb. Arsenic concentrations in the water from most City wells ranged from about 2 to 5 ppb. Water from many wells would exceed the MCL if set at 2 ppb, due to the natural occurrence of arsenic. This is particularly true for wells tapping the deeper groundwater such as most new city wells. No treatment of water from individual wells for arsenic removal is known to be going on at present in the San Joaquin Valley. Compliance with this regulation could be difficult, if an MCL below about 5 ppb is established.

Vertical Distribution

The vertical distribution of constituents in the groundwater can be determined in several ways. First, water samples can be collected from specially designed and constructed test wells or the pilot holes for new wells. Second, wells are sometimes deepened, or replaced by adjacent deeper wells. The quality of water pumped from the well can be compared before and after deepening. Sometimes there are adjacent wells of different depth that can be compared. Open-bottomed, or unperforated casing wells provide extremely useful information related to vertical differences in groundwater quality, since they produce water from specific strata, as opposed to gravel packed wells with perforations extending over several hundred feet in depth. Third, specially designed monitor wells tapping groundwater in discrete depth intervals can be installed and monitored.

In general, data indicates that the quality of groundwater in much of the urban area usually improves with increasing depth to at least about 400 feet. An exception is in part of the east Clovis area (east of Clovis Ave and south of Shaw), where reduced (blue-green) deposits are encountered below that depth. Groundwater in these deposits is present under anaerobic (oxygen deficient) or reduced conditions, and can have high concentrations of iron, manganese, arsenic, and hydrogen sulfide.

Groundwater of high salinity (connate water) underlies the usable groundwater in the Fresno area, except beneath the eastern part. Page and LeBlanc (1969, Plate 17) contoured the base of the fresh groundwater (top of the connate water). Fresh groundwater was defined as having a TDS concentration of less than 2,000 mg/l. The information that they used was primarily derived from interpretation of electric logs for deep oil or gas exploration wells west of Clovis. More recent data obtained from water wells and test holes have shown that the eastern edge of this body of connate water does not extend east of Pinedale. Test wells extending through the alluvium and down to bedrock in the Herndon-Shepherd Plan area have not encountered connate water.

In recent years, numerous test well, and pilot hole sampling programs have been undertaken in the urban area. The results of these programs have confirmed that TDS, nitrate, and hardness concentrations in the groundwater normally decrease with increasing depth, particularly beneath areas that were formerly unsewered or have been irrigated. Groundwater in the older alluvium is normally aerobic (ie oxygen rich) or oxidized. Groundwater in the deeper reduced, underlying continental deposits, on the other hand, is usually reduced. The quality of groundwater below a depth of about 250 feet in most of the area has normally not been affected by man's activities. TDS, nitrate, and hardness concentrations in this deeper groundwater are normally low, but significant concentrations of iron, manganese, hydrogen sulfide, and sometimes arsenic can be present, particularly in deposits that are blue or green in color. The blue-green deposits are particularly important where they are present above a depth of about 500 feet, such as in parts of the east Clovis area. At greater depths, they are usually too deep to be tapped by water wells. Information from test hole T13S/21E-22D, that was drilled east of Fowler Avenue, and about one-quarter mile south of Ashlan Avenue, delineated the vertical distribution of manganese in groundwater at that location. The manganese concentrations ranged from 0.06 to 0.19 mg/l exceeding the recommended MCL, above a depth of 270 feet at this location.

Within the east part of the study area, methane gas was reported in water from a relatively shallow well tapping groundwater in bedrock beneath the alluvium. The extent of the methane gas has not been determined, although such an occurrence in groundwater in the Fresno-Clovis area is highly unusual. Methane is more common in groundwater farther west and south of Fresno, such as in the Corcoran area.

Trace Organic Chemical Constituents

The primary trace organic chemical constituents that have been found at significant levels in water from public-supply wells in the Clovis urban area are DBCP and ethylene dibromide (EDB). Several volatile halocarbons including trichloroethylene (TCE) and tetrachloroethylene (PCE), have been found in parts of the Fresno urban area. In terms of amount of contaminated groundwater, the largest problem by far is due to DBCP.

DBCP

A report was prepared for the City of Fresno on the adjacent North Fresno Growth Area (Kenneth D. Schmidt and Associates, 1987) that included data from nineteen private domestic wells that were sampled for DBCP analysis in spring 1987. These wells were sampled because of the desire to obtain information prior to intensive urbanization. In May 1991, J.H. Kleinfelder and Associates, under contract to the City for Fresno, sampled water from twenty-one private wells in and near the north part of the North Fresno Growth Area for DBCP analyses.

About 30 private domestic wells in the Herndon-Shepherd Plan area were sampled in spring 1989, and about three dozen private wells in the east Clovis area were sampled in June 1990 by Kenneth D. Schmidt and Associates, as part of studies for the City of Clovis. Results of sampling of private domestic wells and small water systems were also available from the County of Fresno Environmental Health.

A map of DBCP concentrations in groundwater in 1989-91 in and near the Fresno-Clovis urban area was presented in the Fresno Water Management Plan report (Kenneth D. Schmidt and Associates, 1991). Two large areas of high DBCP concentrations were present, one in southeast Fresno and one in northeast Fresno (see Plate 25). The latter of these two areas includes the western part of the Herndon-Shepherd Plan Area, and parts of the Central Clovis, Tarpey Village, and the east Clovis areas. In 1990-91, DBCP concentrations exceeding the MCL of 0.20 ppb were present in water from seven City of Clovis wells in this area. The highest DBCP concentrations were present in a northeast band extending from City of Fresno PS 85 (near Maple and Palo Alto Avenues) on the southwest to near Shepherd Avenue, between Peach and Minnewawa Avenues, on the northeast. DBCP concentration exceeded 2.0 ppb in groundwater in this area in 1990-91. The area of DBCP contamination exceeding 0.5 ppb was more than four miles long and averaged about one and a half miles wide. DBCP concentrations exceeding the MCL in groundwater of the Herndon-Shepherd Plan area were primarily west of Marion Avenue. DBCP concentrations generally increased to the west, to near a northeast band connecting Nees and Willow Avenues to Shepherd Avenue just east of Peach Avenue. Northwest of that line, DBCP concentrations decreased to less than the MCL near Willow and Shepherd Avenues. Another fairly large area of DBCP concentration exceeding 1.0 ppb extended northeast from the northeast part of the Fresno Air Terminal to near Ashlan and Locan Avenues.

Plate 25 also shows DBCP concentrations in groundwater in the rest of the study area. The easterly extent of where DBCP has been detected in the groundwater is fairly well delineated. North of Bullard Avenue, this area is generally northeast of the Enterprise Canal. South of Bullard Avenue, the area is generally east of Highland Avenue. Considering the direction of groundwater flow shown previously, DBCP is moving southwest or west and out of the City of Clovis.

Vertical Trends

Ten casing hammer test wells were completed in the Herndon-Shepherd Plan area during 1989-91, partly to determine the vertical distribution of DBCP at prospective sites for new City of Clovis public-supply wells. Results of these test wells illustrated two predominant patterns. First, clay strata in part of this area aren't highly effective as confining layers. At three test well sites in this area, DBCP had migrated to depths exceeding 300 feet which is significantly deeper than normally found in surrounding areas. However, DBCP concentrations exceeding the MCL weren't found in any of the test wells below a depth of 260 feet. The relatively shallow bedrock in the northeast part of this area is a substantial constraint in developing new public-supply wells. The results from the 1989 sampling of water from shallow private domestic wells indicated that the shallow groundwater near Dry Creek had low DBCP concentrations. However, the subsequent drilling of several test wells in this area indicated that high DBCP concentrations were generally present in groundwater below a depth of about 120 feet and above a depth of about 250 feet. Recent recharge from streamflow in Dry Creek is apparently the source of the shallow groundwater in this area, which has low DBCP concentrations. This recharge probably originated after the use of DBCP was banned.

Two casing hammer test wells have been drilled in the east Clovis area, one near Ashlan and Fowler Avenues (T13S/R21E-22D), and another TH-92A farther east. No DBCP was detected in the groundwater at either of these sites.

Ethylene Dibromide

Two areas of ethylene dibromide (EDB) concentrations exceeding the MCL of 0.02 ppb have been found in the Herndon-Shepherd Plan area (see Plate 26). One was found in a test hole (TH-89A) near Villa and Herndon. This well is in an area of high DBCP contents in the shallow groundwater. Another is in a triangular shaped area between Herndon and Nees Avenues and Marion and Fowler Avenues. A new City of Clovis well (No. 24) was recently drilled in this area, but was sealed off opposite shallow strata and has been free of EDB. Based on sampling results for numerous other wells in the plan area, which have had no detectable EDB, the occurrence of EDB in groundwater appears to be highly localized. The source appears to be pesticide applications to agricultural lands in close proximity to the sampled wells.

In the east Clovis area, a zone of EDB concentrations in shallow groundwater exceeding the MCL was found between Barstow and Gettysburg and Fowler and Temperance Avenues. Two City wells (13 and 16) are located in this area, and EDB concentrations in water from them ranged from less than 0.02 ppb to 0.10 ppb in 1990. Water from well 13 had EDB concentrations exceeding the MCL during 1990, but since that time concentrations have been non-detectable. Groundwater in this area also contains relatively high DBCP concentrations. The source of the EDB in this area is also believed to be pesticide applications on agricultural lands in the close proximity to the sampled wells.

Volatile Halocarbons

Although volatile halocarbons have been a problem in groundwater in other parts of the Fresno-Clovis urban area, they do not appear to be a problem in Clovis at present, based on sampling of water from City wells.

Radiological - Radon

Presently there is no MCL for radon in groundwater, but an MCL of 300 picocuries per liter has been proposed by the EPA. The radon activities in water from city wells ranged from 318 to 1,365 and averaged 449 picocuries per liter in 1993. The highest activities (exceeding 600 picocuries per liter) were in water from wells west of Clovis Ave. The lowest activities (less than 400 picocuries per liter) were in Water from wells east of Clovis Ave. Thus an MCL as low as proposed could have a significant impact on City wells.

Conditions in the Proposed Urban Villages

Northwest Urban Village

The proposed northwest urban village is located in an area of limited groundwater. Depth to the top of the bedrock is less than about 250 feet beneath the east part of this area. Near the east edge, depth to bedrock is indicated to be 100 feet deep or less. The deepest bedrock is located near the southwest corner of this area. Deep test holes or wells are not known to have been drilled in the area north of Nees Avenue, and east of Willow

Avenue. A number of unsewered rural residential lots, particularly east of Clovis Avenue, are upgradient of this area. Depth to water in 1991 ranged from about 70 to more than 110 feet. Thus the saturated alluvium in this area is relatively thin. The direction of groundwater flow was to the west -southwest.

An area of nitrate in groundwater exceeding the MCL is located east of Clovis Avenue and upgradient of this area.

Most private wells in the area north of Shepherd Avenue and east of Willow have not been sampled for DBCP and EDB. However, information from sampled wells to the west and south indicates that DBCP concentrations in shallow groundwater beneath most of the area probably exceeds the MCL.

Plate 7 shows that the Fresno Irrigation District delivers canal water to most of the area. It appears that new public supply wells could be developed in the southwest and possibly northwest part of this area. However, wellhead treatment for high DBCP concentrations would be likely. An important data gap to be addressed is the lack of DBCP and EDB analyses of water from wells in the part of the area north of Shepherd Avenue.

The most favorable part of this area for intentional recharge is probably along the east boundary in or near Dry Creek.

Northeast Urban Village

The proposed Northeast Urban Village is located outside of the Fresno Irrigation District, but part of it is within the International Water District. This area is underlain by shallow bedrock, except near the southwest corner where a bedrock depression is present. Depth to the top of the bedrock is less than 200 feet in the part of the area north of Nees Avenue. Depth to groundwater in spring 1991 ranged from 40 to 50 feet in this area, and the direction of groundwater flow was to the southwest. Water levels measured in most wells in this area fell from about 10 to 20 feet during the period 1978 to 1994. There is a lack of well sampling in this area for analysis of nitrate, iron, manganese, DBCP, and EDB. Thus the quality of the groundwater for public supply is not known. Permeable soils along or near Dry Creek may prove to be suitable for intentional recharge.

Southeast Urban Village

This area is located within the Fresno Irrigation District, and much of the land in the area is on canal water service. Depth to bedrock is not well known in this case, as virtually no wells are known to have been drilled that deep. Existing information indicates that the top of the bedrock is likely more than 300 feet deep throughout the area and could be considerably deeper (see Plates 12 & 15). Depth to water ranged from about 40 to 50 feet in spring 1991. The direction of groundwater flows west to southwest. Water-levels in the eastern part of the area were relatively stable from 1978 to 1994. However, in the western part, water levels fell from about 15 to 20 feet during this period. Some permeable topsoil appears to be present in part of the area that could be suitable for intentional recharge with basins.

Nitrate concentrations exceeding the MCL are present in shallow groundwater beneath the eastern part of this area. Manganese concentrations exceeding the recommended MCL are present beneath part of the area. The northern corner of this area is near an area where EDB has been detected in the shallow groundwater. DBCP has been detected in the southwest part of this area at concentrations exceeding the MCL.

Overall, this appears to be the most favorable of the proposed urban villages in terms of potential groundwater supply. However, deeper drilling will be necessary to confirm water quality conditions at greater depths.

7 - WATER BUDGET

The concept of a water budget involves the following:

- Identify or define an "area" to be analyzed.

- Define a base period long enough to contain significant variation from the average condition, but with average hydrologic conditions representative of the long term norm.

- Identify and quantify all significant system inputs, outputs, and changes in storage to prepare a budget over the base period.

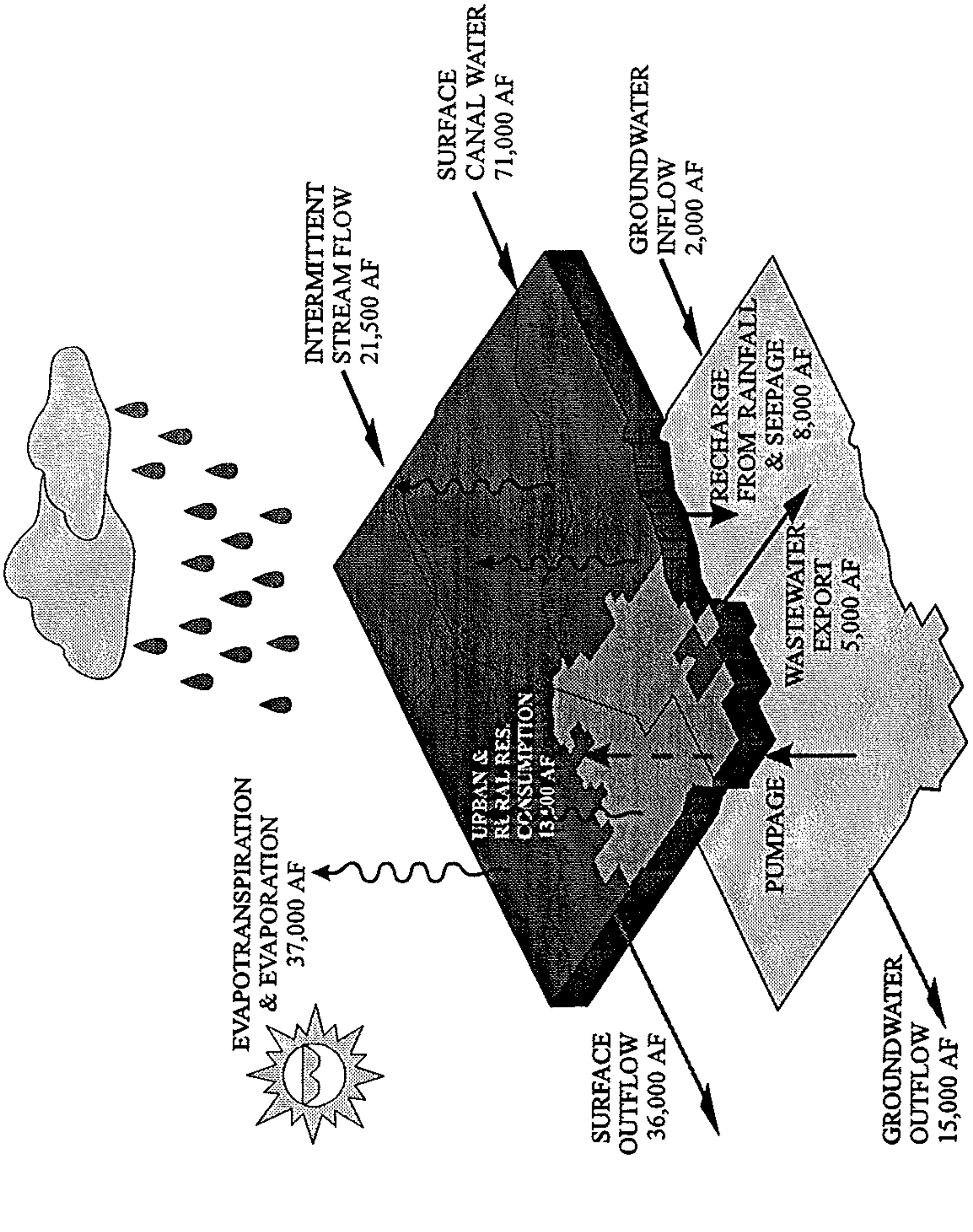
After a water budget has been developed it can be used to assess the effect of how changes in one component of the system impact the water balance and other system components.

Water Budget Models

A water budget may be viewed as a mathematical representation of a hydrologic system. In this case two budgets are put forth. The first covers the total project area and is shown graphically in Figure 7-1. This budget was developed to include both surface and groundwater and compare the change in storage with the calculated difference by evaluating water-level changes. The second budget is more site specific and covers the City of Clovis. By preparing a budget for the present City boundaries, a better understanding of the various factors affecting the overall budget can be realized. The validity of a water budget is limited by the data available for its development. For the City of Clovis, data is adequate to provide useful estimates of the budget. The same applies to the study area budget. Subareas were defined so that a calculation of change in water use could be made. Specific boundary limits of the subareas are shown on Plate 27. This exercise was undertaken to identify changing demand patterns and how the resultant water demand could be met. In addition, it was important to identify these changes due to their potential impact on the adjacent areas. The following sections will discuss the different inputs and outputs in developing the water budget.

It should be noted that the budget addresses only the issue of quantity. Water quality considerations may impose limitations not reflected in water budget calculations.

Figure 7 - 1


EVAPOTRANSPIRATION
& EVAPORATION
37,000 AF
INTERMITTENT
STREAM FLOW
21,500 AF
SURFACE
CANAL WATER
71,000 AF
GROUNDWATER
INFLOW
2,000 AF
RECHARGE
FROM RAINFALL
& SEEPAGE
8,000 AF
WASTEWATER
EXPORT
5,000 AF
PUMPAGE
URBAN &
RURAL RES.
CONSUMPTION
SURFACE
OUTFLOW
36,000 AF
GROUNDWATER
OUTFLOW
15,000 AF

Water Input

The significant sources or inputs for both the Study Area and City of Clovis budgets are:

- Canal water via the Enterprise Canal from the Kings River and Friant-Kern Canal
- Gould Canal seepage and diversions for recharge
- Streamflow from Big Dry, Dog, Redbank, and Fancher Creeks
- Direct recharge from rainfall
- Groundwater Inflow
- Recharge of urban storm runoff

Enterprise Canal Seepage and Diversions

F.I.D. diversions are the largest surface supplies to the area. Recording stations to measure flow are not located at study area boundaries. Therefore quantities used were estimates based upon measurement at stations outside the area. Care was taken to reduce the measured surface deliveries to account for water that was not delivered to the project area. Additional surface water is diverted into the study area from the Friant-Kern Canal by the Garfield Water District and International Water District. Surface water applications to the area have been covered at length in Chapter 5 of this report. The water entering the area via the canal systems has historically provided a significant amount of water to the area both in surface applications and groundwater recharge.

Gould Canal Seepage and Diversions

The FID's Gould Canal operates for an extended period of time to provide recharge water to the City of Fresno's "Leaky acres" recharge project. The canal alignment is along the south boundary of the study area and corresponds to areas where the surface soils are sandy in nature. Because the canal is on the boundary of the study area, it has been treated differently than the Enterprise Canal. Additionally, deliveries to flood control basins and the Clovis Basin are served by this canal. Water volumes considered in this category are both the seepage of the Gould Canal in the study area and dedicated recharge from the canal.

Friant-Kern Canal Seepage

Page & LeBlanc (1969) estimated seepage from the Friant-Kern Canal along the 57 mile reach in Fresno County to average about 10,000 acre feet per year. Since about one tenth of the total length is within or upgradient of the Study Area, an average annual seepage of about 500 acre feet could be calculated for seepage into the area.

Stream Flow

Water enters the Study Area from several streams draining the foothills. Included are Dry, Dog, Redbank, and Fancher Creeks. On the basis of comparison of the watersheds of these streams with that for Mill Creek, a tributary of the Kings River below Pine Flat Dam, Engineering-Science, Inc., (1970) estimated the average annual runoff for these streams as 30,000 acre feet. Of this total, 8,500 acre feet are from Little Dry Creek watershed. Little Dry Creek is tributary to the San Joaquin River and is out of the study area. Therefore, it is estimated that approximately 21,500 acre feet per year enters the Study Area from these streams.

Aside from precipitation within the basin, stream inflow (precipitation outside the basin) can provide a source of water for recharge. The location of Big Dry Creek flood control dam upstream from the area provides an ideal opportunity for capturing runoff.

Direct Recharge of Rainfall

Precipitation that contributes to runoff from the intermittent streams, urban storm runoff, and evapotranspiration by crops are accounted for elsewhere in this report. However, additional recharge occurs due to direct recharge of rainfall in areas of permeable soils. The amount of this recharge is not measured and must be estimated. The volume of recharged rainfall is estimated to average two inches per year over about 15,000 acres of permeable soils in the Study Area. For the Study Area, direct recharge of precipitation is estimated to have averaged 2,500 acre feet per year.

Groundwater Inflow

Groundwater inflow into the study area from the northeast is expected to be minimal. Thin alluvium and shallow bedrock are both present. The groundwater flow is generally constrained by aquifer capacity and groundwater gradients. The water that is collected and percolates within the study area constitutes an important source of groundwater inflow for systems pumping water down gradient. The most significant flow is derived from percolation of streamflow and seepage from the Friant-Kern Canal. Streamflow and canal seepage have been put directly into the water budget. For the Clovis Urban area, significant inflow occurs related specifically from the northwest.

Recharge from Urban Storm Runoff

The estimated recharge from the storm runoff basins operated by the Fresno Metropolitan Flood Control District (FMFCD) in the Clovis Urban Area is 2,000 acre-feet per year. This volume was calculated on the basis of varying amounts of evaporation, depending on infiltration capacities and other factors for individual ponds, which were estimated.

Water Output

The other part of a water balance are those activities through which water leaves the system. For this study, the significant items are:

- Canal water outflow
- Export of intermittent stream and storm runoff
- Evaporation from free water surfaces
- Evapotranspiration by irrigated crops
- Lawn evapotranspiration and other urban consumption
- Rural Residential consumption
- Groundwater outflow
- Wastewater export

Canal Water

Canal water leaves the Study Area in the Enterprise Canal and by return flows from the various FID canal systems that return water to the Gould Canal. Measurement of flows are made in the Enterprise canal at Millbrook Avenue. No measurements are made of return flows to the Gould Canal. The estimated annual outflow of canal water in the Enterprise canal is 22,000 acre-feet per year and 2,000 acre-feet per year of return flows to the Gould Canal.

Export of Intermittent Stream Runoff

The export of runoff from the intermittent streams leaves the Study Area in canals. This volume is generally not measured, except when canal water is being delivered in the winter, for example for irrigation of figs. Much of this water is captured and recharged in the Big Dry Creek Reservoir and the other FMFCD flood control facilities. Operation data suggest approximately half of the flow or 12,000 AF is not captured and spilled into FID facilities.

Groundwater Outflow

The major component of groundwater outflow from the Study Area is along the western boundary with the City of Fresno. The annual groundwater outflow was estimated as 15,000 acre-feet per year.

Consumptive Use by Crops

The consumptive use of water by crops was calculated as discussed earlier.

Land Evapotranspiration & Urban Consumption

Consumptive use in the urban area is primarily from lawn, garden, and park irrigation. From investigations by other consultants, namely Carollo, Montgomery, and Black & Veatch, it has been estimated that 60% of the total demand is for outside use and 40% for household uses. Therefore, it is estimated that 8,500 AF is consumed in this category.

Rural Residential Consumption

Rural domestic consumption includes residential use in agricultural areas and non agricultural use in the rural residential areas. Utilizing the work done by other consultants mentioned earlier, it has been estimated that 30% of total demand is the resultant wastewater flow. In these areas, leach fields are utilized to dispose of effluent. In addition in most cases storm waters are retained on site. Taking these factors into consideration and comparing these values with the water demand calculated earlier in Chapter 4 results in a net consumption of 0.8 acre-feet per acre per year. Applying this value to the land denoted to this classification results in 5,000 AF/Y calculated for the rural residential consumption.

Evaporation from Water Surfaces

The evaporation rate from a free water surface can be estimated from pan evaporation measurements. For the Study Area, evaporation from a free water surface is about four feet per year, or a net of three feet after deducting one foot of precipitation per year.

Wastewater Export

The City is presently undertaking a Wastewater Master Plan effort to quantify the exact amount of wastewater exported in sewers. Recent findings indicate that the City is currently exporting approximately 7,000 AF/Y. For the base period considered, 5,000 AF/Y is utilized as the volume of export.

Change in Storage

The residual between water input and output is equal to the change in storage. This would be the expected change in groundwater levels based upon documented and approximated water inputs and outputs.

Groundwater level changes and specific yields can be used for an independent determination of the change in storage, which in this case is considered more accurate than that based solely on the water budget.

Water-level hydrographs for the City of Clovis, FID, and DWR northeast network wells were used as the primary source of data to evaluate level changes.

Study Area Water Budget

The base period utilized in this evaluation is from 1978 to 1994. This period was utilized due to being approximately equal to the historical long term average surface supply. This period is expected to more accurately reflects recent activities related to water use and development in the local area. The net result shows that the area is in a state of overdraft with a corresponding loss in storage of approximately 4,000 AF/Y. Much of the overdraft is located within the urban area and adjacent agricultural areas.

Table 7-1 summarizes the water budget for the Study Area during the base period. An average of 102,500 acre-feet of water per year (AF/Y) was input to the Study Area during 1978-1993. An average of 106,500 acre-feet of water per year was output during the same period. The overdraft, based on water level measurements, averaged 3,600 acre-feet per year which is in close agreement with estimates from the water budget (-4,000 AF). A pictorial of this budget was included as Figure 7-1.

Table 7 - 1

Water Budget for Study Area During 1978-93

INPUT	AF/Y
Canal Water (Fresno Irrigation District)	67,000
Canal Water (Garfield & International W.D.)	4,000
Gould Canal seepage and recharge	3,000
Seepage from Friant-Kern Canal	500
Intermittent Streams (Dry Creek, Dog Creek, Redbank, Creek, Fancher Creek)	21,500
Direct Recharge of Rainfall	2,500
Groundwater Inflow	2,000
Recharge from Urban Storm Runoff	2,000
Subtotal	**102,500**
OUTPUT	
Canal Water (Fresno Irrigation District)	24,000
Export of Intermittent Stream Runoff	12,000
Groundwater Outflow	15,000
Evapotranspiration by Irrigated Crops	36,500
Lawn Evapotranspiration & Urban Consumption	8,500
Rural-Residential Consumption	5,000
Evaporation from Free Water Surfaces	500
Wastewater Export	5,000
Subtotal	**106,500**
CHANGE IN STORAGE (Based on water budget)	
Calculated Difference	**-4,000**
CHECK ON WATER BUDGET (ALTERNATIVE METHOD)	
CHANGE IN STORAGE (Based on water-level changes)	
Urban Area	-2,200
Rural Area	-1,400
Subtotal	**-3,600**

Note: Water budget values are rounded to the nearest five hundred acre-feet.

Clovis Urban Area Water Budget

Table 7-2 shows the Water Budget for the Clovis Urban Area for the period 1978-93. The budget shows the principle sources being readily identified as diversions and seepage from canal flows, intentional recharge, recharge from urban storm runoff, and groundwater inflow. The principle outputs from the system are through evapotranspiration by crops, urban consumption, sewage export and groundwater outflow. It is expected that with the urbanization of agricultural land, the evaporation/evapotranspiration losses should decrease. One of the major losses of water in the urban area is exported wastewater. This amounts to approximately 6,500 AF/Y which leaves the project area and is treated at the regional plant located southwest of Fresno.

TABLE 7 - 2

WATER BUDGET FOR 1978 - 93
FOR CLOVIS URBAN AREA

INPUT	AF/Y
Diversions for Irrigation and Canal Seepage	6,000
Intentional Recharge	5,500
Groundwater Inflow	10,000
Recharge from urban Storm Runoff	2,000
Subtotal	**23,500**
OUTPUT	
Evapotranspiration by Irrigation Crops	3,500
Lawn Evapotranspiration & Urban Consumption	8,500
Groundwater Outflow	9,000
Sewage Export	5,000
Subtotal	**26,000**
CHANGE IN STORAGE (Based on water budget)	
Calculated Difference	**-2,500**
CHECK ON WATER BUDGET (ALTERNATIVE METHOD)	
CHANGE IN STORAGE (Based on water-level changes)	-2,200

Note: Water budget values are rounded to the nearest five hundred acre-feet.

Change in Water Use By Area

The localized change in water use calculations have been prepared to understand on a more specific scale, the potential impacts from changes in land use. The areas have been divided into the following areas based on the development concept from the General Plan, and on water supply availability. The areas are as follows (Refer to Plate 27):

- Clovis & Growth Areas
- Northwest Village
- Northeast Village
- Southeast Village
- Southeast Corner
- Between Canals
- Northeast Corner
- Northwest Triangle

A review of Figure 7-1, shows the numerous inputs and outputs to the water budget. However, on a smaller scale, the hydrologic inputs and outputs generally compensate for each other in specific areas while the primary impacts on water levels are due to pumping and recharge. Included as Table 7-3 is a summary of existing and future demands for the areas described above. In addition the change in Urban Demand has been shown to indicate the amount of demand that will need to be met by the public water system. Future conditions are estimated based upon projected development.

Following is a brief summary of the results shown in Table 7-3 for each subarea. In reviewing these individual summaries it must be understood that while the numbers are segregated here, the area's individual impacts cannot be confined to such small areas. Decisions affecting any individual area must consider the impacts upon the adjacent areas.

Clovis and Clovis Growth

This area covers the existing City and planned expansion. The estimated existing overdraft is approximately 2,200 AF/Y. There are available surface water supplies to remedy this condition, but historically they have not been utilized to the full degree possible. Under future development and planned build-out (year 2030) demands are expected to increase. Much of the demand will be shifted from agriculture, which has relied on surface water supplies, to urban demands. Demands for municipal water will double from present conditions in the next 30 years. However, the total water demand will only increase about 4,900 acre-feet per year.

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Table 7 - 3 Change in Water Demands by Area

(All Values in Acre-Feet per Year unless otherwise noted)

Area Description	Clovis & Growth Areas	Northwest Village	Northeast Village	Southeast Village	Southeast Corner	Between Canals	NE Corner	NW Triangle	TOTAL
Land Area (Acres)	13,400	3,680	6,250	2,780	5,670	8,480	3,750	2,510	46,520
PRESENT DEMANDS									
Agricuture/Pasture	6,000	8,400	4,860	6,540	9,000	3,000	700	2,100	40,600
Rural Residential	3,700	120	0	800	3,360	5,500	0	1,100	14,600
Urban	16,500	0	0	0	0	0	0	0	16,500
Net Present Water Demand	26,200	8,520	4,860	7,340	12,360	8,500	700	3,200	71,700
FUTURE DEMANDS**									
Agricuture	0	1,700	200	1,100	5,100	2,100	700	1,400	12,300
Rural Residential	200	100	0	0	4,800	8,600	0	2,600	16,300
Urban	28,000	5,100	9,000	5,500	0	0	0	0	47,600
Net Future Demand	28,100	6,900	9,200	6,700	10,000	11,000	700	4,000	76,600
Change in Total Demand	1,900	(1,620)	4,340	(640)	(2,360)	2,500	0	800	4,900
Change in Urban Demand	**11,500**	**5,100**	**9,000**	**5,500**	**0**	**0**	**0**	**0**	31,100

** Assumes buildout conditions (Year 2030)

Villages

In each of the proposed village growth areas there is a small groundwater overdraft. Typically, agriculture predominates these growth areas and the surface water quantities available to the project area have been utilized by these lands. The agricultural lands have received a greater surface supply than other lands within the FID. There are two reasons for this. The first is that water not used by the City has been used on adjacent agricultural land. The second is that during times of drought, the FID has made hardship water available to these areas. Under these conditions, lands within the study area have been allowed to purchase water in excess of their entitlement. Thus the water entitlement for NW and SE villages is actually less than the historical deliveries. Under future conditions it can be shown that shortages are projected to be realized in these areas. It is projected that some excess may be available from the City area to offset some shortage. However, additional water supplies will be required to satisfy all projected uses.

Northwest Village

The change in demands for this village show a conversion of demand from agriculture to urban. Meeting these demands can employ groundwater pumpage or treating surface water. A large amount of surface water is presently delivered to the agricultural lands within the area and maintaining a future water balance is dependant upon keeping this canal water in the immediate area. The method of supply should consider water quality considerations and subsurface geologic limitations.

Northeast Village

The NE village has the least surface water supply due to it's location outside FID. Demands are currently met by pumping groundwater. The proposed development in the area will nearly double the demand (from 0.78 to 1.47 Feet/Acre). Thus the potential annual water deficit in this area alone could approach 5,000 AF/Y. Such an overdraft in this area is not maintainable, because of the thin saturated alluvium.

Southeast Village

This village is located within FID, which has historically provided a surface water supply that has exceeded demands. The result is that a portion of the surface supply is not utilized within the area. With development, if this loss could be eliminated, an increased water supply could be realized. The area is already a substantial water user, and therefore like the Northwest village, the actual demand for water will decline with urban development. Still, the utilization of surface water directly through recharge will be imperative for development to occur.

Southeast Corner

This area consists of the remaining land that is within FID and not included in other subareas. It includes the special study area between Shaw and Bullard discussed in Chapter 2. The area is not presently in overdraft, and is not expected to be in the future. Surface supplies are available from the FID and will continue to be into the future. Specific concerns would relate to keeping this surface supply within the area. Non-utilization of the surface water supply could have potential negative impacts on the groundwater available within the adjacent Southeast village.

Other Areas

The remaining areas are largely outside of FID and have little or no surface water supply from which to draw. The result is a primary reliance upon groundwater. Under future conditions, it is estimated alternative water supplies will be needed for development are not found. In addition, the continued or increased pumping within the already developed areas, without adequate recharge, may lower the water levels in the peripheral areas to an extent such that use of existing wells maybe significantly affected.

8 - WATER SUPPLY ELEMENTS

Introduction

Water supply elements are individual projects that supply water directly or indirectly to the urban area. A wide array of water supply elements are available to the City and they can be combined in various ways to form water supply alternatives or delivery systems. In this chapter, the individual elements will be outlined. In the following chapters, the elements will be used individually and in combination with others to develop alternatives and a more comprehensive recommendation for utilizing water supplies.

The elements are intended to be conceptual and are approximate in size and location; further refinement will be required as additional information and decisions are developed. The costs shown in this chapter are also conceptual; they are not site specific (except in the case of existing facilities), but are general and used to screen and compare elements.

The elements that will be considered are operations or facilities that can be utilized to either a) provide for direct water supply or b) provide the ability to supply water and when used in conjunction with other elements form a water supply alternative. These are the building blocks on which alternatives will be based. The elements which will be considered include:

1. Wells
2. Intentional Recharge
    - Flood Control Basins
    - Single Purpose Basins
    - Well Injection
3. Satellite Surface Water Treatment Plants
4. Regional Surface Water Treatment Plant
5. Dual Distribution System
    - Untreated Surface Water
    - Reclaimed Water
6. Groundwater Banking
7. Water Transfer

Wells

A typical municipal well in Clovis has a capacity of 500 to 2,000 gpm and is 200 to 600 feet deep. For cost estimating purposes, the typical well was assumed to have a capacity of 1,500 gpm and to operate 30% of the year. Annual pumpage per well was therefore assumed to be 725 AF/y.

It is assumed that some form of disinfection unit (chlorination or other disinfectant) will be needed in the future on some existing and all new wells. The capital costs for a new well including a disinfection unit are shown in Table 8-2. The expected useful life for a well is taken as 40 years with replacement of motor, pump, and controls at 20 years. The presence of EDB and DBCP in the study area could result in the required addition of Granular Activated Carbon (GAC) treatment units at each wellhead. One of the complicating factors in retrofitting older wells is that many well sites have insufficient space for the GAC units. For estimating purposes, disinfection and GAC units are assumed to have a 20 year life.

It should be noted that the O & M cost for operating the GAC units are estimated from recent limited information. It is not known what the useful life of the carbon is, what the potential power requirements will be, or the potential impacts on costs from new regulations. **The costs shown should be considered minimum and may escalate rapidly in future years.**

Intentional Recharge

Intentional surface water recharge through designated spreading basins and flood control detention basins in Clovis currently accounts for approximately 4,000 acre-feet per year of groundwater recharge. To meet existing demands from the aquifer, increases in the intentional recharge in the study area are necessary. Several opportunities for increasing groundwater recharge are described below. Costs for recharge are presented in terms of dollars per acre-foot of water recharged to the aquifer.

Several key factors that must be considered in any discussion on recharge include:
(a) proximity and reliability of water supply, (b) infiltration capacity of the soil, (c) transmissivity, and (d) storage capacity of the aquifer. Issues which relate to the geologic condition of the aquifer and raw water supply have been discussed in previous chapters.

Use of Existing Flood Control Basins

There are 15 flood control basins located in Clovis, in addition to 2 larger basins to the immediate east. The location of the various flood control basins are shown on Plate 9. The basins were generally developed for flood control use, with recharge facilities added more recently.

In 1993, the Fresno Irrigation District delivered a total of 3,770 AF of water to eight different flood control basins within the City (See Table 5-5). In addition, over 4,400 AF were delivered for recharge via Big Dry Creek that runs through the center of Clovis. Although this was the highest amount of recharge in 20 years for the City, it did not eliminate the long term groundwater overdraft. About two-thirds of the water was recharged into Basin S and the Clovis Basin, which are located in the southwestern corner of the city where they are down gradient of most City wells. In order for recharge to be more effective, it is essential that water be recharged in the northern portions of the City, where the demand currently out paces the supply, or locate future wells proximate to the superior recharge areas. Several opportunities for increasing groundwater recharge are described in the following sections, with costs summarized in Table 8-2.

In 1994, only 5 basins were utilized for recharge in the first five months of the water year. Of the water recharged, 55% was recharged in Basin S and the Clovis Basin, with 33% recharged into Basin 7-C. When reviewing data related to percolation, it becomes apparent that basin 7C has the highest rates of the existing basins. Basin CZ, located at Chestnut and Alluvial in Fresno, and operated for the first time in 1994, percolated water faster than could be delivered. This implies that there are opportunities in the area for increased intentional recharge.

One of the challenges of attempting to utilize flood control basins, is that the City presently has no control over the use of the basins which are operated and maintained by the Fresno Metropolitan Flood Control District (FMFCD). With continued growth and reliance upon groundwater resources, it is critical that the city develop some arrangement to insure that adequate quantities of water are recharged. To do so cost effectively will require greater utilization of existing basins.

Another significant problem with utilizing flood control basins for intentional recharge is the timing of maintenance and availability for use. As evidenced last year, basins were not available until June or July. This limited the recharge season to less than three months. Ten of the basins have the capability to operate as recharge basins and have been used historically. The estimated cost of connecting four of the remaining basins to the FID canal system vary from $20-40/AF. Because of the dual use of the basins, they must remain empty during the rainy season, and thus are only available for recharge about seven months out of the year. Still the existing basins have not been fully utilized and remain a viable source for remediating some of the overdraft.

Two of the basins which offer some potential but which are not currently utilized for recharge are the Alluvial Drain and Pup Creek Basins. Together they comprise 117 acres in locations which are upgradient from the areas with the highest demands. Use of either of these basins would require a significant capital investment as the estimated cost for improving the basins range from $146,000 for the Alluvial Drain to $289,000 for the Pup Creek Basin. The Alluvial drain would be most economical except for its location outside the FID boundaries. To obtain water deliveries at this site would require an annexation process or entering into an alternative arrangement to provide water to the basin. The use of Pup Creek would require the construction of a delivery system to convey the water from the Enterprise Canal. Still assuming that acceptable rate of percolation can be achieved, the cost per acre foot for recharge in these basins is lower than constructing new basins or converting existing single use basins primarily due to the size and capacity of these two basins.

Construction of Additional Single Purpose Recharge Basins

Although percolation rates vary throughout the study area, recharge basins could be constructed in most of the study area if land is available. However, due to subsurface geologic conditions, it appears that the best recharge areas will be found along the existing Dry Creek, the remnants of Dog Creek drainage, and along the Redbank Creek drainage. Existing basins have a recharge rate of 0.1 to 0.3 feet per day. The best existing recharge basin is Basin 7C as evidenced by recharge activities in 1994. Basin CZ, located east of Clovis at Chestnut and Alluvial Avenues, was first used for recharge in 1994 and showed significant recharge capability in excess of 0.2 ft per day. If this rate is sustainable, a 20 acre recharge facility with 18 acres of infiltrative surface and an infiltration rate of 0.2 feet per day, operated for 10 months of the year, would have a capacity of 1,090 AF/y. Capital cost for basin construction is estimated to be $1,200,000. Annualized costs, including operation and maintenance(O & M) would be about $88,000 with the resultant cost for recharge being $80 per acre foot.

One of the most significant costs related to this method is land costs. If basins are purchased and constructed in the more rural developing area this cost could be reduced substantially.

Recharge Enhancements

Experience has indicated that infiltration capacity of a given recharge location can be increased by certain design and operational considerations. Designs can consist of excavated basins and/or ponds that are not nearly as deep. Many of the FMFCD basins are of the excavated type. If soils are permeable, much of the water may be percolated out the side rather than through the bottom of the site. Following are some recommendations applicable to existing and proposed basins.

- If there is a restrictive layer at a depth less than 15 feet, consideration should be given to excavating through the restricting layer.

- Recharge basins should be operated with alternative wet and dry cycles.

- Shallow water depths (less than a foot, and preferable six inches or less) tend to minimize algae growth, which otherwise can contribute significantly to clogging.

- Basin floors should be dead level, with ridges and furrows. The furrows increase the infiltration surface area, encouraging settling of fines in the furrow troughs, and the furrow slopes tend to discourage algae growth.

- Periodic windrowing and removal of fines from the basin floor should be practiced. This should be completed before basins are disked or ripped.

- Basin floors should be periodically ripped to a depth of 18 inches to break up any compaction and to aerate the soil. Track-driven equipment just large enough to pull ripping equipment will result in the least compaction. Unless the water carried a significant load of sediment, renovation of the basin bottom should be scheduled at intervals of from two to five years.

- Banks can be protected from wave action and erosion by gravel mats. This will limit the migration of fines from banks into the basins which can cause clogging.

- If the water source carries considerable fines, settling basins should be incorporated to trap fines near the discharge into the basin.

Well Injection

This element is an exciting development as an alternative to intentional surface recharge. The most notable utilities that have used this technique are in Arizona and Nevada where tests have been performed on treated Central Arizona Project water and results are positive. In addition, the same technique has been used on treated effluent in Southern California but the purpose is different. There the goal has been to inject the treated water to limit sea water intrusion into the groundwater zones (thus to control quality degradation) rather than for an increase in storage.

There are three general advantages to well injection listed below that are common to either existing well use or dedicated injection wells.

- Injection wells require minimal property for installation, and thus maybe located within a right-of-way or located on a small outlot.

- Injection wells offer the opportunity to recharge water in areas where there are geologic constraints to surface recharge. Specifically in areas with sufficient aquifer thickness which are overlain by hardpan or significant clay layers.

- Injection wells are easily adapted to existing distribution grids and offer the capability of selectively recharging in selected geographic locations or into specific subsurface geologic strata.

Existing Wells

The use of existing wells for recharge could have several advantages, including the cost savings due to utilization of existing facilities, and the direct availability and recovery of recharged water. Costs included for this element are only reflective of the additional costs for modification of the systems to allow for recharging water back through the existing wells. Modifications would typically include modifications to the headworks and additions to the existing control system.

There is a certain amount of risk associated with the use of existing wells. The greatest being potential plugging of the well and a reduction in pumping capacity. Aside from the risk, careful consideration should be made for the impacts upon the pump and headworks on an individual basis.

Single Purpose Injection Wells

The construction of single purpose wells include the ability to locate recharge in precise areas, or spaced as desired to maximize recovery or impacts upon water quality in specific zones. Such injection wells can effectively utilize excess capacity generated from surface treatment plants with no risk to existing wells. Single use injection wells cost less than supply wells to construct, as the casing is generally smaller, and the well can be relatively shallow.

Satellite Surface Water Treatment Plant

Treated water from modular canal-side water treatment plants (WTP) could be pumped into the potable water system with minimal improvements to the distribution system. An assumed 2 MGD (6 AF/day) plant would include an intake structure, raw water pump, piping, package WTP, chlorination facilities and chlorine contact chamber, backwash storage, and backwash piping to a sanitary sewer. A package plant typically includes a pretreatment zone for coagulation/flocculation , a clarifier unit, a filtration bed, tankage and pumping units for chemicals, a backwash systems, controls and instrumentation.

Annual water production would approximate 1,380 AF/y operating at 75% capacity for ten months a year. Capital costs including land acquisition were estimated at $2,400,000 initially for an annual cost of $158,600. Annual O & M costs were estimated at $100,000 per year, with a resulting unit cost of $187 per/AF.

One of the advantages of a package plant is the flexibility allowed in locating and installing the plant. A package plant has minimal space requirements and may be conveniently installed on a small site (depending upon the planned ultimate capacity) requiring minimal improvements. Thus if a site can be secured convenient to both the water source and the distribution system, substantial cost savings can be achieved. Additionally, the packaged plants incur minimal environmental impact, and can generally be housed in a small, lightweight, unobtrusive structure.

Another advantage of modular WTP's is that they are easily phased, and thus can readily be tied to specific building or growth criteria. But while this is a distinct advantage, steps should be taken to insure that small individual plants are not allowed to be constructed on single growth related sites, ie. small plants for individual subdivisions. This type of piecemeal development which is typical for well dependant growth, is not suitable for plants that require much greater maintenance and operational attention. The preferred pattern would be the selection and procurement of individual sites that will house a specific number of units at buildout. The distribution mains, headworks, and other site facilities are then size for the ultimate capacity, with individual units installed as needed.

To be cost efficient a single site with multiple plants should utilize common facilities. Capacity for the site is limited by the impact upon the distribution system. Concentrating treatment capacity will create the need for larger distribution mains to disburse the water into the grid. For the Clovis area, a minimum size that will avoid undue multiplicity, is estimated to be a 2 MGD plant. Ideally, a single site if planned properly should have a total capacity of 5-6 MGD. A plant of this size, allows operational efficiencies with minimal disturbance to the distribution grid.

Regional Surface Water Treatment Plant

In Conjunction with City of Fresno

The Fresno/Clovis Metropolitan Water Resources Management Plan, (FWRMP) completed in 1994, researched the water needs of the region in detail and developed several alternative solutions that were reviewed and discussed by the involved public entities. The alternative that was selected after public review, recommended the construction of two regional water treatment plants (WTP). The first WTP, located on the Enterprise Canal would have an ultimate capacity of 30,000 AF/Y, constructed in two steps, with the first initial phase to be completed in 1998, and the final phase to be completed by 2010. The second WTP was to be located on the Gould Canal with an initial capacity of 15,000 AF/y per year in 2010, and an ultimate capacity of 30,000 Ac-Ft per year in 2050.

The implementation of the FWRMP is currently in question with many difficult issues remaining to be addressed. These include control, construction, cost allocation, and water rights issues that will have to be resolved prior to going forward with the proposed improvements. Costs for a regional plant included in Table 8-1 were from the FWRMP report with adjustment of costs to 1995 dollars. Also included were costs for conveyance from a regional plant to the City's distribution system.

From a regional view point, a larger plant servicing a wide area has merit in terms of concentrating operations, and reduced costs from efficiencies of scale. The downside of such a regional facility is that it crosses political boundaries and creates questions about control of the operations.

Three major drawbacks of utilizing a regional plant in joint venture with the City of Fresno are: 1) As previously mentioned, *control* of supply, costs, and maintenance would be lost. 2) The *timing* of the plant construction is in question, and the ability to meet short term needs could be jeopardized. In the worst case, growth could draw to a standstill if the plant were stalled for any one of many possible reasons. Conversely if the plant went forward, and growth slowed, the City would still be responsible for their proportion of the cost regardless of need. 3) The *cost* both initial and long term would be substantial. Additional work to the distribution grid would be required to facilitate a point source.

City of Clovis Water Treatment Plant

For the purposes of this study, a Clovis regional WTP is proposed as a stand alone installation that would be constructed by the City to meet the increased water needs for the planning period. Based on costs from the FWRMP, with minor adjustments, the estimated capital cost for a 10 MGD (11,000 AF/y) plant would be$ 28.3 million with an annual O & M cost of $850,000. All estimates were made based upon a 10 month operating period, which would allow the traditional 2 months for improvements and maintenance to the canals.

The water source for the WTP was assumed to be the FID Enterprise Canal. The Enterprise is favored over the Gould Canal because of the greater quantities of stormwaters that are discharged into the Gould Canal during periods of high runoff. Storm runoff would increase the contaminant load and possibly increase the operational costs for the plant. The ideal location would be near a large recharge basin that could be used to provide a backup supply of water for emergencies, and operational efficiencies.

If Clovis does proceed with an independent WTP several issues must be addressed. First some arrangement must be made with FID to insure the reliable conveyance of the water supply. Second, consideration must be made for the potential of Fresno developing a WTP on the Enterprise canal also.

Dual Water Distribution System

One of the elements that must be considered to maximize utilization of resources is the use of either untreated or reclaimed water in a dual system for irrigation of public and private landscaped areas, or agricultural lands. A dual system is defined as a second or independent system that is constructed to distribute non-potable water for intensive water uses such as irrigation, industrial, or groundwater recharge. The system must meet certain State criteria to insure that applicable health standards are met and that the secondary system is not interconnected at any point with the potable municipal water supply. This water may come from a variety of sources, which will be discussed in the following sections.

For this study, untreated (or raw) water is generally defined as surface water delivered by a canal system. Irrigation water is not treated beyond screening or rough filtration. Reclaimed or recycled water is defined as wastewater from a municipal or industrial source that has been treated to the level required to provide a "safe" effluent that is not a health risk to potential users. State law limits the potential uses for reclaimed water to primarily irrigation applications. Recent changes to the standards allow irrigation use for residential applications, although it is generally agreed that use of a dual system on parcels less than one acre is not economically viable. Thus a dual system, while not applicable in medium to high density residential areas, should be considered in areas with large rural lots where the major percentage of water demand will be consumed for irrigation and agricultural uses.

Generally a dual system is only considered where there is an adequate supply of reclaimed or raw water that can meet demands not requiring potable water. With the expansion of Clovis, there will be increased semi-rural areas with heavy water demands that could reuse the wastewater generated by the growth, or use untreated surface water.

Untreated Surface Water Use for Landscape Irrigation

As the demand for water in Clovis increases, the cost of supplying potable water may make it economically viable for the distribution of untreated "raw" water for irrigation usage. The advantage of this element is that it avoids the treatment cost, minimizes pumpage, and utilizes the surface water supply effectively during peak demand periods in the summer months. In addition to uses as landscape irrigation, there may be potential for delivery of water to lakes and the City's recharge basins. The source will invariably be water delivered through the FID system. Two options exist for utilizing FID surface water supplies.

The first is the potential use of Bureau contract water transferred to the City due to urbanization and annexation of property. Land which has entitlements to FID contract water annexed into the City, will allow those water entitlements to be controlled by the City. The City, therefore, will have increased water entitlements as it continues to develop and convert agricultural land to urban uses. It should be noted that the FID entitlement for Class II water, is subject to availability (historically deliveries are available 45% of the years).

The second source of water supply is FID entitlement. Using this as a water source will limit the place of use to lands within the FID or namely the Southeast or Northwest villages.

Reclaimed Water for Landscape and Agricultural Irrigation

The City of Clovis has initiated a wastewater planning study in parallel with and similar in scope to this report. Therefore, the discussion of wastewater treatment in this report is limited to a brief discussion of the potential uses of reclaimed water. For a more compete discussion of wastewater and related issues, the reader is referred to the wastewater report.

Treated wastewater or "reclaimed water" could be used as an alternative water source for landscape irrigation, agricultural irrigation, or dedicated recharge. The wastewater treated at the regional WWTP is disposed of to the underlying aquifer through agricultural application and recharge.

The cost of distributing reclaimed water is comparatively high primarily because of the lack of control over application and use. Because the use can fluctuate widely, a wide area of application must be provided in addition to storage facilities that are able to store a relatively large amount of the daily production. Constructing an independent system for distribution over a relatively large area is expensive. An alternative to reduce the cost would be to utilize the reclaimed water for direct recharge in dedicated recharge basins. This would decrease the unit distribution costs, while increasing the available supply.

Groundwater Banking

Groundwater banking is defined here to mean water that is intentionally put into storage for removal at some later date to make up for a shortfall of supplies. When a third party, such as FID does the banking, the city obtains a firm surface water supply from FID without shortage. With regards to the City, there are two reasons for banking as follows:

(1) To firm up Kings River water (FID entitlement) supply, thus limiting the negative impact of below average precipitation years and full utilization of water allocation in wet years.

(2) To make firm Class II water supplies so that they become available on an annual basis.

In order for a banking program to succeed, both recharge facilities need to be available to utilize <u>excess</u> flow capacity in wet years and facilities need to be available to provide for delivery of stored water in dry years.

The City already has an excellent site for the extraction of groundwater at the Regional Waste Water Treatment Plant. The water would be pumped into the FID canal system and exchanged for surface water supplies. Extraction at that location can not have any potential negative impacts on neighboring wells.

The harder question is where can water be put in the ground or "banked". If FID is doing the banking then the recharge site can be anywhere in the FID. In any event enough water has to be in groundwater storage to carry the extractions through the longest drought period of record. A safety factor might need to be added to the quantity of water which must be stored to protect against a "new" record drought. The area of recharge needed is not only dependant upon the reliability of the surface water to be made firm, but also on the recharge rate of the basin. Recharge rates within FID vary from 0.1 feet per day to 0.9 feet per day. Realizing that percolation rates could be two to three times that of the study area and the associated cost of recharge is directly related to the purchase of property, it could be expected that significant cost savings could be achieved by banking water outside the study area. Class I water would be the easiest to make firm followed by class II supplies.

Water Transfers

Water transfers within the water districts of the Friant unit of the CVP have been commonplace and are utilized to effectively manage the greater variation in water supplies of the San Joaquin River. It is not known how new provisions of the CVPIA will affect the ease or cost of future transfers. By far, the easiest transfer of water to the City would be from a contractor from the Friant unit of the CVP.

A good Class I water supply contract will provide about 2 acre-feet per acre. In 1977, there was only a 25% delivery. With a changed priority for M&I use (new Bureau policy) the delivery in 1977 might have been 75% or 1.5 acre-feet per acre. If land could be found (probably in Kern County) that does not have a permanent crop, it would cost around $2,000 per acre. Therefore, the capital cost for acquiring the water would be approximately $1,300 per acre-foot.

Annualizing this cost for 40 years at 6 percent yields an average annual purchase cost of $100 /AF. Present cost of service rates for municipal water supply from the Friant-Kern canal varies from $32 to $56 per AF, and reflect repayment of deficit as well as project future water deliveries. For this purpose of this study, it is estimated that charges will approximate the City of Fresno costs which for 1994 are estimated at $52 per AF. This is a total cost for 40 years at $152 per AF.

Summary of Water Supply Elements & Costs

Table 8-1 summarizes the pros and cons associated with the respective water supply elements.

The probable costs of the various water supply elements are summarized in Table 8-2. The costs represented therein are based upon assumptions outlined in the Appendix. The costs were developed based upon a variety of resources and are sufficient for estimating the magnitude of various items. Actual costs will depend upon numerous variables. Every effort has been made to insure a consistent basis for relative comparisons. The capital recovery factor is based on a 6% cost of capital and estimated useful lives that vary by facility type and use. The reader should exercise care in comparing the various costs presented as each element entails some differences that make direct comparisons difficult. For example, the cost per acre-foot for various elements is strongly dependant upon the efficiency or utilization of the particular element. A well that operates 80% of the time will appear to provide a lower cost per acre-foot than the same well operating 30% of the time.

Table 8 - 1
Alternative Elements Summary

Water Supply Element	Pros	Cons
Intentional Recharge:	Replenishes groundwater	
Single Purpose Basins	Flexibility in location Greater control over use	Limited Areas Excessive land costs
Dual Purpose Basins	Cost effective/ less land required	Limited control of use Uncertain subsurface conditions
Wellhead Injection	Low cost, no additional land, control may be integrated with existing system control No additional water lines	Water must be treated prior to recharge
Wells	Experience, low cost source	Limited groundwater resources
With Treatment	May use lower quality grndwater	High capital/operational costs
Without Treatment	Lowest cost water source	May be restricted by new standards
Satellite Package Surface Water Treatment Plant	Economical, flexibility in capacity and location, conducive to phasing	Reliant upon surface water supply.
Regional Surface Water Treatment Plant	Centralizes water treatment facilities.	High initial capital cost. May require improvements to distribution system.
Dual System:	Reduces demand upon groundwater sources.	Requires the installation of dual distribution system.
Untreated Surface Water for Landscape Irrigation	Utilizes surface water resources on smaller parcels	Reliant upon surface water deliveries.
Reclaimed Water (SE) for Landscape and Agricultural Use	Maintains local water balance, supplements water supply in area with limited resources.	Requires installation of WWTP.
Reclaimed Water (NW) for Landscape Use	Mitigates disposal capacity problems. Reduces demands on Groundwater supply.	Requires installation of WWTP.
Water Banking w/ FID	Utilizes existing resources	Institutional Agreements
Water Transfer	Secures surface water supply	Expense

Table 8-2
Summary of Water Supply Elements & Estimated Costs

	Cost / Acre-Foot
1 *Well Costs*	
New Well Construction with Disinfection Unit	$90
Adding Granular Activated Carbon (GAC) Unit	$130
Total	$210
Retrofit Existing Wells with Disinfection Unit	$60
Adding Granular Activated Carbon (GAC) Unit	$140
Total	$200
2 *Intentional Recharge*	
Single Purpose Basins - New Construction	$80
Dual Use - Conversion of Existing Flood Control Basins	$30
Well Injection - Existing Well*	$50
Well Injection - Single Use Well*	$30
* - Does not include water treatment costs.	
3 *Satellite Surface Water Treatment Plant*	
Install 2 MGD Package Plant	$130
O & M Costs	$70
Total	$200
4 *Regional Surface Water Treatment Plant*	
Clovis Water Treatment Plant	
Capital Cost - Install 10.7 MGD Plant (10,000 AF/Y)	$170
O & M Costs	$70
Total	$240
Fresno/Clovis Regional Plant	
Capital Costs	$170
O & M Costs	*$50*
Transmission Facilities	*$50*
Total	*$270*
5 *Dual System - Costs of Conveyance System Only*	
Untreated Surface Water for Landscape Irrigation	$70
Reclaimed Water from Satellite WWTP for Landscape Irrigation (SE)	$170
Reclaimed Water from Satellite WWTP for Agricultural Use (SE)	$140
Reclaimed Water from Satellite WWTP for Landscape Irrigation (NW)	$190
6 *Water Banking with Fresno Irrigation District (FID)*	Undetermined
7 *Water Transfer*	$160

DISCLAIMER
All costs listed in this report are for planning and evaluation purposes and should be considered order of magnitude estimates. Actual construction costs will vary.

9 - SUPPLY ALTERNATIVES

Overview

Much of the technical information contained earlier in this report addresses the existing water supply. Projections of future water demands and the means for meeting them have been addressed. In this chapter, elements discussed in Chapters 7 & 8 will be utilized to meet the expanding needs of City development. It should be understood that many different methods can be employed to meet this goal. Hearings, discussions, and input from the community should be encouraged to follow this report so that consensus can be achieved and implementation can progress.

This chapter concludes with three alternative solutions to fulfill the future water needs of the City. These alternatives are not necessarily stand alone, immediate solutions but are solutions that address the overall needs of the area, as it continues to grow. While some specific recommendations may be included, there is no intent to provide a comprehensive plan. This will require a greater depth of work to further develop specific costs, benefits, and resources that have been addressed in this and other chapters.

Existing Conditions

The data collected shows that water levels are declining in parts of the Study Area. Detrimental factors that are a result of declining water levels include:

- Higher pumpage costs
- Well production declines
- Increased exposure to drought related problems

In order to alleviate deficiencies in the existing system, and correct the present overdraft situation, it is essential that measures be implemented. Table 7-2 showed an overdraft of 2,500 AF/Y based upon existing conditions. That indicates that the current levels of pumping exceed the capacity of the aquifer under the existing conditions. Thus over the long term, there must be increased levels of recharge implemented or a surface supply needs to be established to reduce the pumping demands upon the system. Table 9-1 outlines the alternatives that are available for immediate application.

Table 9-1
Alternative Measures to Remedy Existing Water Shortfall

Alternative Elements	Measures to Remedy 2,500 AF/Y Shortfall*
1. Increase Direct Recharge	Acquire and develop **160 Acres** for recharge basins.
2. Surface Water Treatment Plant	Install **2.5 MGD** water treatment plant
3. Reuse Reclaimed Water	Install a **2.5 MGD waste treatment plant**, and **dual system** for distribution of reclaimed water.
* 2,500 AF/Y shortfall identified in Table 7-2.	

$$\textit{Acres Required for Recharge} = 2{,}500\,AF/Yr/(0.70 \cdot 213\,days/Yr \cdot 0.10\,ft/day)$$

Increased Direct Recharge

The traditional method of alleviating overdraft is through increased recharge activities. As discussed earlier, the City has not utilized its full entitlement of surface water for recharge activities; in addition, a large portion of recharge that is carried out occurs in basins on the periphery of the city. The use of the flood control basins, and the recharge through Big Dry Creek account for the majority of recharge activity within the area. In order to relieve the present overdraft situation, the amount of recharge must be increased 2,500 AF/Y, beyond the present average of 5,000 AF/Y. Such recharge activities should be strategically located to maximize groundwater replenishment in the Clovis service area.

The most cost efficient method would be to increase the utilization of existing basins. The use of basin 7C could provide an estimated 900 AF capacity due in part to it's location in the prime subsurface geologic area near the Big Dry Creek riverbed. As a next step, dedicated single purpose basins should be initiated where economically and technically feasible. Within the City area, specific areas of interest would be along the Dry Creek where soils would consist of more sands (see Plate 10). In addition, potential sites should be evaluated in the eastern Clovis area along the Dog Creek drainage, specifically in Sections 11, 12, 13 and 14.

The importance of recharging the groundwater cannot be overemphasized. Under any of the various alternatives, recharge will always be a component as long as groundwater is being pumped. This is a central theme that grows in importance as the natural recharge activities are further eliminated by development.

The 160 acre amount shown in Table 9-1 is in addition to the 200+ acres of flood control basins presently utilized. The estimate of required acres for recharge is based upon the assumption that the prime areas for recharge are for the most part developed. The percolation rate estimated for the remaining areas is 0.1 ft/day. Basins located in sandy areas, such as Basin 7C have rates of up to 0.3 ft/day. Other assumptions made in estimating basin sizes include the operational period (taken as 7 months/year) and the net area available for recharge (estimated as 70%). If the City is able to develop a basin in an area that will percolate water at a higher rate, the area required can be reduced proportionately.

A brief survey of aerial photographs of the area indicate few, large vacant parcels in excess of 20 acres. Two areas that are within the "sandy" zone are: the Caltrans property along the future 168 alignment, and an area running from the intersection of Gettysburg and Armstrong to the intersection of Shaw and Locan. Potential for use of the state property is minimal, and the second area is currently being developed for residential use.

Surface Water Treatment

An alternative to, or in concert with construction of recharge facilities is the installation of a package surface water treatment plant. Small package plants have a unit cost ($209/AF) that is less than the cost for a recharge/well system ($80/AF for basin and $200/AF for wells fitted with GAC). Specifically in the north Clovis area where DBCP has been detected, surface water treatment is less expensive than the more traditional recharge basin/well extraction system. In order to utilize the available surface water supply for direct use, a 2.5 MGD plant could be installed and operated with minimal changes to the distribution grid if located in a suitable location. A package plant would provide operational flexibility in areas that have the greatest demands (specifically the northern portions of Clovis). A plant can operate 100% of the time for extended periods while wells are usually operated intermittently to prevent degradation of well capacity. A final benefit of constructing a modular treatment plant or pilot plant is the operational knowledge gained for future considerations of surface water treatment.

Reuse of Reclaimed Water

The use of reclaimed water is generally limited to areas with a serious water supply shortage. This is not the case in Clovis, where the surface water supply has not been utilized fully. The primary reason for considering a waste water treatment plant (WWTP) is that Clovis has reached its purchased capacity at the regional WWTP.

In order for a satellite WWTP plant to be functional, it would require the standard collection system along with a disposal or "dual " system which would have to be installed to distribute the reclaimed water to an area sufficient to dispose of it under varying operating conditions. This could include new basins, or use of adjacent agricultural lands. More information on this alternative will be available with the completion of the Waste Water Master Plan Update, currently underway by others.

Future Conditions

The driving force behind this report is to examine the feasibility of growth into the rural areas adjacent to Clovis, as outlined in the General Plan. This section will outline the issues that are most critical to providing a public water supply to these individual areas. Each area will be addressed, after which the alternatives will be presented in summary form. A complete presentation of the final recommendation will be made in Chapter 10.

Clovis and Growth Areas

Other than the development of some minor parcels within the City, the majority of change will take place in the growth areas where 9,500 acres of agricultural and rural residential land is slated for urban development. The resulting change in water demand will result in a gross increase in urban demand of 11,500 AF/Y. A substantial portion of this demand will be due to growth in the area Northeast of Clovis, outside the boundaries of FID. This area has poor groundwater resources and thus is anticipated to rely upon the City's municipal system to fulfill their needs. In addition, the loss of 6,000 acres of agricultural area will increase the need for active recharge programs to alleviate further reductions in the groundwater levels.

Fortunately, the development of the new areas adjacent to the City and within FID will increase the Cities FID surface water entitlement, thereby increasing the amount of surface water available for treatment or recharge. Maintaining a water balance requires that the City utilize this water resource fully.

Northwest Village

Intense development has recently occurred within this area and the substantial water level declines associated with development and the drought have recently been evidenced on the southern boundaries. Use of surface water supplies was the reason the water levels remained relatively constant historically; thus, as development proceeds, the goal should be to fully utilize the surface supplies as much as practical.

In this area, shallow bedrock exists beneath the east part and surface soils are San Joaquin Loam which consists of significant layering with hardpan. Water quality problems are also evident, with an area of high nitrates upgradient and to the east and DBCP in the western and southern parts.

Northeast Village

Existing irrigation demands have been supplied in large part by groundwater. Minimal Class I and II surface supplies have been delivered and utilized fully. Existing overdraft is minor. With projected urbanization, a significant increase in demand is expected. Of specific concern to future water supply features is the quality of the groundwater and whether it can be utilized for municipal and industrial purposes. Assuming groundwater can be utilized, a significant shortage is still projected to exist. Water will have to be obtained from Bureau supplies or transferred from other areas. Limitations on groundwater storage and recharge areas will further restrict the potential development of the groundwater supply. In this area, at least 60 percent of the water supply will need to be treated canal water, if the groundwater is usable. If it is not, decisions may require 100% treated surface water or a mixture of treated water coupled with a dual system to provide for outside landscape demands to be met with reclaimed or untreated canal water.

Southeast Village

Based upon available data, this village has the least water supply problems. It is wholly within the FID and has received significant surface water supplies resulting in little or no overdraft. Information to date suggests that an aquifer of adequate thickness is available in most of the area from which to draw water. Mapping by the Soil Conservation Service of surface soils imply that there are soils within the area that may have the properties to percolate water to the underground at acceptable rates. However the lower subsurface geologic conditions haven't been fully evaluated in this regard. Iron and Manganese have been found exceeding the MCL in wells adjacent to the area. In addition, nitrates in groundwater are above the MCL in much of the area. It is thought that new wells if constructed correctly could be installed that will avoid these contaminants. However, no deep wells are known to have been drilled and tested for other quality constituents.

Approximately 350 acres of recharge area will be required to insure that the total municipal and industrial supply is recharged and then recovered by wells. Review of soils maps indicate that favorable soils are found within the village area. However, deeper subsurface geologic conditions must first be evaluated through soil borings. In addition, further consideration should be given to whether this land use is preferable or whether other elements, such as well injection could be utilized.

Remaining Areas

It would be remiss if other areas were not discussed in some detail due to the potential impacts to the more urbanized growth areas. At present, small overdraft exists in some portions of the area. Under future conditions with the associated growth, overdraft is expected to be exacerbated. It is projected that 5,000 AF/Y of water shortage will occur in these areas without increased intentional recharge.

From an area wide viewpoint, elements that benefit one of the villages or the City may be utilized to benefit other portions of the developing area outside the urban villages. Recharge basins will help localized areas and raise groundwater levels while surface water and associated treatment can be moved throughout the system. An added benefit of providing treated surface water is that well injection could then be utilized.

There are several advantages to well injection in combination with surface treatment; it allows a water treatment plant to relieve baseline pumping demands during peak periods while unused treatment capacity may be used for recharge without the expense of purchasing and maintaining basins. Additionally, the use of existing wells for recharge would eliminate the need to drill new injection wells.

Introduction of Alternatives

With the tabulation of the water budgets, it became clear that there is an adequate water supply to most of the area if it can be developed. The unresolved issue is how that water will be converted from agricultural to municipal uses. While many associated elements have been discussed, the delivery of potable water entails either pumping groundwater or treating surface water. The components and associated elements can be intermingled in an endless variety of forms. For simplicity, the three principle alternatives presented consist of: 1) Continued sole reliance upon groundwater resources, 2) The conversion to surface water treatment, 3) A conjunctive use approach encompassing both ground and surface water elements. The three alternatives are summarized in the following tables along with the change in demands that drive the changes.

Table 9-2

Summary of Changes in Urban Demand
(all values in AF/Y unless otherwise noted)

Change in Storage (existing overdraft) from Table 7-1		(4,000)
Increase in Urban Demand (by area) Typical for All Alternatives		
	Clovis & Growth Area	11,500
	Northwest Village	5,100
	Northeast Village	9,000
	Southeast Village	5,400
	Total Increase in Urban Demand plus Overdraft	**35,000**

Alternative 1 - Groundwater

This alternative would continue the present system into the future. The total municipal demand approximates 48,000 AF/Y at buildout in the year 2030. Pumpage of this amount is possible within the study area; however, enlargement of much of the distribution system would be needed to pump water from the south and west areas to the growth areas. Also, the Northeast Village would require pumped groundwater to be supplied from the existing Clovis Urban area. In order for these quantities to be pumped, significant recharge would be required. It is essential that the recharge occur in the area where the water is being pumped. This is especially critical in areas where the aquifer is thin.

To utilize percolated water from basins in the prime area, approximately 600 to 1,000 acres would be needed. Recognizing that the land most suitable for recharge use is already developed means that other land would have to be secured and developed. The use of less desirable land with lower percolation rates increases the net land requirement dramatically. As shown in table 9-3 the land required to attain sufficient percolation of groundwater would make this a prohibitively expensive alternative. The following table summarizes the pros and cons for this alternative.

Pros	Cons
Minimal changes in operations. Expand existing system.	Requires significant land for recharge. Pumping will be concentrated in thickest aquifer section. Adversely impacts distribution system piping. Significant pumping cost to supply water to the Northeast Village. Potential treatment requirements Limited aquifer in some areas.

Alternative 2 - Surface Water Treatment

This alternative assumes that the City changes its mode of water supply operations and undertakes an aggressive program to treat currently available surface water. Two of the most significant problems relate to distribution and supply. With the construction of treatment plants, the water supply will be concentrated to one point rather than wells interspersed throughout the system. New conveyance pipelines would need to be constructed into the distribution system with multiple connections to disperse the supply. The inclusion of new pipelines would increase the unit cost of the water treatment element.

In order to meet the peak demands, a water treatment plant would need to be constructed with a capacity of 50 MGD. This capacity would utilize nearly 100% of the surface water entitlement in an average year and run below capacity or on purchased water in low water years. In addition to the plant, significant storage facilities would be required to handle the daily fluctuations in use.

If a severe enough drought (similar in magnitude to the 1977 drought) were to happen, it is estimated that surface supplies for the buildout condition would approximate 13,000 AF. In order to secure any additional supply, the City would have to buy and transfer water at a high dollar cost or pump groundwater. By pumping groundwater, a redundant system would need to be in place due to the ability to supply only 25% of demand from treated surface water supplies in a critically dry year.

Pros	Cons
Water quality regulations easier to meet. Reduced well pumping costs Reduce need for well head treatment	Major modification of distribution system. Inability to meet demands using existing supplies in dry year. Difficult to phase capacity w/ growth.

Alternative 3 - Conjunctive Use Plan

This alternative consists of a conjunctive use approach. It can be expected that numerous variations of this alternative are possible. As a basis for discussion, surface water treatment capacity at buildout is assumed to be 20 MGD. Additional recharge of 10,000 AF/Y would be required in addition to the 5,000 AF/Y which the City is currently recharging. A surface treatment plant or plants could come in the form of one centralized plant or multiple packaged units dispersed over the area. The ultimate size and capacity of the surface treatment system would depend upon the extent of recharge implemented, and the utilization of alternative sources such as untreated or reclaimed water, and water conservation measures.

Because a large part of the seasonal fluctuation in use is due to landscape applications, it is assumed that in new growth areas, a dual system would be installed to use untreated canal water for landscape purposes. The use of a dual system for the peak months will substantially reduce the size of treatment plant required to serve the area. In the absence of a dual system, the demand will have to be supplied by either increased treated water or pumped groundwater. The first will necessitate a larger plant, while the second will require greater recharge capacity. The 4,000 AF/Y shown for the dual system supply, is a minimal amount of untreated canal water delivered for landscape irrigation. Increasing the amount of untreated water for irrigation will reduce the treatment capacity required.

Based upon Kings River entitlement records for the period 1895 - 1993, it is estimated that the surface water supply would be sufficient to fully utilize the treatment plant(s) capacity in more than 85% of the years. In the remaining years , the plants would operate at less than 100% and draw upon the groundwater banked during the wetter years. This alternative assumes that an agreement with FID can be reached so that ultimately the entire yield of the City's entitlement can be utilized.

The remainder of the supply is estimated to come from groundwater pumping. However, a dual system delivering either untreated surface water or reclaimed wastewater could be utilized to offset pumping or surface supplies. Approximate pumping quantities under this scenario are 30,000 AF/Y which is twice the present level of urban pumping.

Pros	Cons
Minimal system modifications. Allows flexibility. Conducive to phased growth. More certain water quality possible. Ability to recharge water in existing wells Improve groundwater quality	Increased water quality testing Increased operational complexity.

10 - RECOMMENDATIONS

After careful consideration and examination of the several alternatives, Alternative 3 is recommended for implementation. Prior to implementation, the following activities need to be initiated:

- Begin negotiations with FID to develop a firm canal water supply.
- Perform tests on surface water supplies to ascertain quality.
- Investigate any steps that maybe required to secure and protect the surface water conveyance system from hazardous waste, toxins, pesticides.
- Investigate alternative sites for recharge, storage, and treatment plants.
- Perform subsurface geologic evaluation to locate best potential recharge/storage sites.
- Sample water in developing areas to ascertain suitability of groundwater for public supply.
- Perform utilization review to insure that existing facilities (flood control basins, creeks, etc.) are being fully utilized. Implement a monitoring program for quantities recharged.
- Perform engineering analysis on existing distribution system to insure feasibility of distribution improvements and water treatment plant locations.
- Prepare a more in depth and thorough cost analysis on specific facilities.
- Prepare preliminary environmental studies/documentation
- Develop a schedule for plan implementation

Following is an outline of the elements that combine to form the recommended alternative, and a brief explanation of the roles and relationships between each component of the program.

Key Elements of Alternative Three

Many of the alternatives discussed in this report are integrated into the final recommendation. None of these elements are stand alone items; rather, they constitute individual components that combine to form an operational and cost efficient system that will insure a safe, reliable water supply for current and future Clovis residents. While many of the components appear complex, their efficiency when combined provides a superior system that will allow the City to handle growth, improve water quality, resist the effects of droughts, and improve service while conserving water and capital resources.

Included as Figure 10-1 is a conceptual diagram that represents how each of the elements discussed combine to utilize available surface water supply over a theoretical 20 year period (based upon historic flows). Also shown is the projected ultimate urban demand of the area.

Adaptation w/Existing System

Integration of the future system with the existing network of wells and pipelines is vital to providing a viable delivery system. The existing grid system is based upon the principle that supply is dispersed in relationship to demands. This is different from a centralized system where the distribution mains are required to transport water from point sources into a smaller distribution grid. The advantage of the conjunctive approach is that it allows the continued dispersion of sources including wells and satellite water treatment plants that can be spaced sufficiently to minimize the additional costs required for larger water mains.

Existing Wells

Under the conjunctive use plan, the existing wells will continue to provide the base water supply for the community. In addition, their role may be expanded if they are capable of being used for recharge with treated water. Existing and new wells provide operational flexibility that will allow the City to better manage groundwater levels in various areas and influence the movement of contaminants. The essential nature of wells and pumping capacity is manifested by the fact that even at buildout in 40 years the wells will provide over 50% of the water supply in a normal year and more in dry years.

Distribution System

As discussed above, the utilization and maintenance of the existing distribution system is an essential aspect to conserving capital, while providing an efficient system for the developing parts of Clovis. Careful planning should allow the City to implement the proposed improvements with minimal changes to the existing grid system.

Utilization of Surface Water Supply at Buildout

Alternative #3

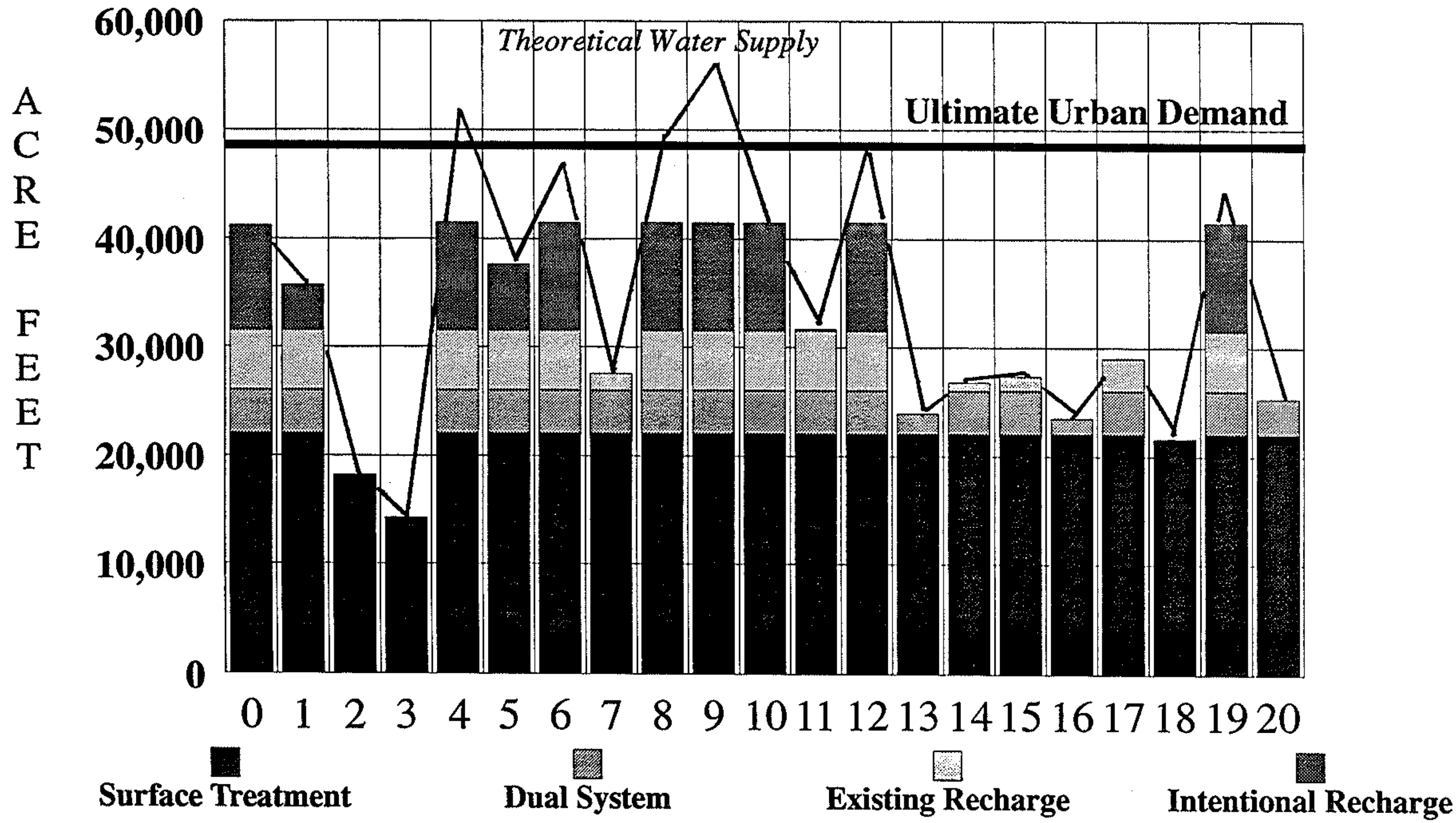

Figure 10-1

Recharge

Recharge of the groundwater aquifer in any form is essential to protecting the groundwater supply in Clovis. As increased development and diminished agricultural irrigation reduce the historic recharge amounts, it is essential that Clovis insure that sufficient water is provided to replace that water which is being removed from the aquifer in increasing quantities.

Single Use Basins

While there are cost and geologic considerations that limit their applicability, single use basins may still be a part of the overall system. Their most likely use will be in conjunction with satellite water treatment plants where they can store several days operating supply for a small plant, while encouraging percolation. In conjunction with adjacent wells they can raise local water levels, thus reducing pumping costs. Still the primary factor that must be considered is the geologic formations that vary widely across the study area.

Dual Use Basins

While several flood control basins are currently used for recharge, increasing demands upon the groundwater will necessitate the utilization of every resource that is geologically and economically viable. Some of the potential basins that are not currently used, but which hold some potential for either storage or recharge, include the Pup Creek, Alluvial Drain, and Dry Creek Reservoirs, none of which are currently utilized for recharge. In addition they have potential to store water during the peak use season which could alleviate potential canal use conflicts.

Well Injection

Well injection allows point recharge of water in areas where land is too expensive or already developed. In addition it requires very little in improvements and utilizes the existing distribution system for its water source. These capabilities allow the storage of treated water during off peak periods from treatment plants, and act as storage for the overall system. In addition this process allows the dilution of contaminants in areas of marginal water quality.

Dual Use System

As growth moves into the rural areas, the costs of treated water for irrigation of large parcels will become sufficient to justify the installation of dual delivery systems to utilize either untreated surface water, or reclaimed water.

Untreated Surface Water

As growth occurs in the agricultural and rural areas that have historically relied upon surface water for irrigation, it is possible that dual systems will be a cost effective alternative to meeting the peak demands that are driven primarily by irrigation needs in the summer months. The use of untreated water would also be an economical alternative to treated surface water. The sizing of treatment plants proposed in this section assumes that all commercial agricultural needs will continue to be serviced by canal water regardless of the ultimate delivery mechanism.

Reclaimed Water

In the Northern and Northeastern portions of the study area, there is a minimal existing surface water supply and very limited groundwater supplies. Thus in these and other areas the demand for water may justify the installation of treatment facilities that will allow for the use of reclaimed water in the area, primarily for irrigation and landscape application. The use of reclaimed water is commonly accepted in dry regions and gathering acceptance in larger areas with scarce water resources. To be successful, it requires careful planning and program administration.

Surface Water Treatment

The continued growth of the Clovis area will see the transition from agricultural use of water to urban uses. As discussed earlier in this report, the change from agricultural to urban use generally infers an actual reduction in water use per acre. The water source now requires some form of treatment before it can be put into the community system. Treatment may mean a natural process such as recharge and pumping, or plant treatment. Due to the geologic limitations which include aquifer thickness, soil types, bedrock depth, etc. the treatment of surface water will become a necessity as growth continues. Given the magnitude of the capacity that will ultimately be required, there must be some consideration of the alternative of a single large plant or modular packaged units. A larger capacity single plant has merits primarily in economies of scale which are expected from concentrating large capacity and operations in one facility. In recent times the use of package plants has become increasingly cost competitive by reducing the initial construction costs, while remaining competitive on operational costs. In addition the smaller units allow greater operational, location, and capital flexibility.

Plant Flexibility

The chief advantages of package water treatment plants to Clovis are that they are economical, efficient, and are ideal for situations where growth may require additional capacity in small steps. In addition the use of multiple small plants reduces the impact on the distribution system, and allows the "source" to be distributed in the grid system similar to wells.

The proposed alternative calls for the immediate increase in surface water utilization, providing an opportunity for a pilot plant that could be installed at minimal cost, and exposure. The added benefits are the knowledge and experience of operating a plant and understanding peculiarities prior to installation of other units. As the growth occurs in the extended areas, the new demands and costs are easily allocated to the new users who will derive the benefit of the plants. Finally water treatment plants provide the treated water that will be stored or "banked" via well head injection during the off peak hours. This banking forms an integral part of a recharge program and thus drought resistance to the entire supply.

Operational Storage

A normal component of any treatment facility is storage. For the proposed alternative, storage will be handled in a variety of ways, including use of the existing city facilities. Raw water storage ideally will be negotiated to allow an even supply throughout the high demand months. This generally means storage in existing reservoirs. On site storage of a short term raw water supply could be accomplished by utilizing a recharge, or flood control basin and provide protection from interruption of raw water deliveries. Finally, treated water storage is provided by the existing well network via the well injection method described above in addition to existing water storage. The three options combined should minimize the need for further surface storage.

Drought Resistance

One of the primary concerns associated with the use of surface water, is the exposure to drought related shortages. The traditional defense against droughts has been conservation, and drawing upon the groundwater supply. As pointed out in the report, an essential part of the overall system is recharging the groundwater supply in wet years, and maximizing use of the surface supply with the direct intention of preserving the groundwater supply for years when the surface supply is reduced. Even in drought years there is a minimal entitlement that could be supplemented with purchased water if the need arose. For long term supply and water balance to be preserved, it is essential that monitoring of the supply and usage be implemented and maintained as an ongoing operation. Much of the data required for such monitoring is already collected in various forms, such as pumpage amounts, well water levels, recharge quantities, and wastewater exports. Compilation of this and other data should provide a basis for the analysis required to establish levels that provide a sufficient factor of safety against severe drought conditions.

Timing

Shown in Plate 28 are the areas that should be considered for the specific facilities discussed previously. One of the major considerations that must be made for the planning element of this report is how the future supplies will be phased to match the intermittent growth rates. The historic norm of requiring well construction as part of development is limited by the groundwater supply and geologic conditions already addressed. The transition to surface water treatment generally assumes greater single step costs, such as those incurred with the construction of a large capacity facility. In the case of development, this generally means that the community must borrow capital to build the facilities in advance of development. In order to avoid the fiscal challenges associated with such a scenario (in addition to the overall cost and operational advantages) the recommendation of this report is that the city proceed with a phased development approach using the modular "package plants" described. As stated earlier, this would allow the installation of the smallest unit initially with additional units added to match development. The ultimate surface capacity of 20 MGD recommended could then easily be correlated to the respective growth and resultant demands.

The specific approach recommended for the city is to select and acquire the locations at which the plants will installed, and then install units as growth occurs. The benefits to be derived from the installation of a pilot 2.5 MGD plant are two fold. First from an operational standpoint, the plant could be located in the northern area to remediate some of the current operational deficiencies. Second, installation of a pilot plant would allow the staff an opportunity to gain experience with the operations of a small plant that would be beneficial given the ultimate need for treated surface water.

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PLATE 1

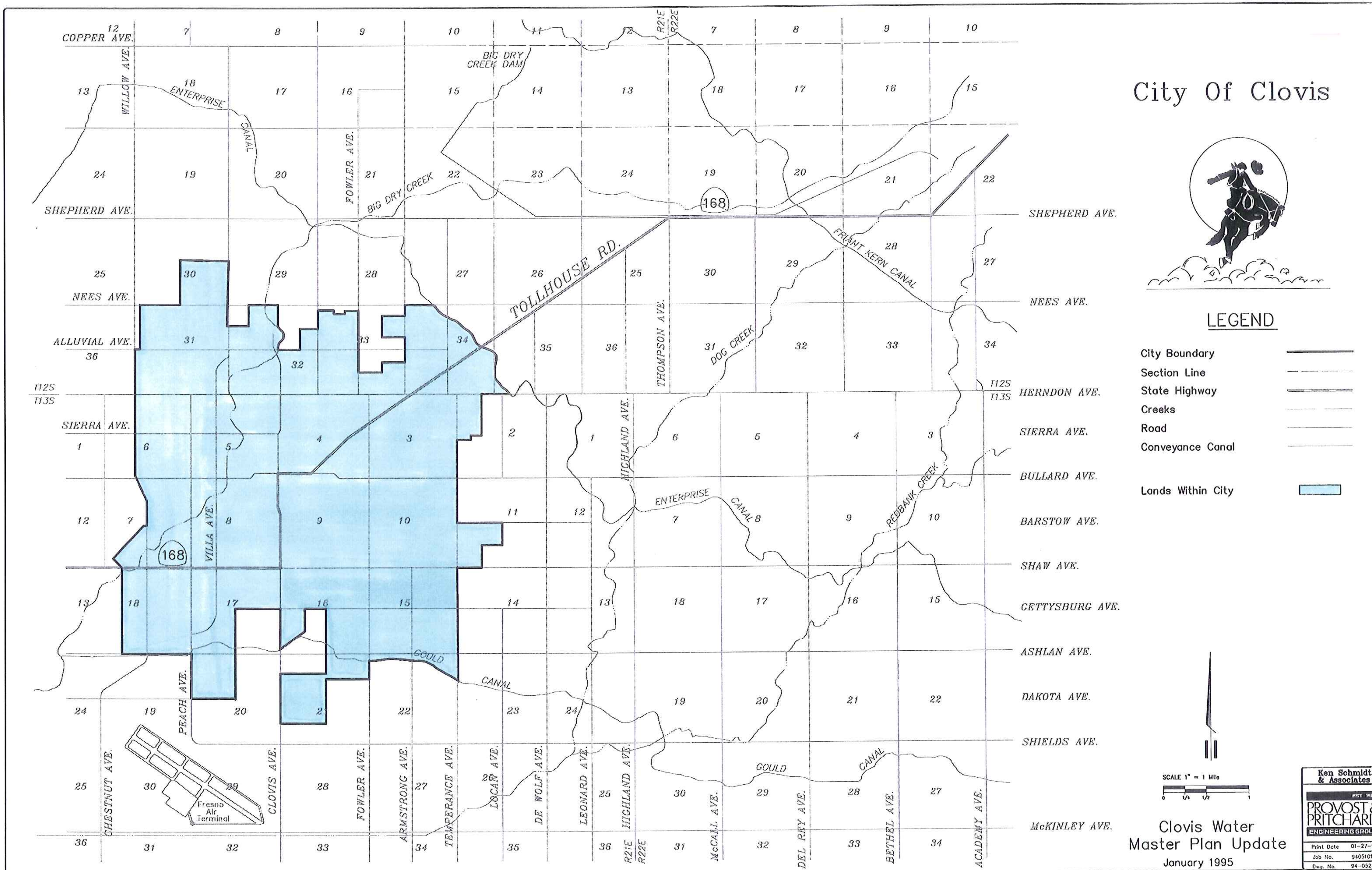

City Of Clovis
LEGEND
City Boundary
Section Line
State Highway
Creeks
Road
Conveyance Canal
Lands Within City
SCALE 1" = 1 Mile
Clovis Water
Master Plan Update
January 1995
Ken Schmidt & Associates
PROVOST & PRITCHARD
ENGINEERING GROUP
Print Date 01-27-95
Job No. 9405101
Dwg. No. 94-0521
COPPER AVE.
SHEPHERD AVE.
NEES AVE.
ALLUVIAL AVE.
HERNDON AVE.
SIERRA AVE.
BULLARD AVE.
BARSTOW AVE.
SHAW AVE.
GETTYSBURG AVE.
ASHLAN AVE.
DAKOTA AVE.
SHIELDS AVE.
McKINLEY AVE.
WILLOW AVE.
VILLA AVE.
PEACH AVE.
CHESTNUT AVE.
CLOVIS AVE.
FOWLER AVE.
ARMSTRONG AVE.
TEMPERANCE AVE.
LOCAN AVE.
DE WOLF AVE.
LEONARD AVE.
HIGHLAND AVE.
THOMPSON AVE.
McCALL AVE.
DEL REY AVE.
BETHEL AVE.
ACADEMY AVE.
TOLLHOUSE RD.
168
BIG DRY CREEK DAM
BIG DRY CREEK
ENTERPRISE CANAL
DOG CREEK
FRIANT KERN CANAL
REDBANK CREEK
GOULD CANAL
Fresno Air Terminal
T12S
T13S
R21E
R22E

PLATE 2

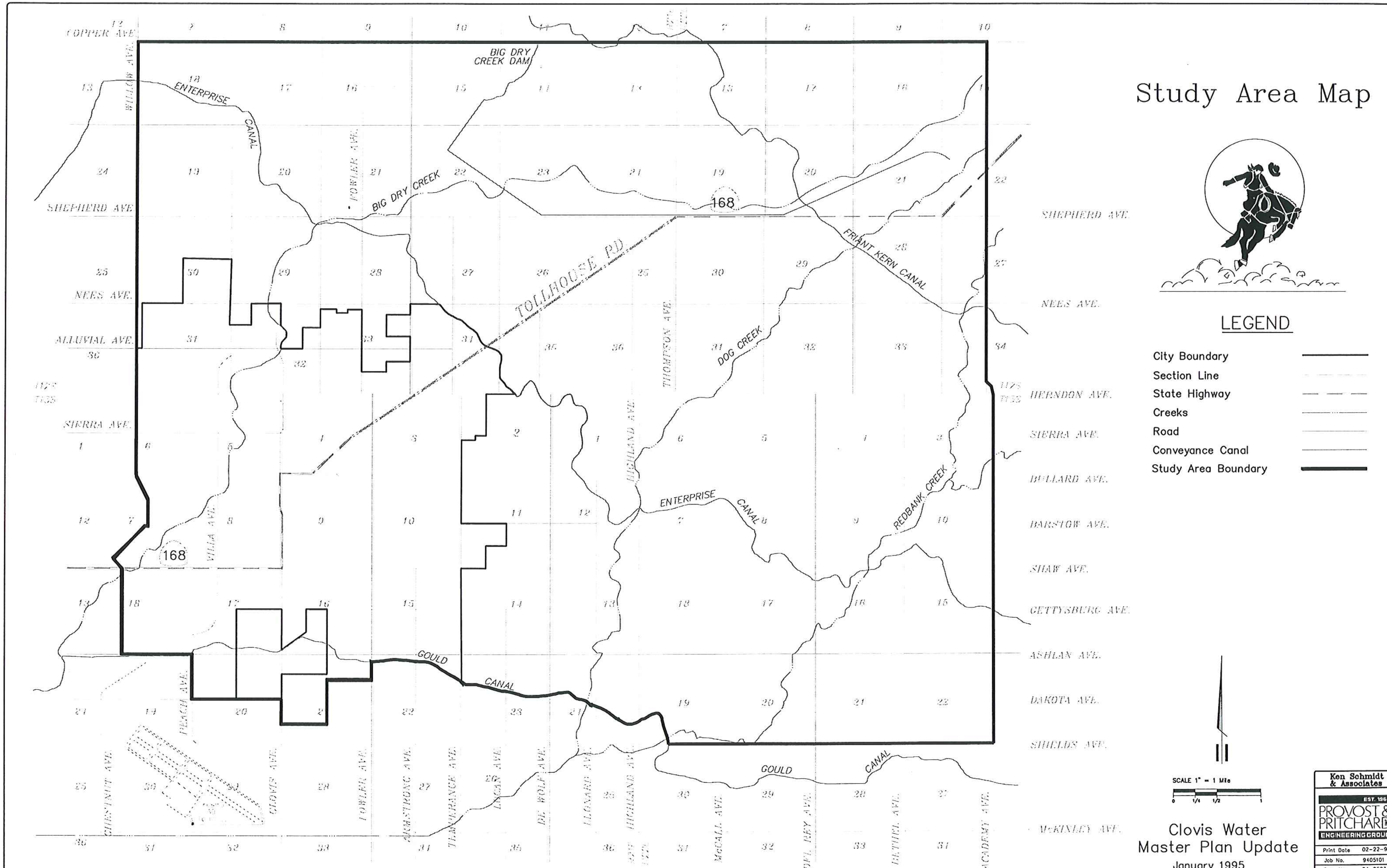
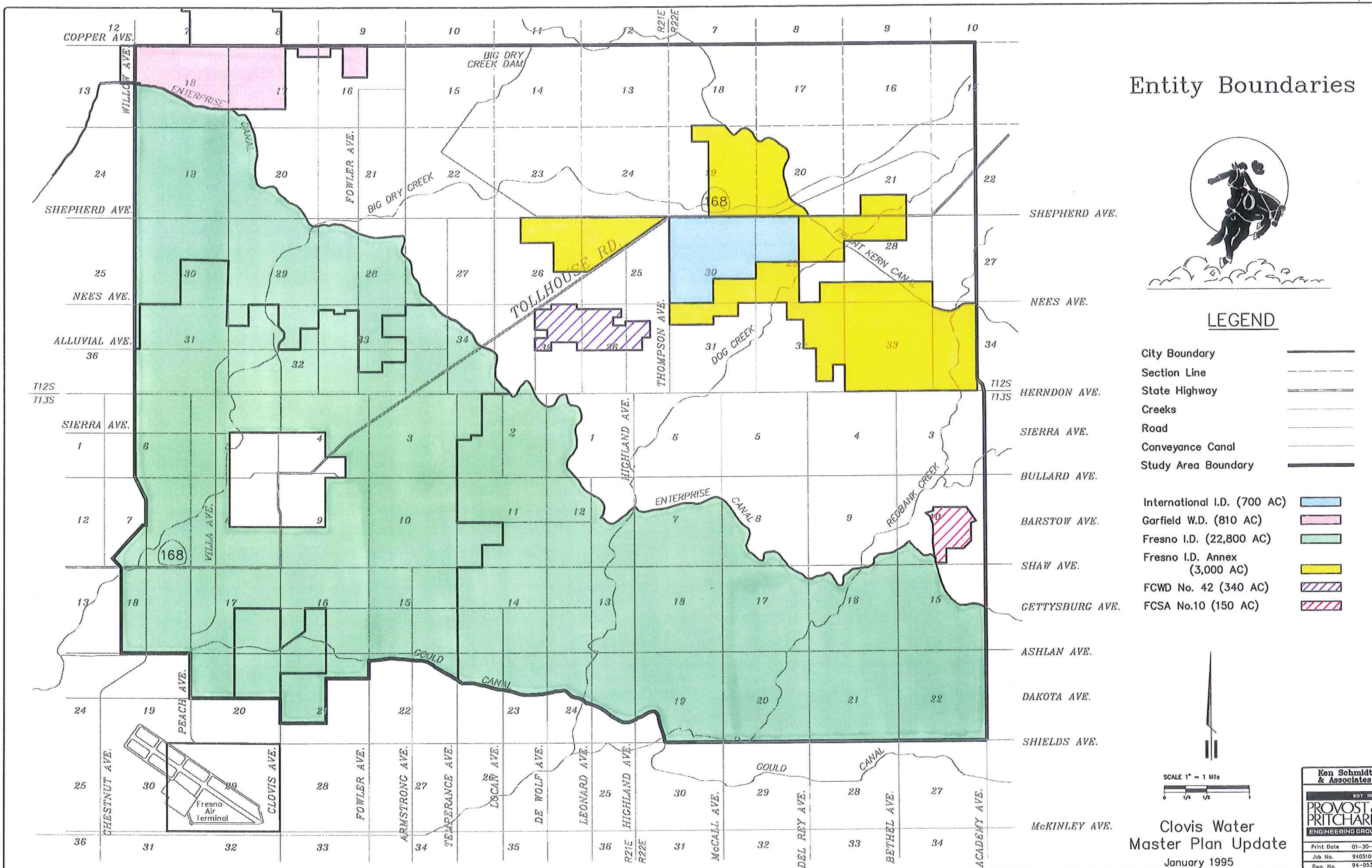

Study Area Map
LEGEND
City Boundary
Section Line
State Highway
Creeks
Road
Conveyance Canal
Study Area Boundary
SCALE 1" = 1 Mile
0
1/4
1/2
1
Clovis Water
Master Plan Update
January 1995
Ken Schmidt & Associates
EST. 1968
PROVOST & PRITCHARD
ENGINEERING GROUP
Print Date 02-22-95
Job No. 9405101
Dwg. No. 94-0523
BIG DRY CREEK DAM
ENTERPRISE CANAL
BIG DRY CREEK
FRIANT KERN CANAL
TOLLHOUSE RD.
DOG CREEK
REDBANK CREEK
GOULD CANAL
168
COPPER AVE.
SHEPHERD AVE.
NEES AVE.
ALLUVIAL AVE.
HERNDON AVE.
SIERRA AVE.
BULLARD AVE.
BARSTOW AVE.
SHAW AVE.
GETTYSBURG AVE.
ASHLAN AVE.
DAKOTA AVE.
SHIELDS AVE.
McKINLEY AVE.
WILLOW AVE.
FOWLER AVE.
THOMPSON AVE.
HIGHLAND AVE.
VILLA AVE.
PEACH AVE.
CHESTNUT AVE.
CLOVIS AVE.
ARMSTRONG AVE.
TEMPERANCE AVE.
LOCAN AVE.
DE WOLF AVE.
LEONARD AVE.
McCALL AVE.
DEL REY AVE.
BETHEL AVE.
ACADEMY AVE.

PLATE 3


Entity Boundaries
LEGEND
City Boundary
Section Line
State Highway
Creeks
Road
Conveyance Canal
Study Area Boundary
International I.D. (700 AC)
Garfield W.D. (810 AC)
Fresno I.D. (22,800 AC)
Fresno I.D. Annex (3,000 AC)
FCWD No. 42 (340 AC)
FCSA No.10 (150 AC)
SCALE 1" = 1 Mile
Clovis Water Master Plan Update
January 1995
Ken Schmidt & Associates
PROVOST & PRITCHARD ENGINEERING GROUP
Print Date 01-30-95
Job No. 9405101
Dwg. No. 94-0530
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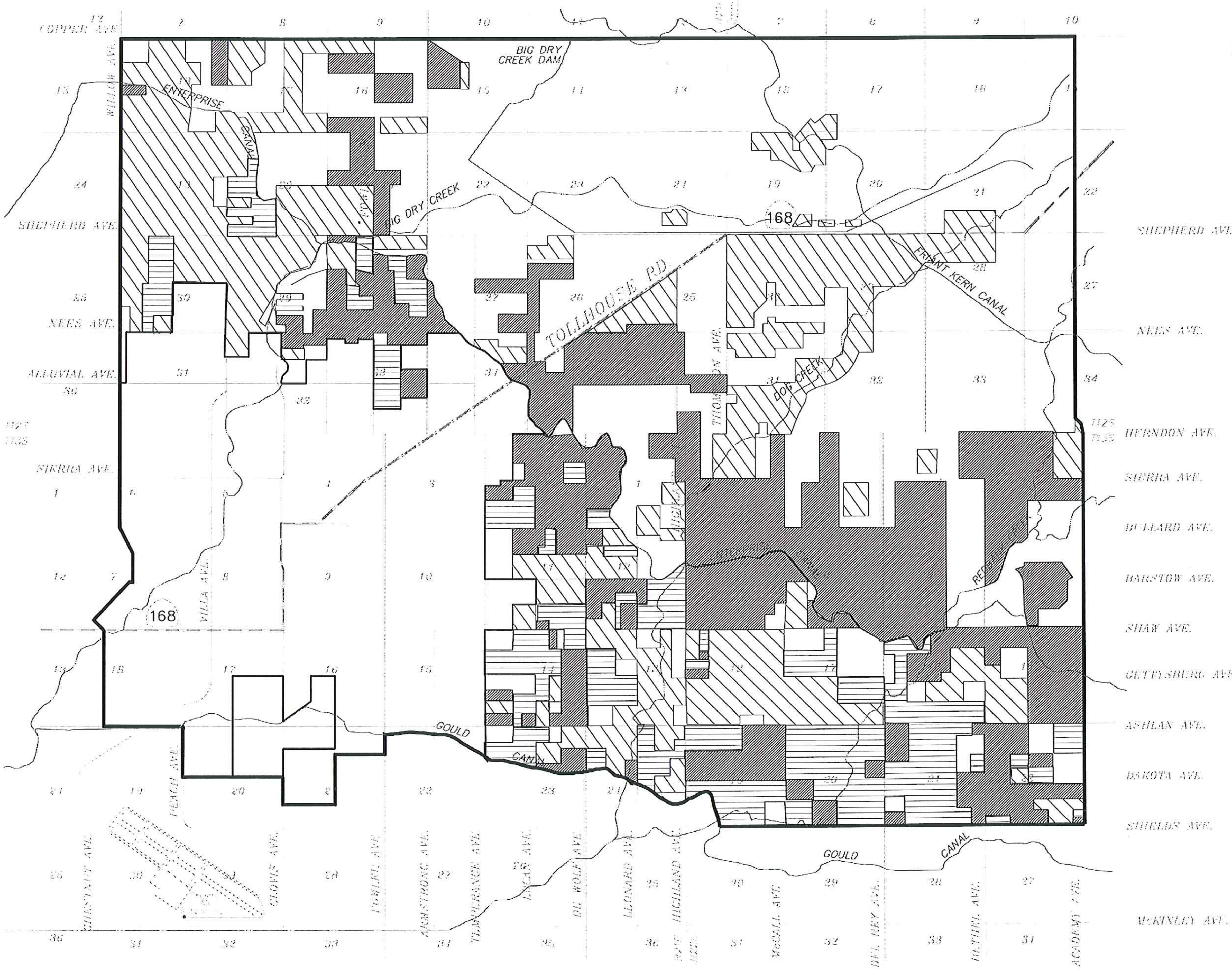
SHEPHERD AVE.
NEES AVE.
ALLUVIAL AVE.
HERNDON AVE.
SIERRA AVE.
BULLARD AVE.
BARSTOW AVE.
SHAW AVE.
GETTYSBURG AVE.
ASHLAN AVE.
DAKOTA AVE.
SHIELDS AVE.
McKINLEY AVE.
WILLOW AVE.
FOWLER AVE.
TOLLHOUSE RD.
THOMPSON AVE.
HIGHLAND AVE.
VILLA AVE.
PEACH AVE.
CHESTNUT AVE.
CLOVIS AVE.
ARMSTRONG AVE.
TEMPERANCE AVE.
LOCAN AVE.
DE WOLF AVE.
LEONARD AVE.
McCALL AVE.
DEL REY AVE.
BETHEL AVE.
ACADEMY AVE.
BIG DRY CREEK DAM
BIG DRY CREEK
DOG CREEK
REDBANK CREEK
ENTERPRISE CANAL
FRIANT KERN CANAL
GOULD CANAL
Fresno Air Terminal
T12S
T13S
R21E
R22E
168



Existing Land Use Outside Current City Boundary

LEGEND

- City Boundary
- Section Line
- State Highway
- Creeks
- Road
- Conveyance Canal
- Study Area Boundary
- Rural Residential
- Agricultural
  - Permanent Crops
  - Pasture/Other Crops

SCALE 1" = 1 Mile

0 1/4 1/2 1

Clovis Water Master Plan Update

January 1995

Ken Schmidt & Associates

EST. 1968

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Print Date	02-22-95
Job No.	9405101
Dwg. No.	94-0531

PLATE 5

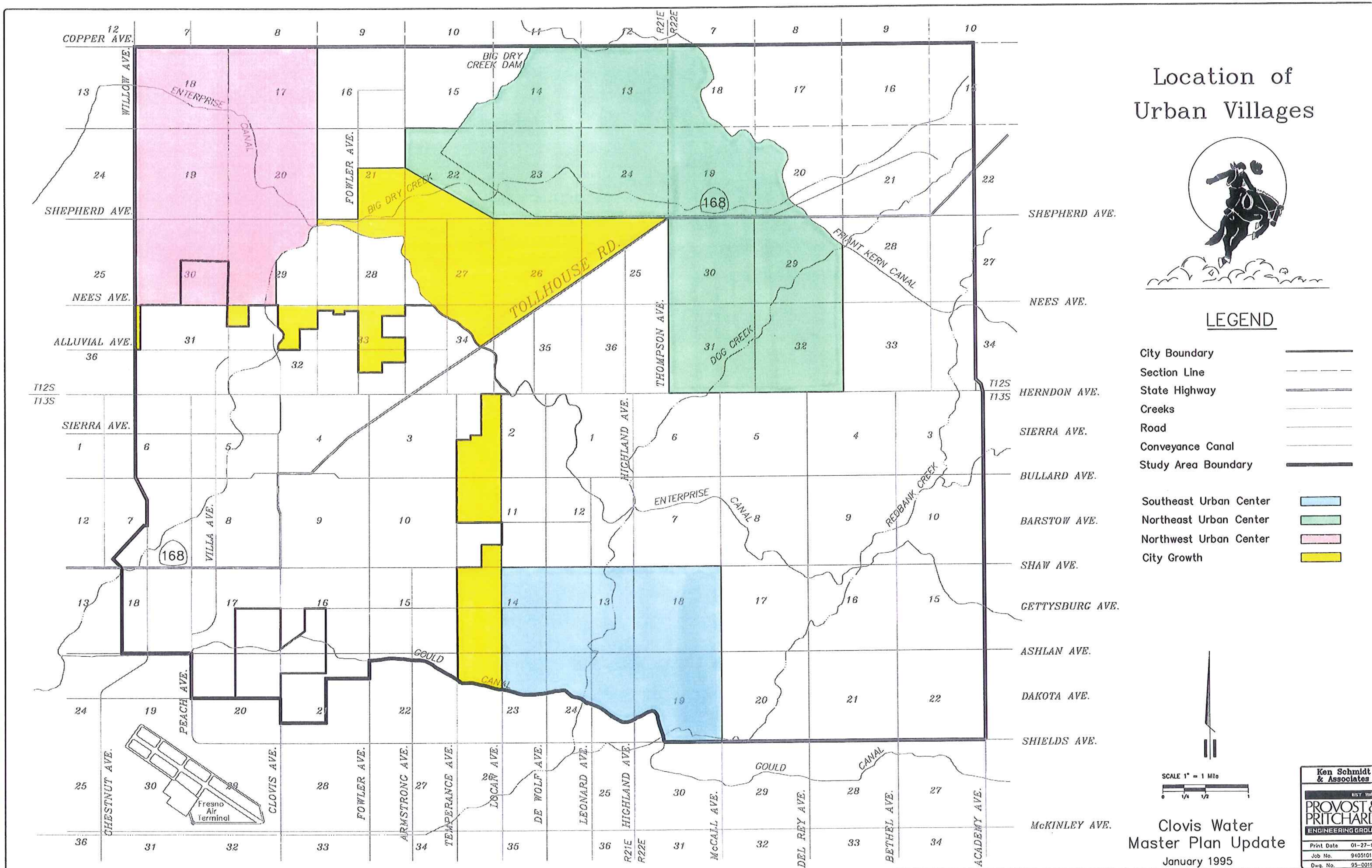

Location of Urban Villages
LEGEND
City Boundary
Section Line
State Highway
Creeks
Road
Conveyance Canal
Study Area Boundary
Southeast Urban Center
Northeast Urban Center
Northwest Urban Center
City Growth
COPPER AVE.
SHEPHERD AVE.
NEES AVE.
ALLUVIAL AVE.
HERNDON AVE.
SIERRA AVE.
BULLARD AVE.
BARSTOW AVE.
SHAW AVE.
GETTYSBURG AVE.
ASHLAN AVE.
DAKOTA AVE.
SHIELDS AVE.
McKINLEY AVE.
WILLOW AVE.
FOWLER AVE.
THOMPSON AVE.
HIGHLAND AVE.
VILLA AVE.
PEACH AVE.
CHESTNUT AVE.
CLOVIS AVE.
ARMSTRONG AVE.
TEMPERANCE AVE.
LOCAN AVE.
DE WOLF AVE.
LEONARD AVE.
McCALL AVE.
DEL REY AVE.
BETHEL AVE.
ACADEMY AVE.
TOLLHOUSE RD.
BIG DRY CREEK
BIG DRY CREEK DAM
ENTERPRISE CANAL
FRIANT KERN CANAL
DOG CREEK
REDBANK CREEK
GOULD CANAL
168
Fresno Air Terminal
T12S
T13S
R21E
R22E
SCALE 1" = 1 Mile
Clovis Water Master Plan Update
January 1995
Ken Schmidt & Associates
PROVOST & PRITCHARD ENGINEERING GROUP
Print Date 01-27-95
Job No. 9405101
Dwg. No. 95-0019

PLATE 6

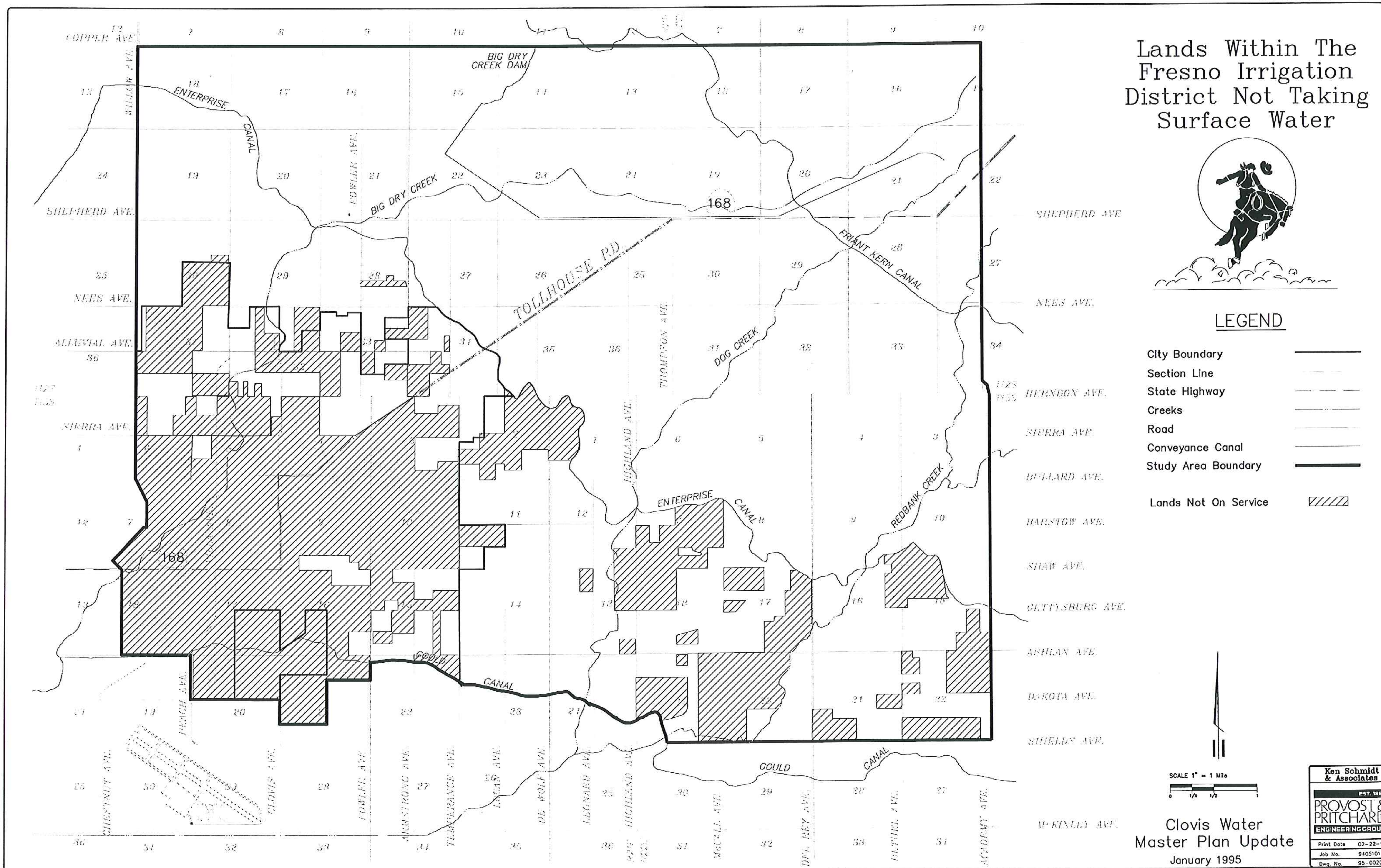

Lands Within The Fresno Irrigation District Not Taking Surface Water
LEGEND
City Boundary
Section Line
State Highway
Creeks
Road
Conveyance Canal
Study Area Boundary
Lands Not On Service
SCALE 1" = 1 Mile
Clovis Water
Master Plan Update
January 1995
Ken Schmidt & Associates
EST. 1968
PROVOST & PRITCHARD
ENGINEERING GROUP
Print Date 02-22-95
Job No. 9405101
Dwg. No. 95-0020
COPPER AVE.
SHEPHERD AVE.
NEES AVE.
ALLUVIAL AVE.
HERNDON AVE.
SIERRA AVE.
BULLARD AVE.
BARSTOW AVE.
SHAW AVE.
GETTYSBURG AVE.
ASHLAN AVE.
DAKOTA AVE.
SHIELDS AVE.
McKINLEY AVE.
WILLOW AVE.
FOWLER AVE.
THOMPSON AVE.
HIGHLAND AVE.
CHESTNUT AVE.
PEACH AVE.
CLOVIS AVE.
ARMSTRONG AVE.
TEMPERANCE AVE.
LOCAN AVE.
DE WOLF AVE.
LEONARD AVE.
McCALL AVE.
DEL REY AVE.
BETHEL AVE.
ACADEMY AVE.
BIG DRY CREEK DAM
BIG DRY CREEK
ENTERPRISE CANAL
TOLLHOUSE RD.
FRIANT KERN CANAL
DOG CREEK
REDBANK CREEK
GOULD CANAL
168

PLATE 7

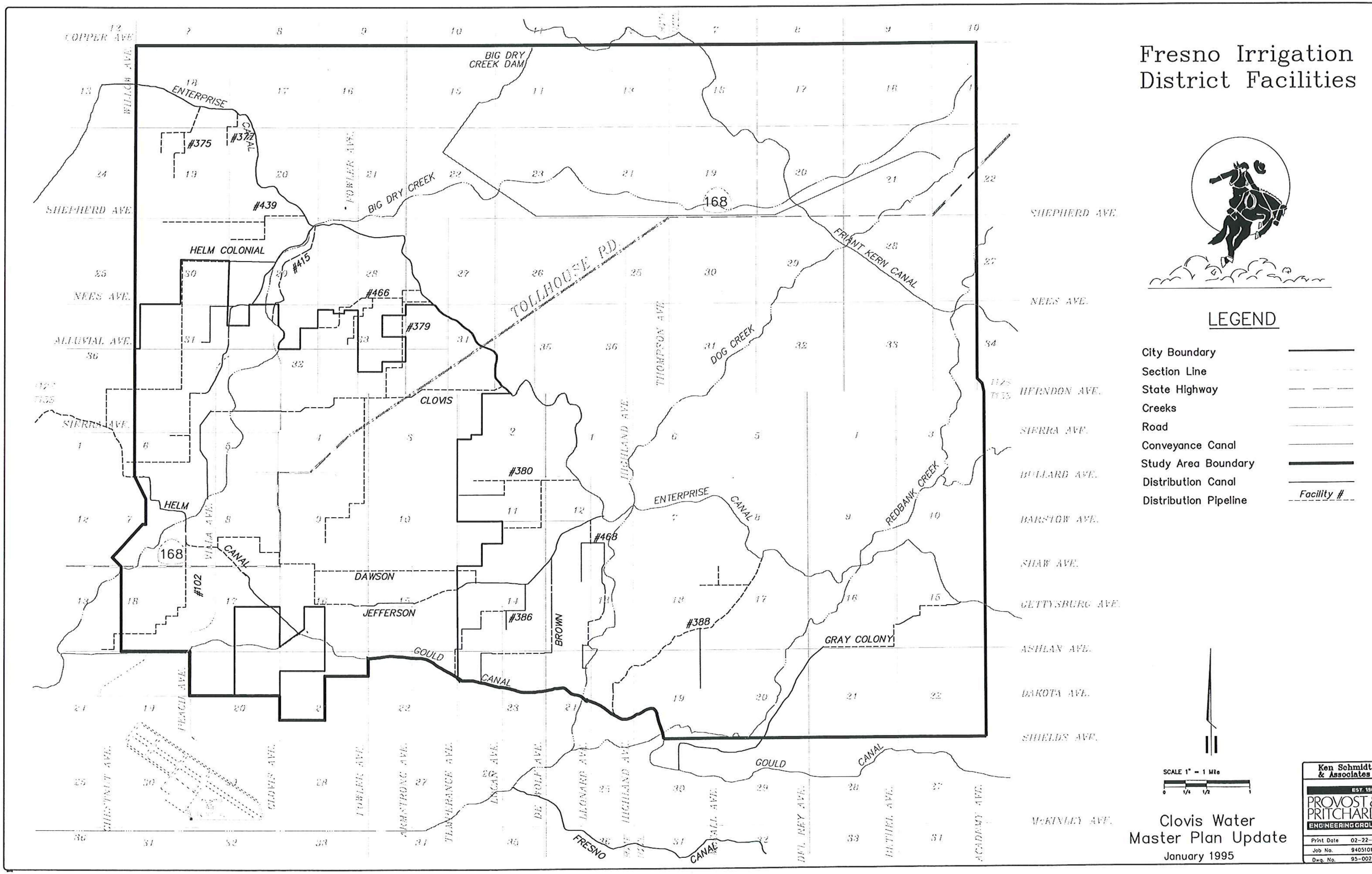
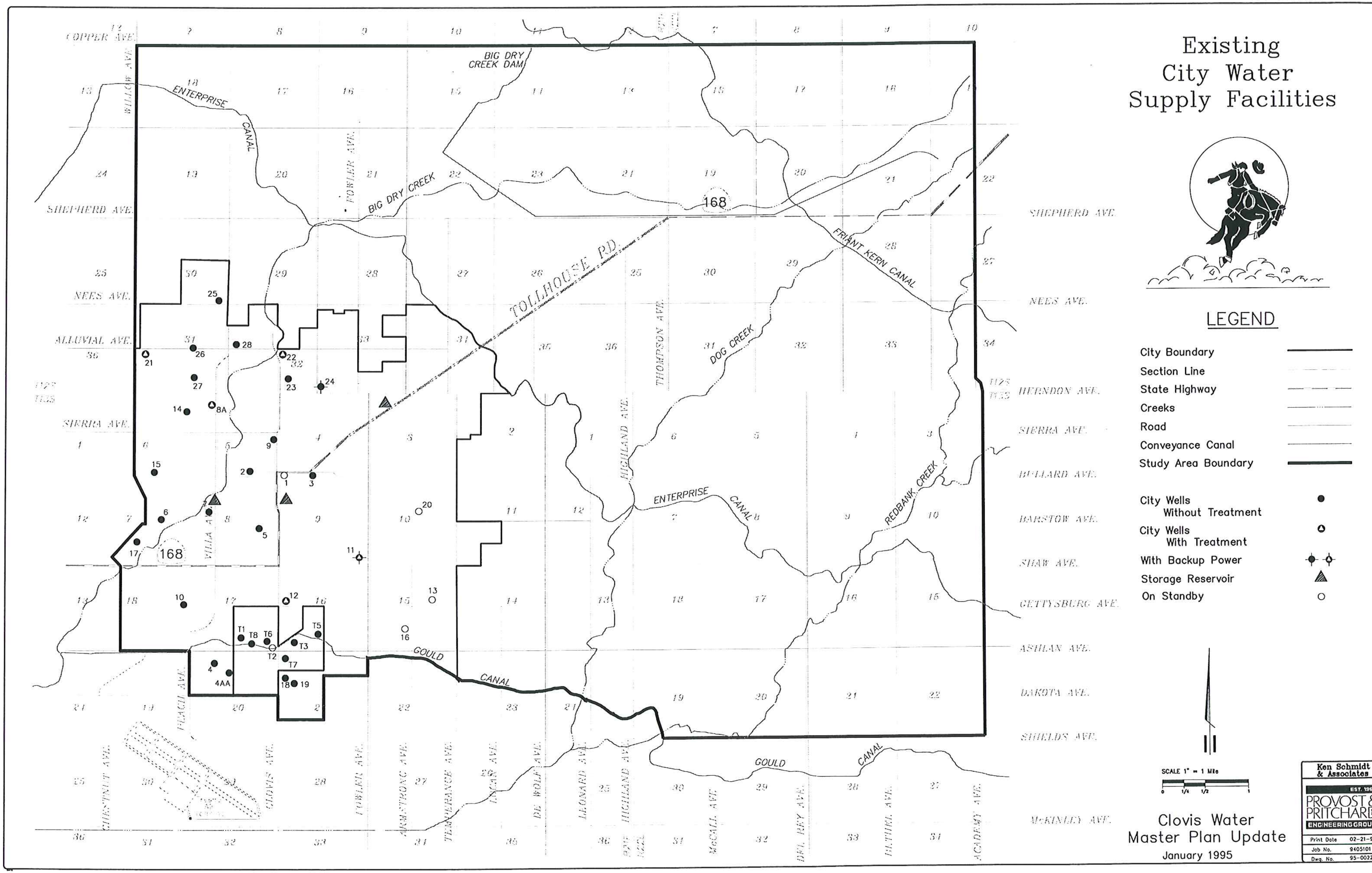

Fresno Irrigation District Facilities
LEGEND
City Boundary
Section Line
State Highway
Creeks
Road
Conveyance Canal
Study Area Boundary
Distribution Canal
Distribution Pipeline
Facility #
SCALE 1" = 1 Mile
Clovis Water Master Plan Update
January 1995
Ken Schmidt & Associates
PROVOST & PRITCHARD ENGINEERING GROUP
Print Date 02-22-95
Job No. 9405101
Dwg. No. 95-0021
COPPER AVE.
SHEPHERD AVE.
NEES AVE.
ALLUVIAL AVE.
HERNDON AVE.
SIERRA AVE.
BULLARD AVE.
BARSTOW AVE.
SHAW AVE.
GETTYSBURG AVE.
ASHLAN AVE.
DAKOTA AVE.
SHIELDS AVE.
McKINLEY AVE.
FOWLER AVE.
THOMPSON AVE.
HIGHLAND AVE.
PEACH AVE.
CLOVIS AVE.
ARMSTRONG AVE.
TEMPERANCE AVE.
LEONARD AVE.
DEL REY AVE.
BETHEL AVE.
ACADEMY AVE.
TOLLHOUSE RD.
BIG DRY CREEK DAM
BIG DRY CREEK
DOG CREEK
REDBANK CREEK
ENTERPRISE CANAL
FRIANT KERN CANAL
HELM COLONIAL
HELM CANAL
DAWSON
JEFFERSON
GOULD CANAL
GRAY COLONY
BROWN
FRESNO CANAL
CLOVIS
168
#375
#377
#439
#415
#466
#379
#380
#468
#102
#386
#388

PLATE 8


Existing City Water Supply Facilities
LEGEND
City Boundary
Section Line
State Highway
Creeks
Road
Conveyance Canal
Study Area Boundary
City Wells Without Treatment
City Wells With Treatment
With Backup Power
Storage Reservoir
On Standby
SCALE 1" = 1 Mile
Clovis Water Master Plan Update
January 1995
Ken Schmidt & Associates
PROVOST & PRITCHARD ENGINEERING GROUP
EST. 1968
Print Date 02-21-95
Job No. 9405101
Dwg. No. 95-0022
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NEES AVE.
ALLUVIAL AVE.
HERNDON AVE.
SIERRA AVE.
BULLARD AVE.
BARSTOW AVE.
SHAW AVE.
GETTYSBURG AVE.
ASHLAN AVE.
DAKOTA AVE.
SHIELDS AVE.
McKINLEY AVE.
WILLOW AVE.
FOWLER AVE.
THOMPSON AVE.
HIGHLAND AVE.
VILLA AVE.
PEACH AVE.
CHESTNUT AVE.
CLOVIS AVE.
ARMSTRONG AVE.
TEMPERANCE AVE.
LOCAN AVE.
DE WOLF AVE.
LEONARD AVE.
McCALL AVE.
DEL REY AVE.
BETHEL AVE.
ACADEMY AVE.
BIG DRY CREEK DAM
BIG DRY CREEK
ENTERPRISE CANAL
TOLLHOUSE RD.
FRIANT KERN CANAL
DOG CREEK
REDBANK CREEK
GOULD CANAL
168

PLATE 9

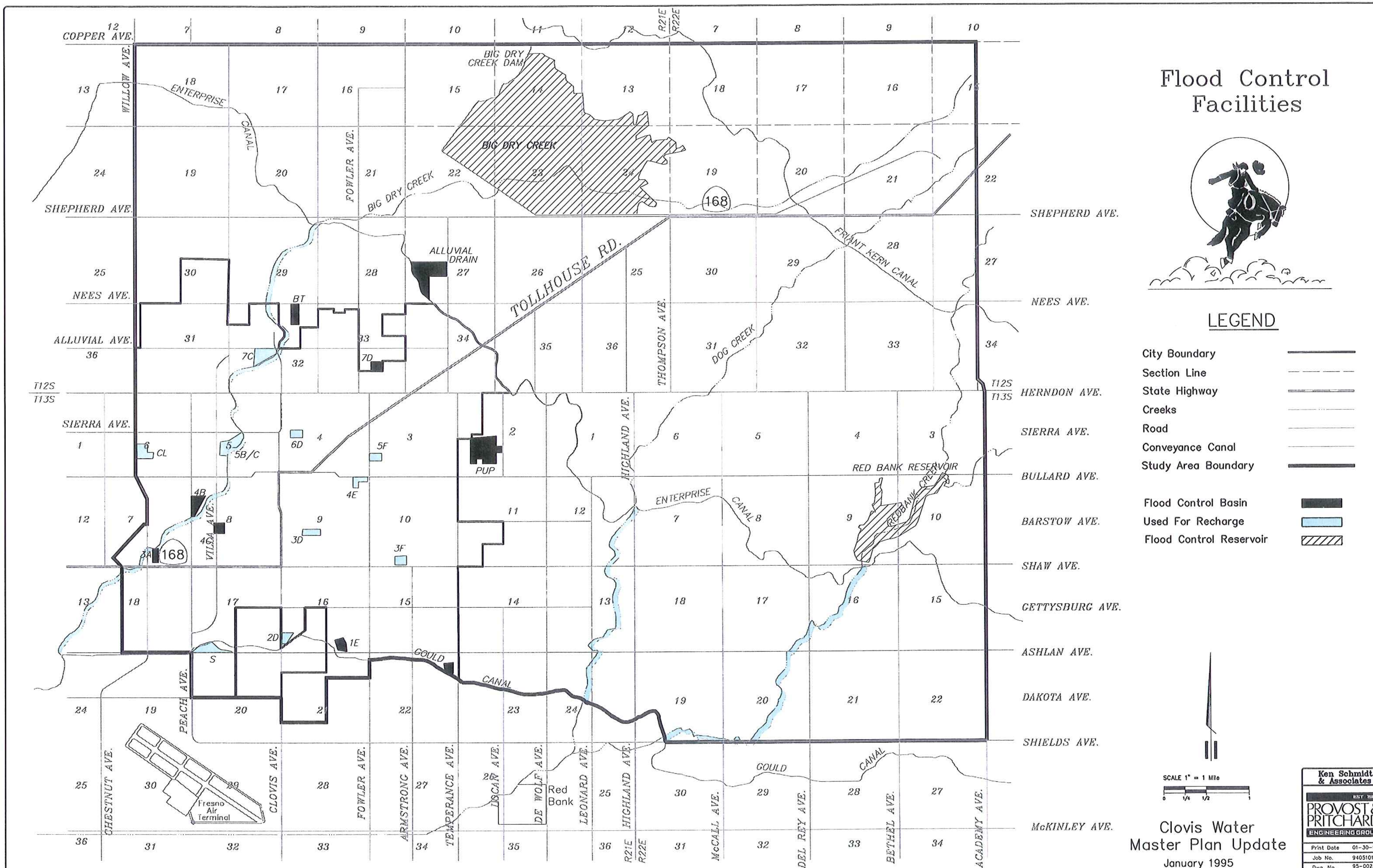
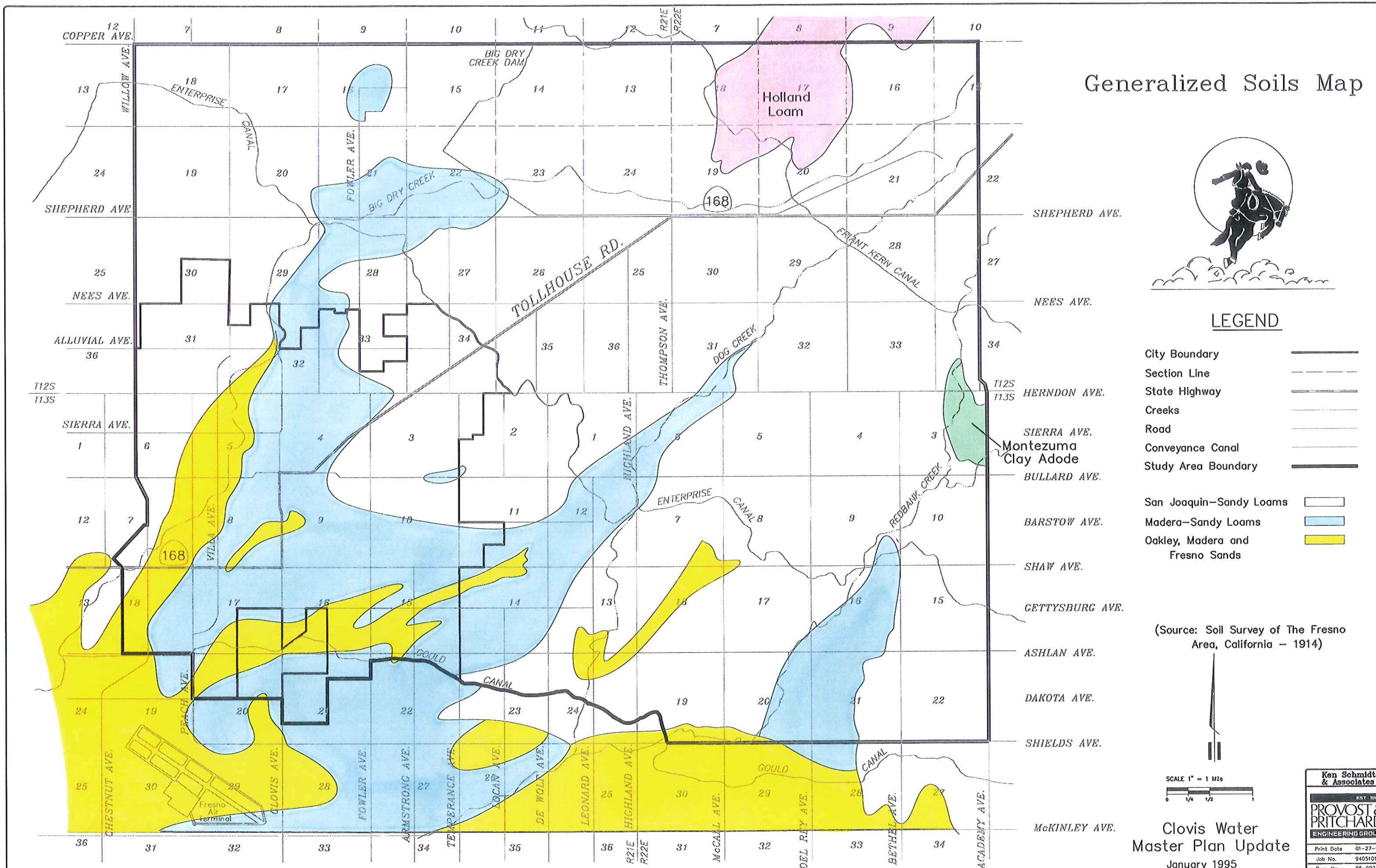
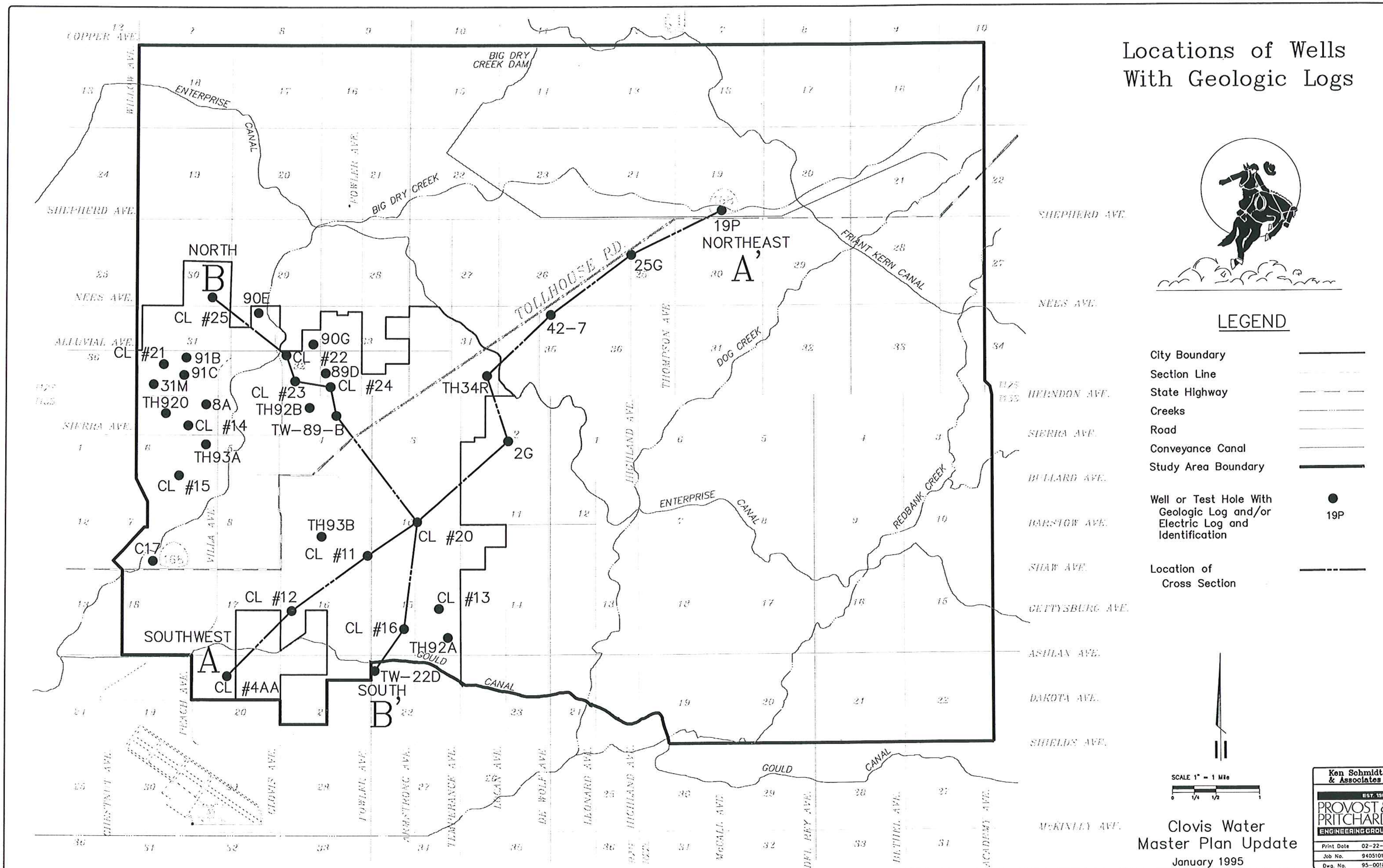

Flood Control Facilities
LEGEND
City Boundary
Section Line
State Highway
Creeks
Road
Conveyance Canal
Study Area Boundary
Flood Control Basin
Used For Recharge
Flood Control Reservoir
COPPER AVE.
SHEPHERD AVE.
NEES AVE.
ALLUVIAL AVE.
SIERRA AVE.
HERNDON AVE.
BULLARD AVE.
BARSTOW AVE.
SHAW AVE.
GETTYSBURG AVE.
ASHLAN AVE.
DAKOTA AVE.
SHIELDS AVE.
McKINLEY AVE.
WILLOW AVE.
FOWLER AVE.
THOMPSON AVE.
HIGHLAND AVE.
VILLA AVE.
PEACH AVE.
CHESTNUT AVE.
CLOVIS AVE.
ARMSTRONG AVE.
TEMPERANCE AVE.
LOCAN AVE.
DE WOLF AVE.
LEONARD AVE.
McCALL AVE.
DEL REY AVE.
BETHEL AVE.
ACADEMY AVE.
TOLLHOUSE RD.
BIG DRY CREEK DAM
BIG DRY CREEK
DOG CREEK
REDBANK CREEK
RED BANK RESERVOIR
ENTERPRISE CANAL
FRIANT KERN CANAL
GOULD CANAL
ALLUVIAL DRAIN
PUP
Red Bank
Fresno Air Terminal
T12S
T13S
R21E
R22E
168
SCALE 1" = 1 Mile
Clovis Water Master Plan Update
January 1995
Ken Schmidt & Associates
PROVOST & PRITCHARD ENGINEERING GROUP
Print Date 01-30-95
Job No. 9405101
Dwg. No. 95-0023

PLATE 10



Generalized Soils Map
LEGEND
City Boundary
Section Line
State Highway
Creeks
Road
Conveyance Canal
Study Area Boundary
San Joaquin-Sandy Loams
Madera-Sandy Loams
Oakley, Madera and Fresno Sands
(Source: Soil Survey of The Fresno Area, California - 1914)
Holland Loam
Montezuma Clay Adobe
COPPER AVE.
SHEPHERD AVE.
NEES AVE.
ALLUVIAL AVE.
SIERRA AVE.
HERNDON AVE.
BULLARD AVE.
BARSTOW AVE.
SHAW AVE.
GETTYSBURG AVE.
ASHLAN AVE.
DAKOTA AVE.
SHIELDS AVE.
McKINLEY AVE.
WILLOW AVE.
FOWLER AVE.
THOMPSON AVE.
HIGHLAND AVE.
VILLA AVE.
PEACH AVE.
CHESTNUT AVE.
CLOVIS AVE.
ARMSTRONG AVE.
TEMPERANCE AVE.
LOCAN AVE.
DE WOLF AVE.
LEONARD AVE.
McCALL AVE.
DEL REY AVE.
BETHEL AVE.
ACADEMY AVE.
TOLLHOUSE RD.
ENTERPRISE CANAL
GOULD CANAL
FRIANT KERN CANAL
BIG DRY CREEK
BIG DRY CREEK DAM
DOG CREEK
REDBANK CREEK
168
T12S
T13S
R21E
R22E
Fresno Air Terminal
SCALE 1" = 1 Mile
Clovis Water Master Plan Update
January 1995
Ken Schmidt & Associates
PROVOST & PRITCHARD ENGINEERING GROUP
Print Date 01-27-95
Job No. 9405101
Dwg. No. 95-0024



Clovis Water
Master Plan Update
January 1995

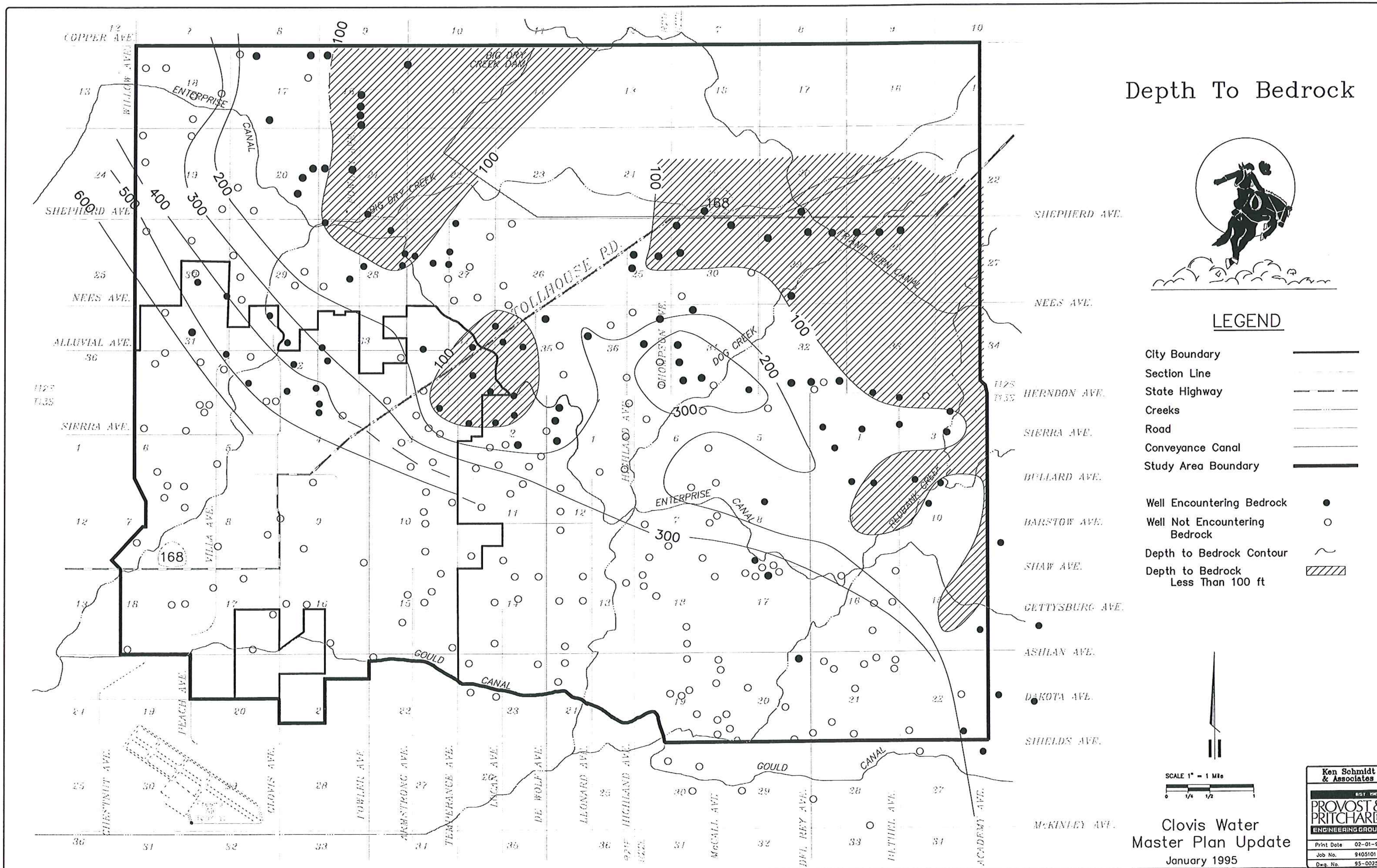
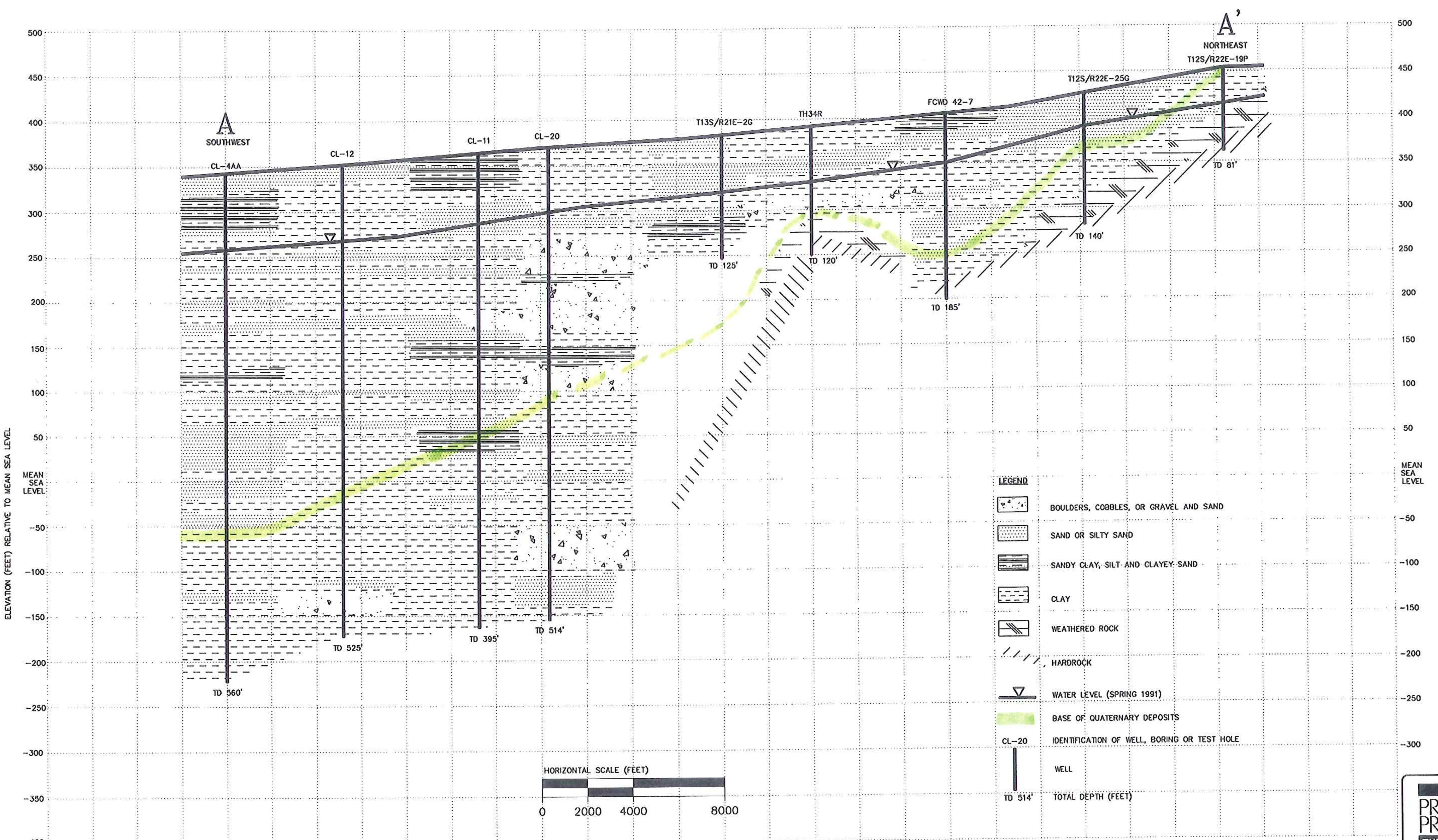

Depth To Bedrock
LEGEND
City Boundary
Section Line
State Highway
Creeks
Road
Conveyance Canal
Study Area Boundary
Well Encountering Bedrock
Well Not Encountering Bedrock
Depth to Bedrock Contour
Depth to Bedrock Less Than 100 ft
SCALE 1" = 1 Mile
Clovis Water Master Plan Update
January 1995
Ken Schmidt & Associates
PROVOST & PRITCHARD
ENGINEERING GROUP
Print Date 02-01-95
Job No. 9405101
Dwg. No. 95-0025
COPPER AVE.
SHEPHERD AVE.
NEES AVE.
ALLUVIAL AVE.
HERNDON AVE.
SIERRA AVE.
BULLARD AVE.
BARSTOW AVE.
SHAW AVE.
GETTYSBURG AVE.
ASHLAN AVE.
DAKOTA AVE.
SHIELDS AVE.
McKINLEY AVE.
TOLLHOUSE RD.
ENTERPRISE CANAL
GOULD CANAL
BIG DRY CREEK
BIG DRY CREEK DAM
DOG CREEK
REDBANK CREEK
FRIANT KERN CANAL
WILLOW AVE.
VILLA AVE.
PEACH AVE.
CHESTNUT AVE.
CLOVIS AVE.
FOWLER AVE.
ARMSTRONG AVE.
TEMPERANCE AVE.
LOCAN AVE.
DE WOLF AVE.
LEONARD AVE.
HIGHLAND AVE.
THOMPSON AVE.
McCALL AVE.
DEL REY AVE.
BETHEL AVE.
ACADEMY AVE.
168
100
200
300
400
500
600

PLATE 13



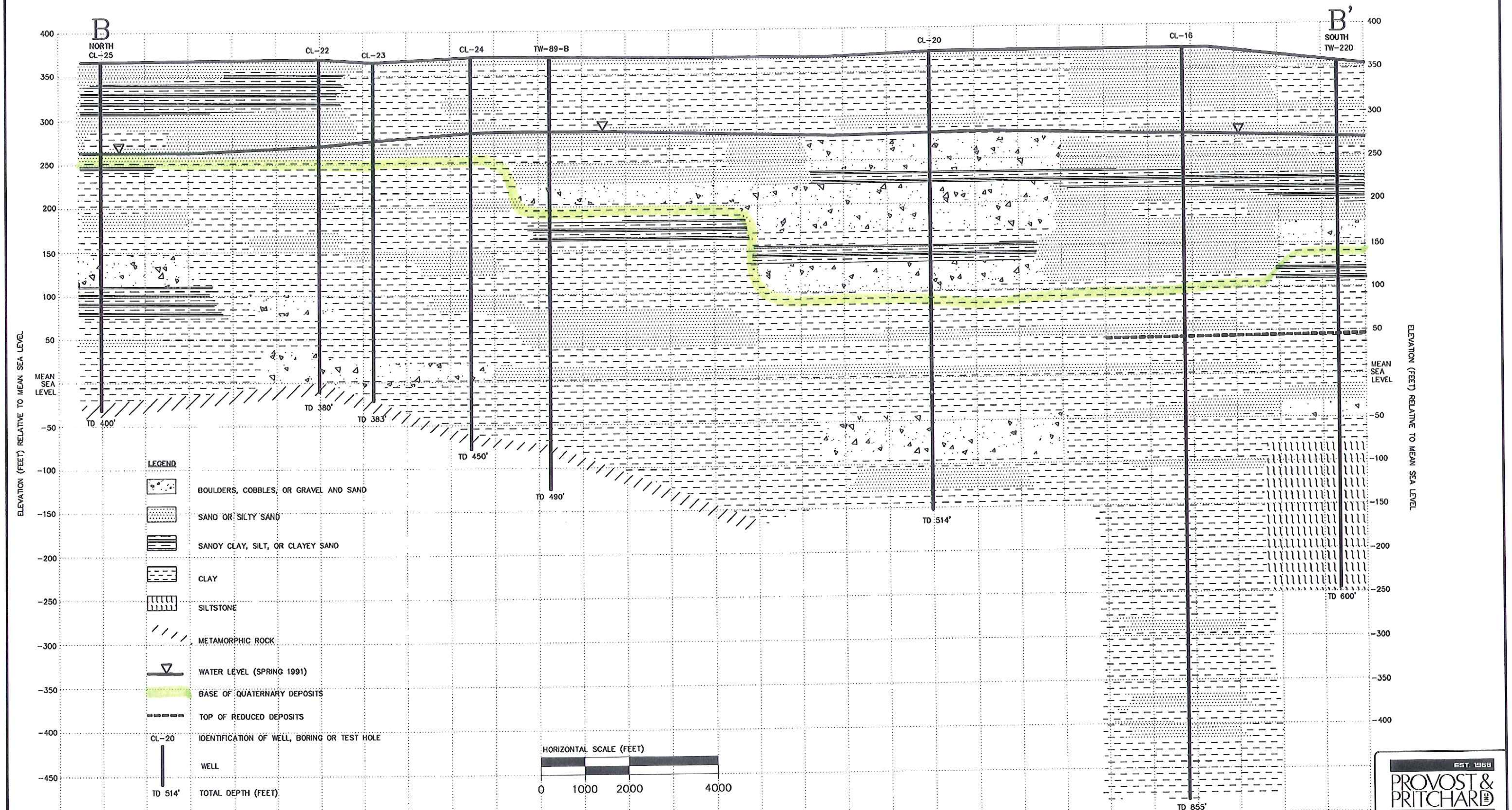
SUBSURFACE GEOLOGIC CROSS SECTION A–A'

PREPARED BY
KENNETH D. SCHMIDT
AND ASSOCIATES

EST. 1968
PROVOST & PRITCHARD INC
ENGINEERING GROUP
286 WEST CROMWELL AVENUE
FRESNO, CALIFORNIA 93711-6162
209/449-2700 FAX 209/449-2715

Job No. 9405101
Dwg. No. 95-0011

SB017



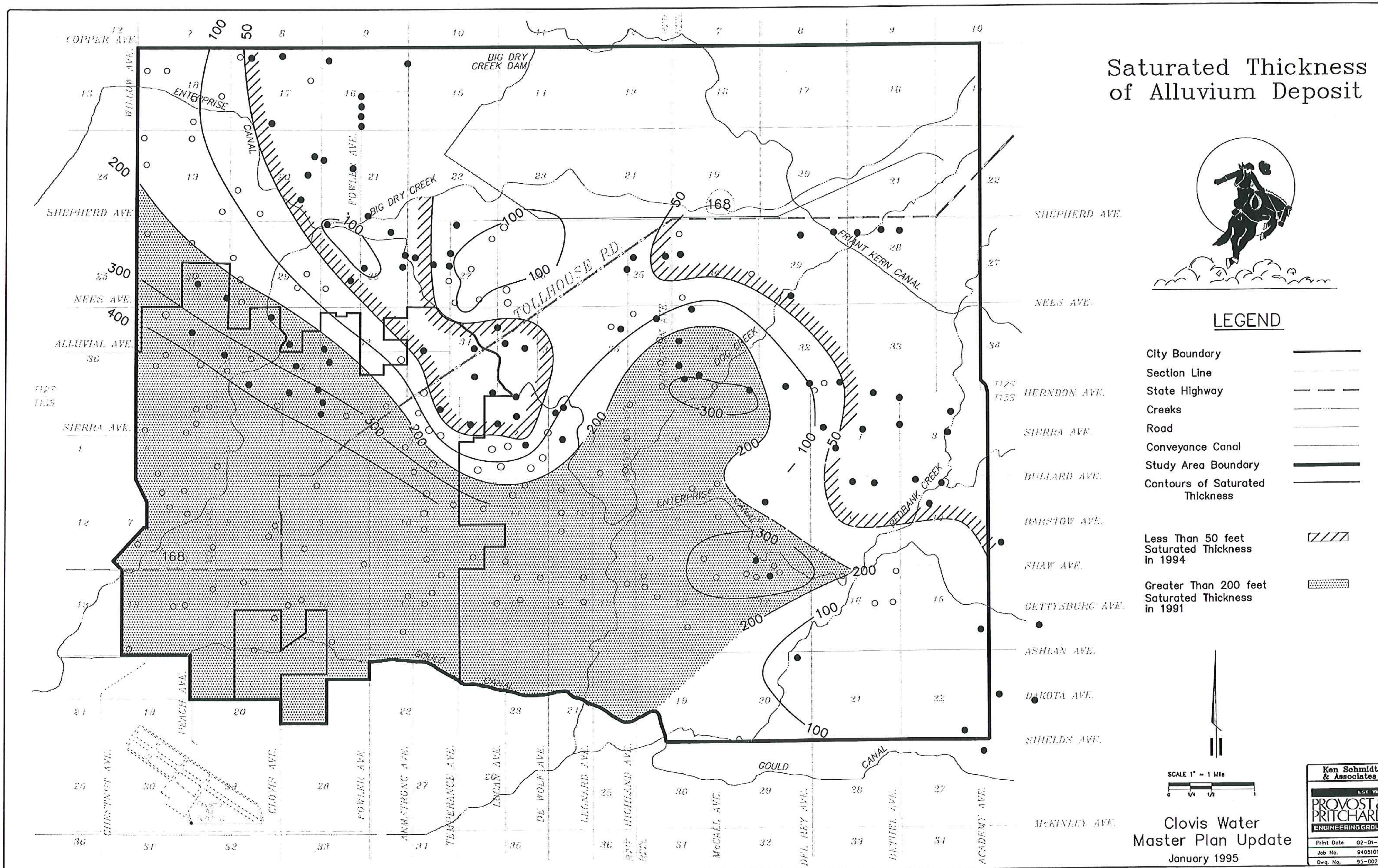
SUBSURFACE GEOLOGIC CROSS SECTION B-B'

PREPARED BY KENNETH D. SCHMIDT AND ASSOCIATES

EST 1968
PROVOST & PRITCHARD ENGINEERING GROUP
286 WEST CROMWELL AVENUE
FRESNO, CALIFORNIA 93711-6162
209/449-2700 FAX 209/449-2715

Job No. 9405101
Dwg. No. 95-0012

SB017

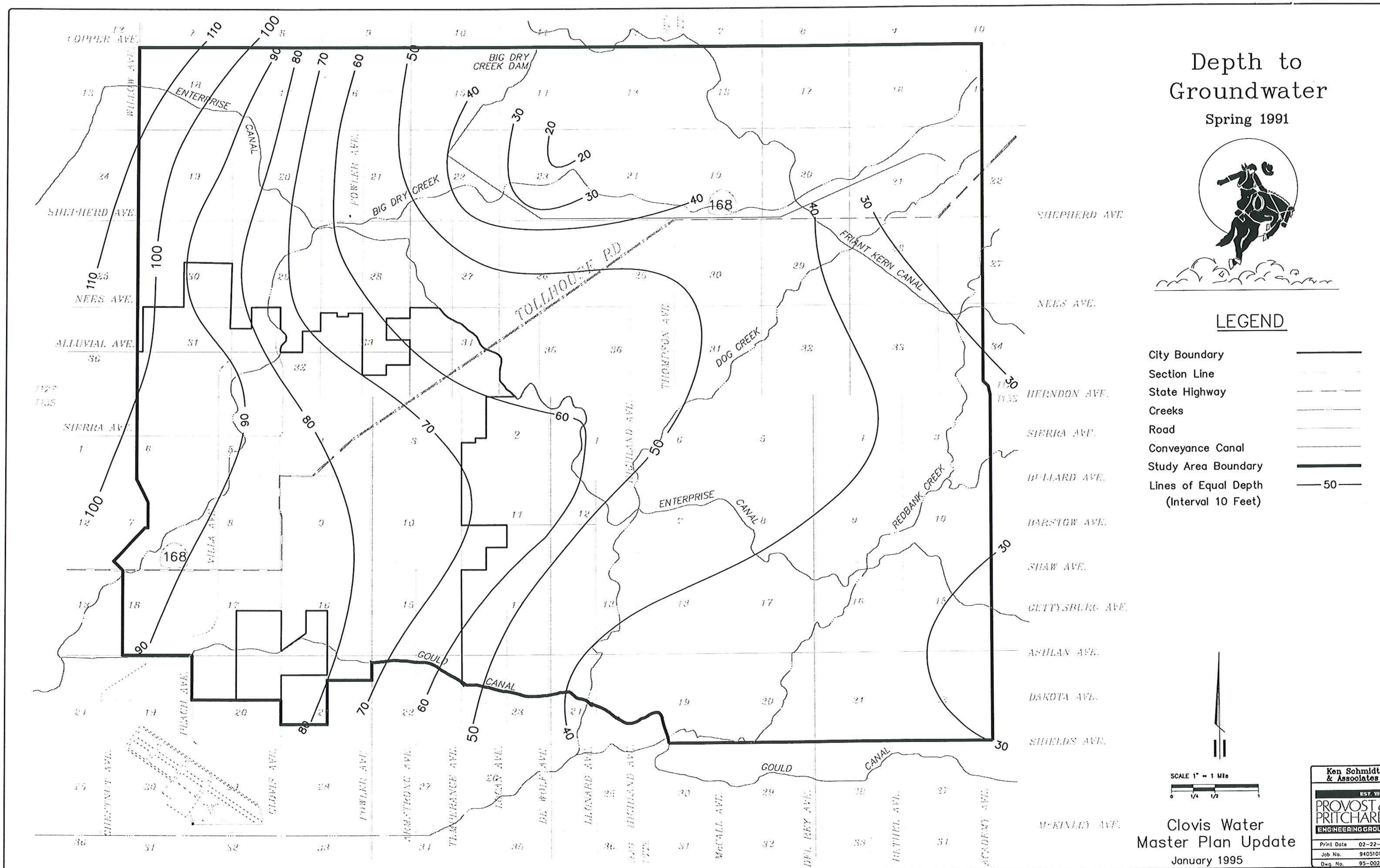


Clovis Water Master Plan Update
January 1995

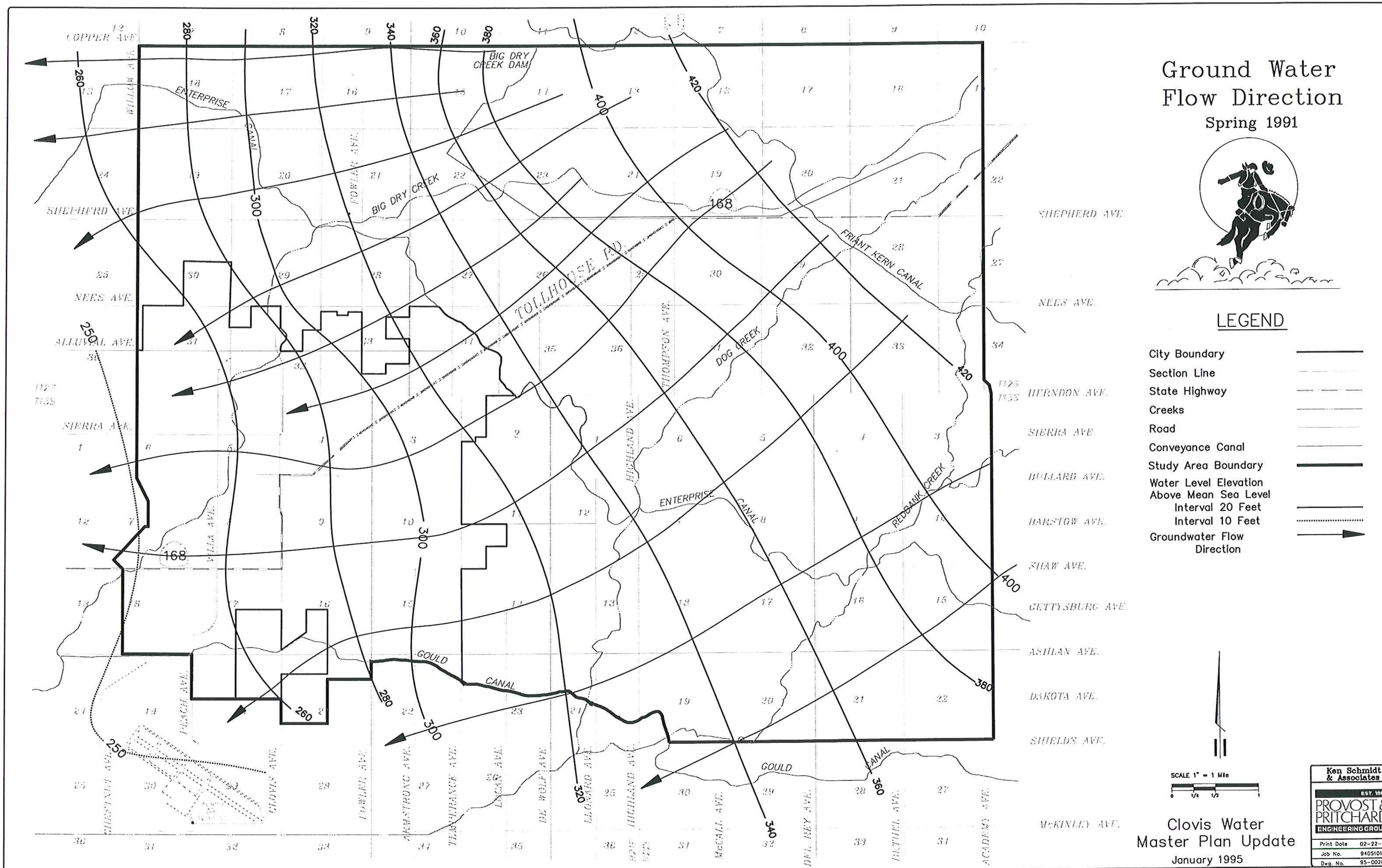
Ken Schmidt & Associates
PROVOST & PRITCHARD ENGINEERING GROUP
EST 1968

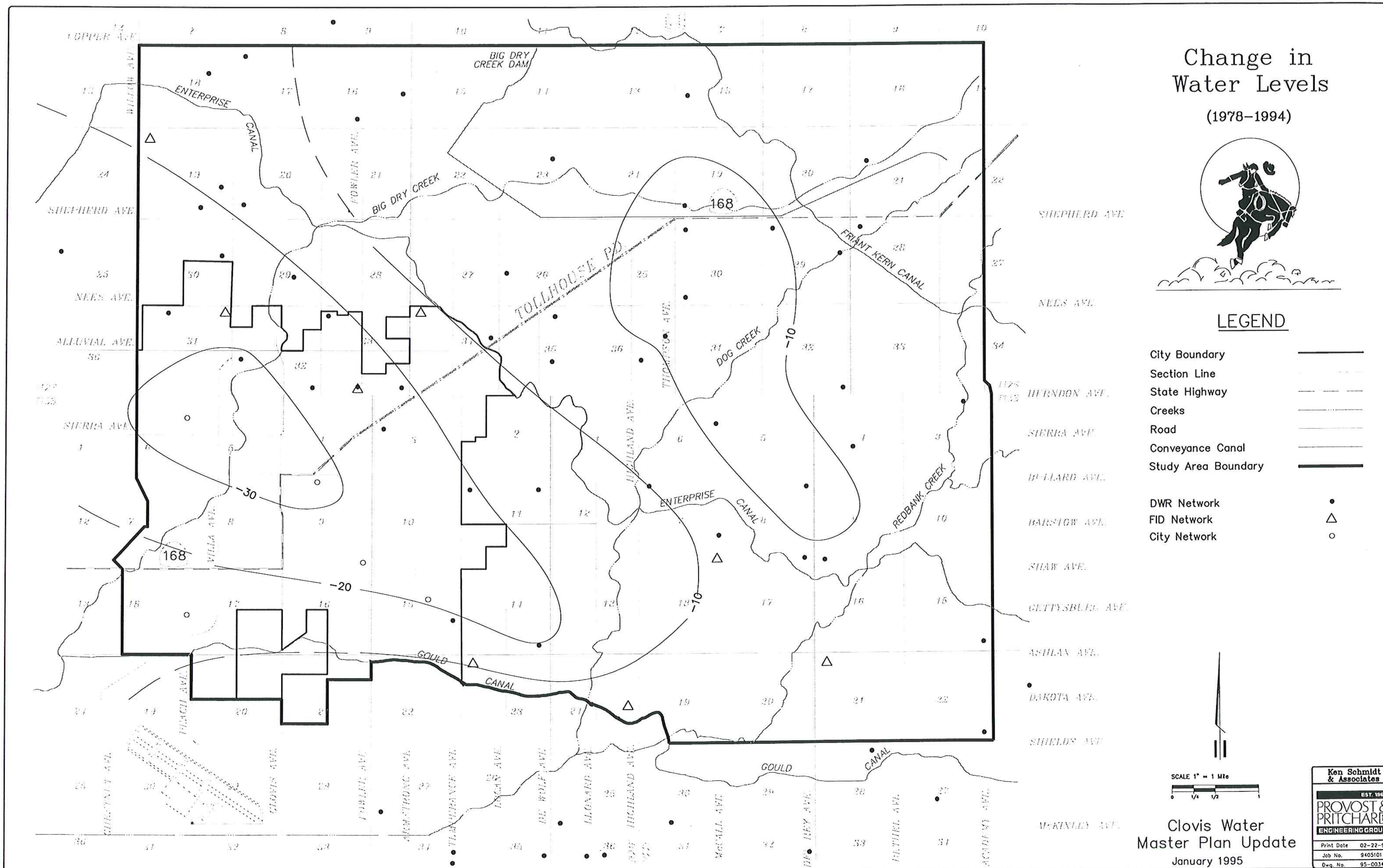
Print Date	02-01-95
Job No.	9405101
Dwg. No.	95-0026

PLATE 16

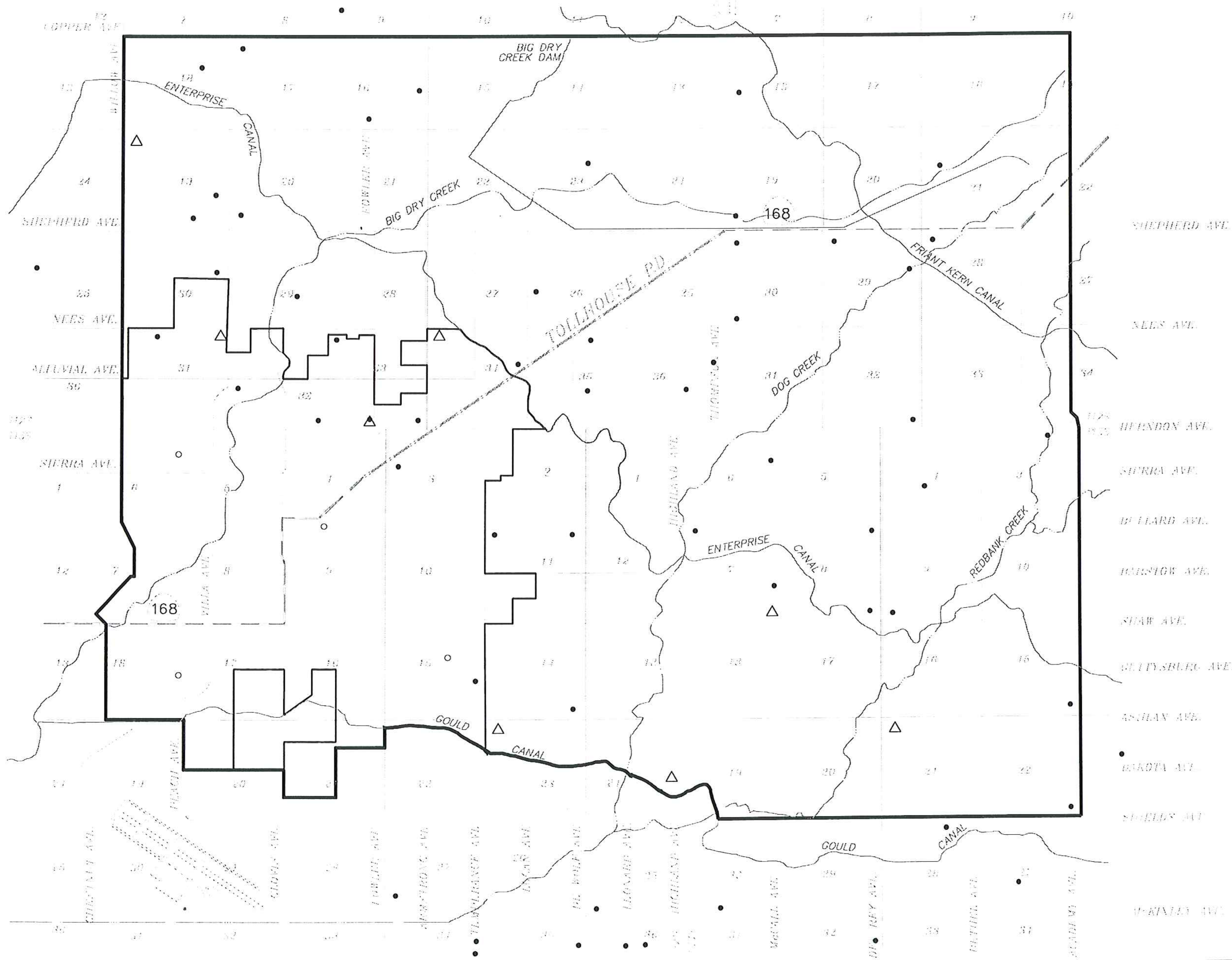


Depth to Groundwater
Spring 1991
LEGEND
City Boundary
Section Line
State Highway
Creeks
Road
Conveyance Canal
Study Area Boundary
Lines of Equal Depth (Interval 10 Feet)
50
SCALE 1" = 1 Mile
Clovis Water Master Plan Update
January 1995
Ken Schmidt & Associates
PROVOST & PRITCHARD ENGINEERING GROUP
EST. 1968
Print Date 02-22-95
Job No. 9405101
Dwg. No. 95-0027
COPPER AVE.
SHEPHERD AVE.
NEES AVE.
ALLUVIAL AVE.
HERNDON AVE.
SIERRA AVE.
BULLARD AVE.
BARSTOW AVE.
SHAW AVE.
GETTYSBURG AVE.
ASHLAN AVE.
DAKOTA AVE.
SHIELDS AVE.
McKINLEY AVE.
WILLOW AVE.
FOWLER AVE.
THOMPSON AVE.
HIGHLAND AVE.
VILLA AVE.
PEACH AVE.
CHESTNUT AVE.
CLOVIS AVE.
ARMSTRONG AVE.
TEMPERANCE AVE.
LOCAN AVE.
DE WOLF AVE.
LEONARD AVE.
McCALL AVE.
DEL REY AVE.
BETHEL AVE.
ACADEMY AVE.
BIG DRY CREEK DAM
BIG DRY CREEK
ENTERPRISE CANAL
TOLLHOUSE RD
FRIANT KERN CANAL
DOG CREEK
REDBANK CREEK
GOULD CANAL
168
110
100
90
80
70
60
50
40
30
20


Ground Water Flow Direction
Spring 1991
LEGEND
City Boundary
Section Line
State Highway
Creeks
Road
Conveyance Canal
Study Area Boundary
Water Level Elevation Above Mean Sea Level
Interval 20 Feet
Interval 10 Feet
Groundwater Flow Direction
SHEPHERD AVE.
NEES AVE.
HERNDON AVE.
SIERRA AVE.
BULLARD AVE.
BARSTOW AVE.
SHAW AVE.
GETTYSBURG AVE.
ASHLAN AVE.
DAKOTA AVE.
SHIELDS AVE.
McKINLEY AVE.
COPPER AVE.
ALLUVIAL AVE.
BIG DRY CREEK DAM
ENTERPRISE CANAL
BIG DRY CREEK
TOLLHOUSE RD.
FRIANT KERN CANAL
DOG CREEK
REDBANK CREEK
GOULD CANAL
THOMPSON AVE.
HIGHLAND AVE.
FOWLER AVE.
VILLA AVE.
CLOVIS AVE.
ARMSTRONG AVE.
TEMPERANCE AVE.
DE WOLF AVE.
LEONARD AVE.
McCALL AVE.
DEL REY AVE.
BETHEL AVE.
ACADEMY AVE.
PEACH AVE.
CHESTNUT AVE.
168
250
260
280
300
320
340
360
380
400
420
SCALE 1" = 1 Mile
Clovis Water Master Plan Update
January 1995
Ken Schmidt & Associates
EST. 1968
PROVOST & PRITCHARD ENGINEERING GROUP
Print Date 02-22-95
Job No. 9405101
Dwg. No. 95-0028


Change in Water Levels
(1978–1994)
LEGEND
City Boundary
Section Line
State Highway
Creeks
Road
Conveyance Canal
Study Area Boundary
DWR Network
FID Network
City Network
SCALE 1" = 1 Mile
Clovis Water Master Plan Update
January 1995
Ken Schmidt & Associates
PROVOST & PRITCHARD ENGINEERING GROUP
Print Date 02-22-95
Job No. 9405101
Dwg. No. 95-0034
BIG DRY CREEK DAM
ENTERPRISE CANAL
BIG DRY CREEK
TOLLHOUSE RD
FRIANT KERN CANAL
DOG CREEK
REDBANK CREEK
GOULD CANAL
168
-10
-20
-30
SHEPHERD AVE
NEES AVE
ALLUVIAL AVE
HERNDON AVE
SIERRA AVE
BULLARD AVE
BARSTOW AVE
SHAW AVE
GETTYSBURG AVE
ASHLAN AVE
DAKOTA AVE
SHIELDS AVE
McKINLEY AVE
FOWLER AVE
THOMPSON AVE
HIGHLAND AVE
VILLA AVE
PEACH AVE
DE WOLF AVE
LEONARD AVE
McCALL AVE
DE WEY AVE
BETHEL AVE
ACADEMY AVE

Location of Wells With Water-Level Hydrographs



LEGEND

City Boundary
Section Line
State Highway
Creeks
Road
Conveyance Canal
Study Area Boundary

DWR Network •
FID Network △
City Network ○

SCALE 1" = 1 Mile

0 1/4 1/2 1

Clovis Water Master Plan Update

January 1995

Ken Schmidt & Associates

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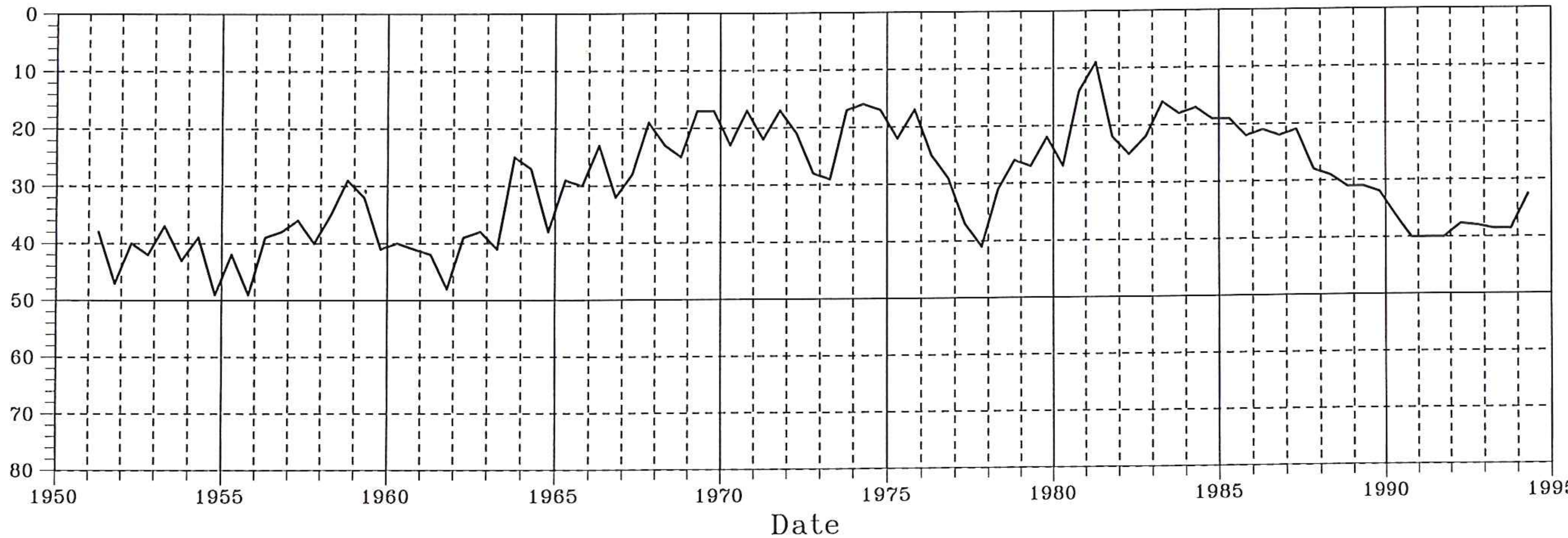
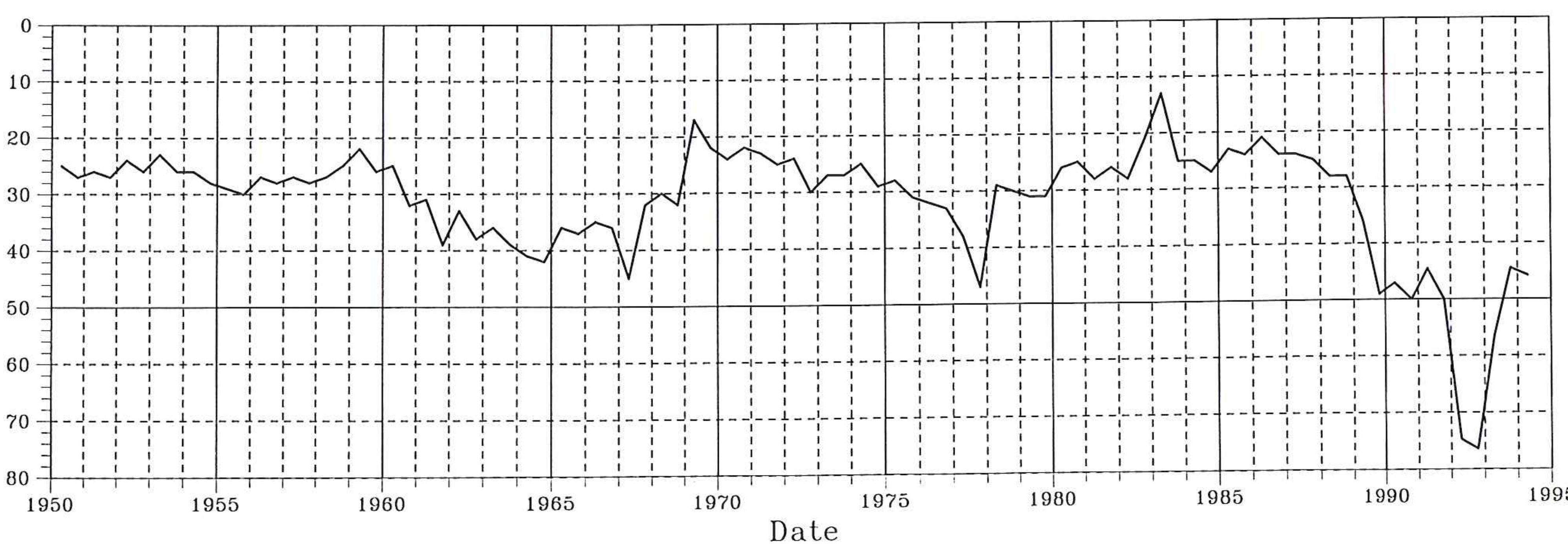
Print Date	02-22-95
Job No.	9405101
Dwg. No.	95-0029

Water Level Trends

Well T13S R22E 21 D2



Well T13S R22E 7R



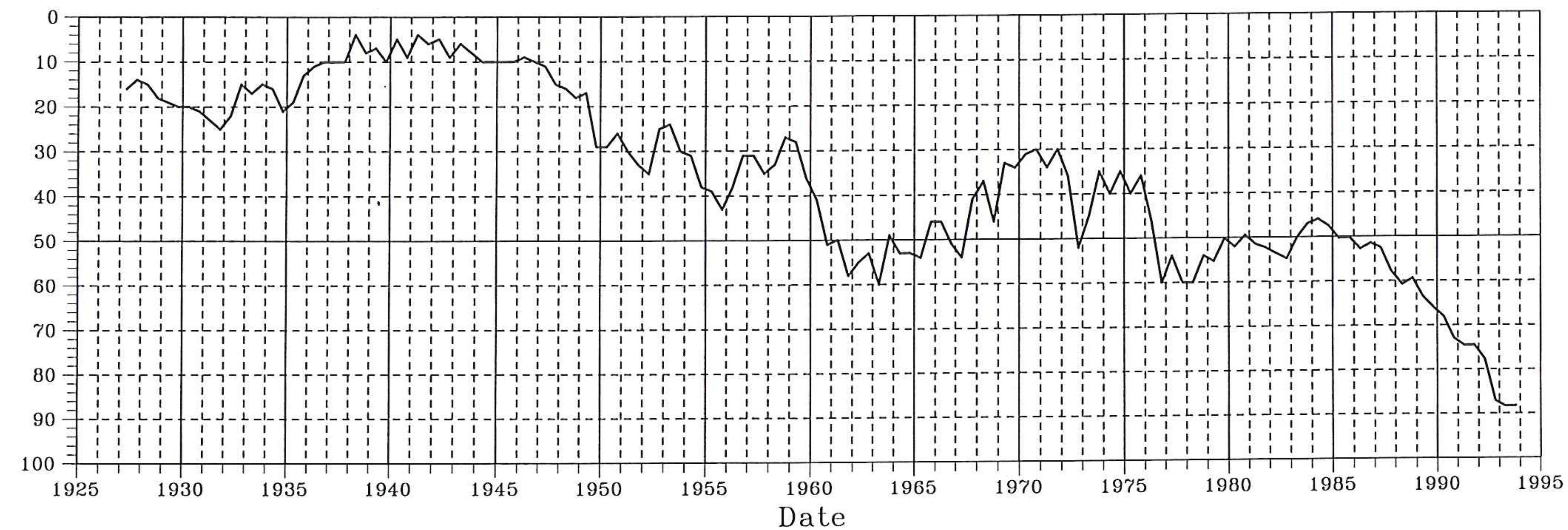
Within FID
SE of Enterprise Canal

Clovis Water
Master Plan Update
January 1995

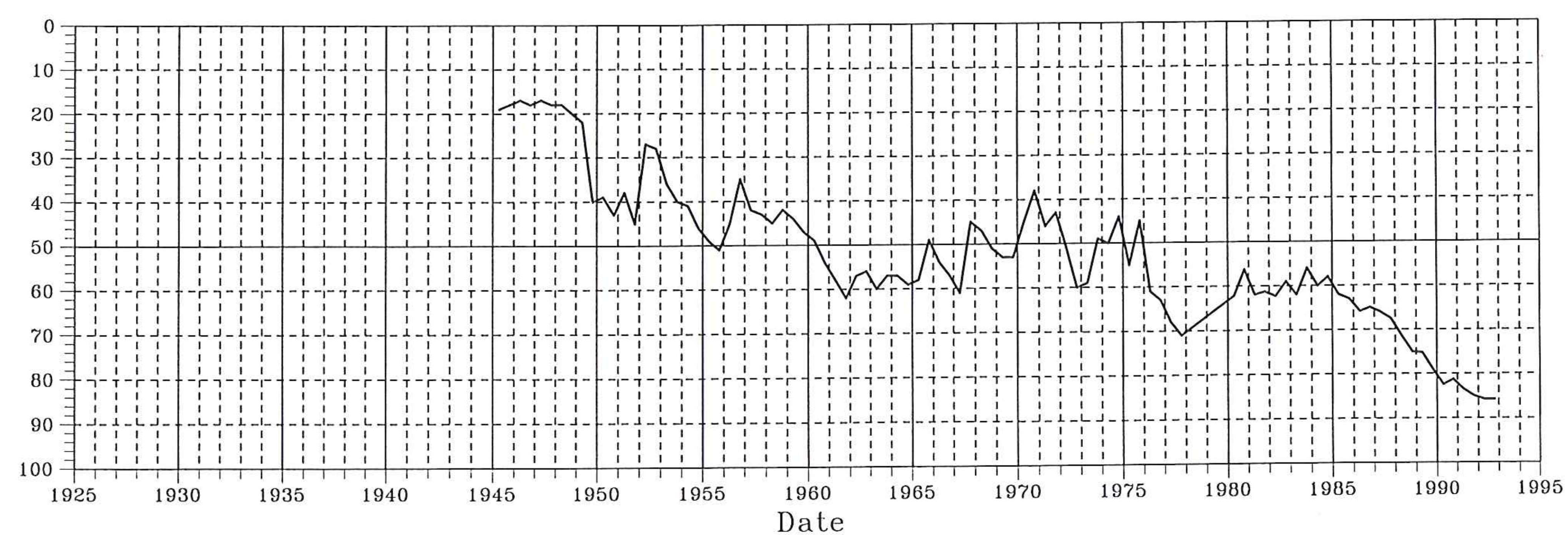
Ken Schmidt & Associates
EST. 1968
PROVOST & PRITCHARD
ENGINEERING GROUP
Print Date: 01/13/95
Job No. 9405101
Dwg No. HYGRAPH1.DWG

Water Level Trends

Well T12S R21E 33 P



Well T12S R21E 31 A



Within FID
Herdon Shepherd Plan Area

Clovis Water
Master Plan Update
January 1995

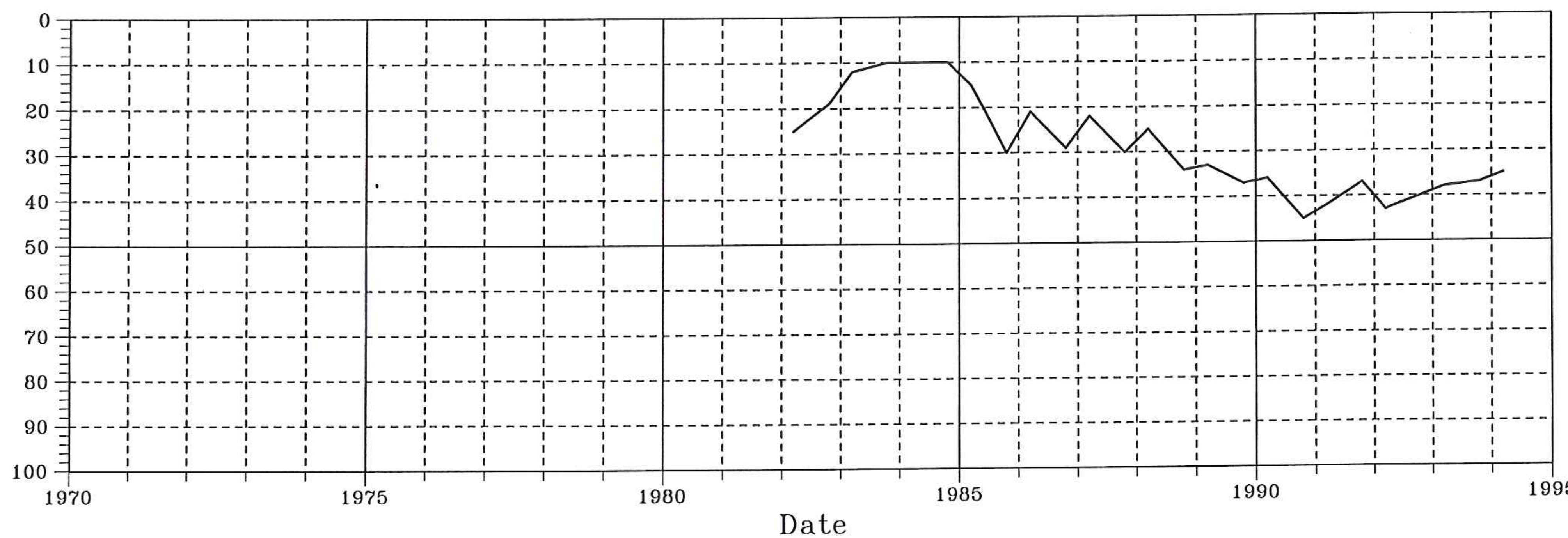
Ken Schmidt & Associates

EST. 1968
PROVOST & PRITCHARD
ENGINEERING GROUP

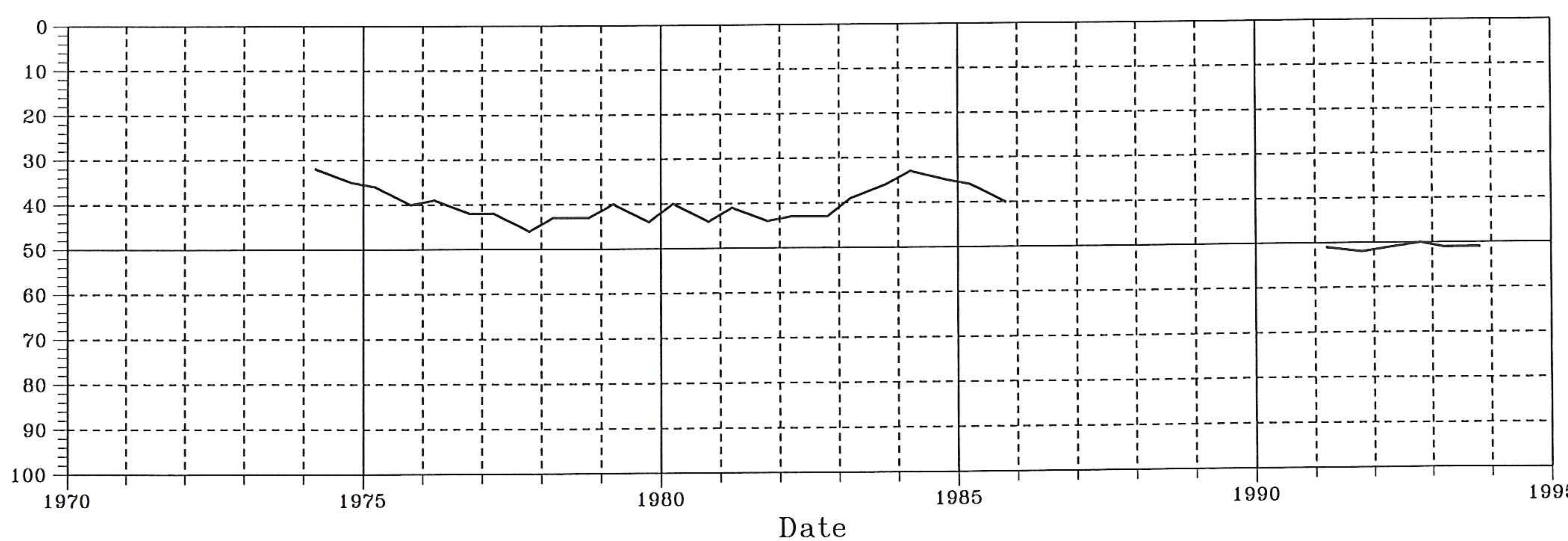
Print Date: 01/13/95
Job No. 9405101
Dwg No. HYGRAPH2.DWG

Water Level Trends

Well T12S R22E 30 D



Well T13S R22E 8 A



Outside FID
NE of Enterprise Canal

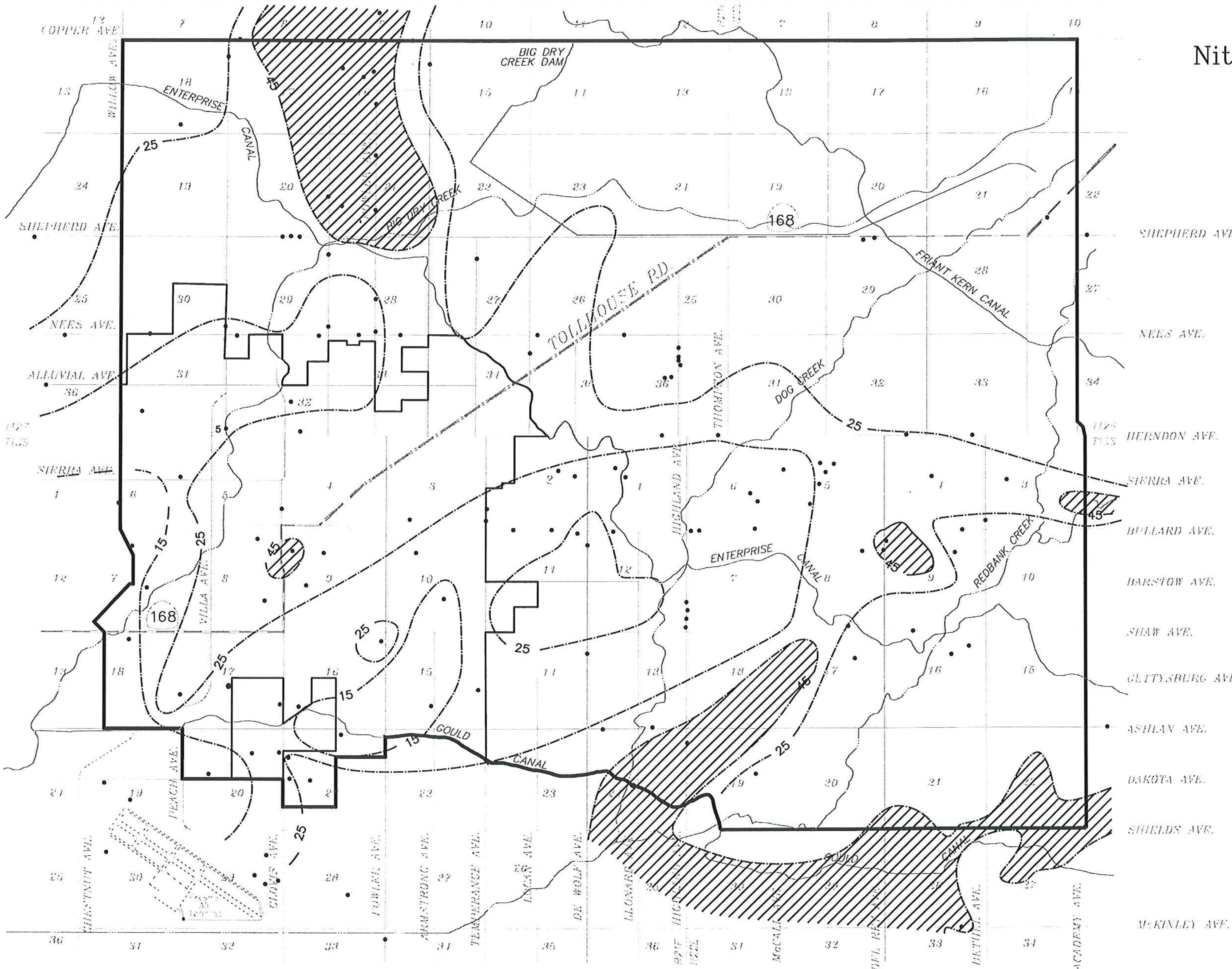
Clovis Water
Master Plan Update
January 1995

Ken Schmidt & Associates
EST 1968
PROVOST & PRITCHARD
ENGINEERING GROUP
Print Date: 01/13/95
Job No. 9405101
Dwg. No. HYGRAPH3.DWG

PLATE 23

Nitrate Concentrations In Well Water

(1989–1991)



LEGEND

- City Boundary
- Section Line
- State Highway
- Creeks
- Road
- Conveyance Canal
- Study Area Boundary
- Contour of Nitrate Content (in mg/l) (MCL is 45 mg/l)
- Nitrate Exceeds MCL
- Well Location

(Cross Hatched Area South of Ashlan From County of Fresno, Sampling 1978)

SCALE 1" = 1 Mile

Clovis Water Master Plan Update

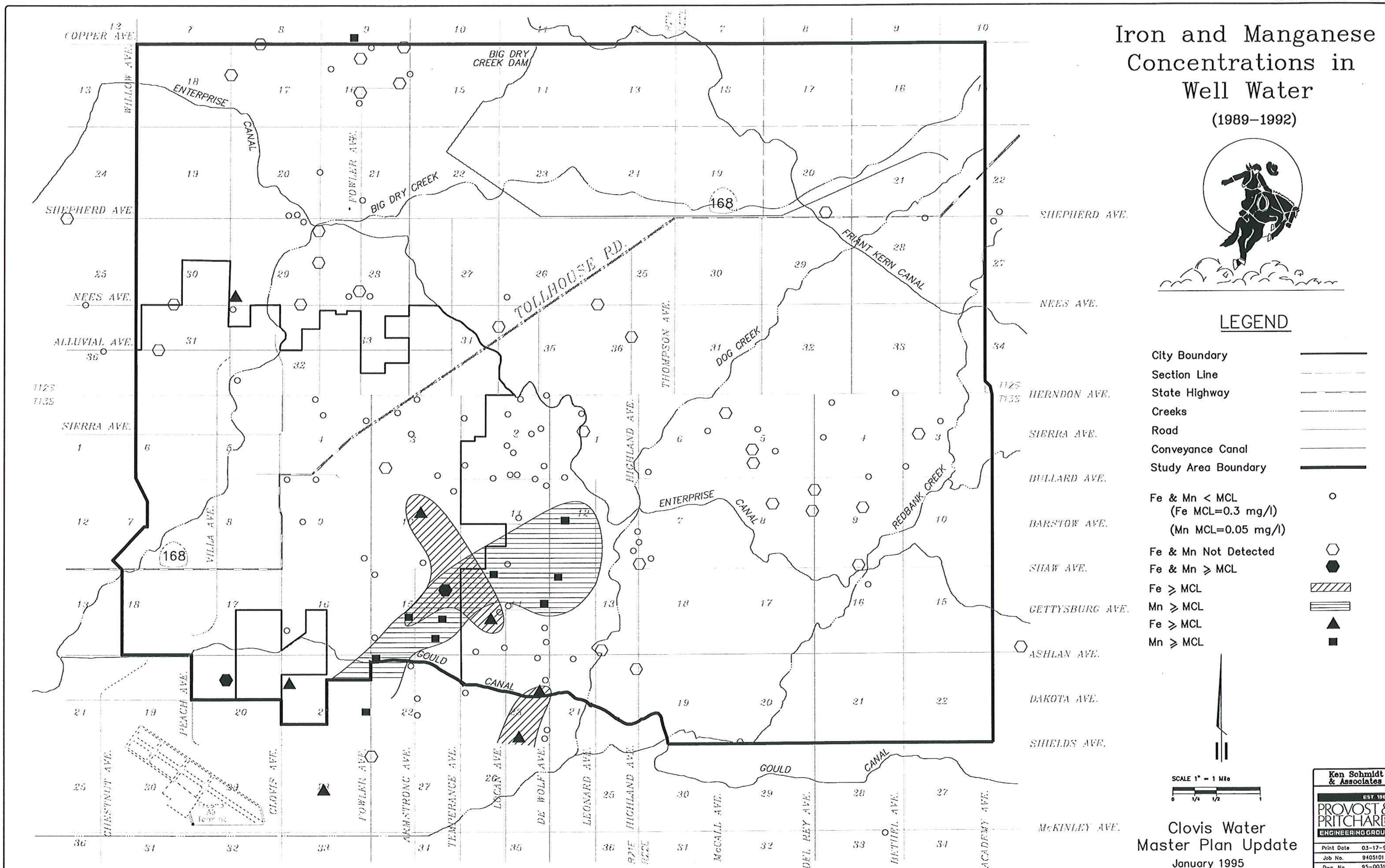
January 1995

Ken Schmidt & Associates

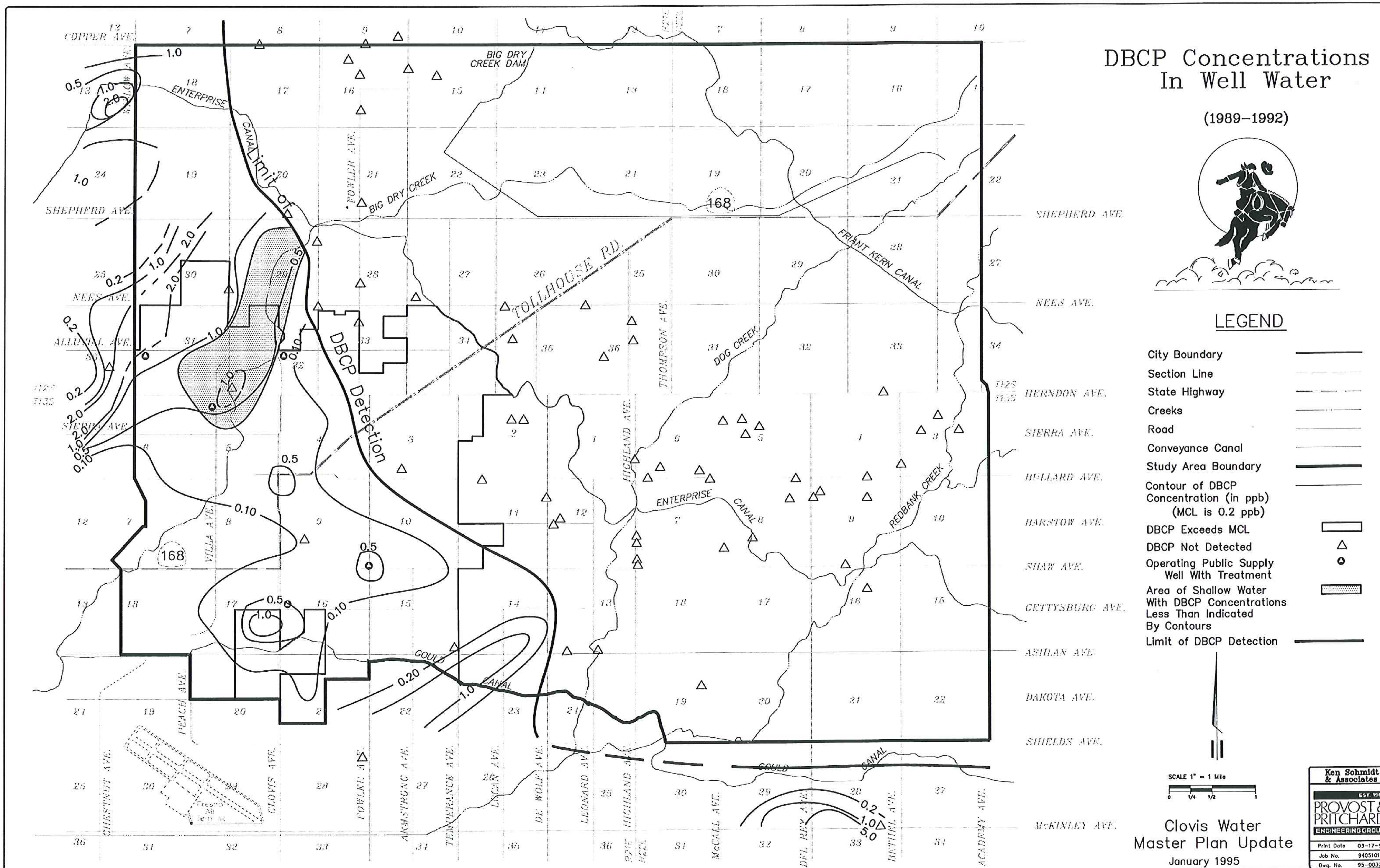
PROVOST & PRITCHARD ENGINEERING GROUP

EST. 1968

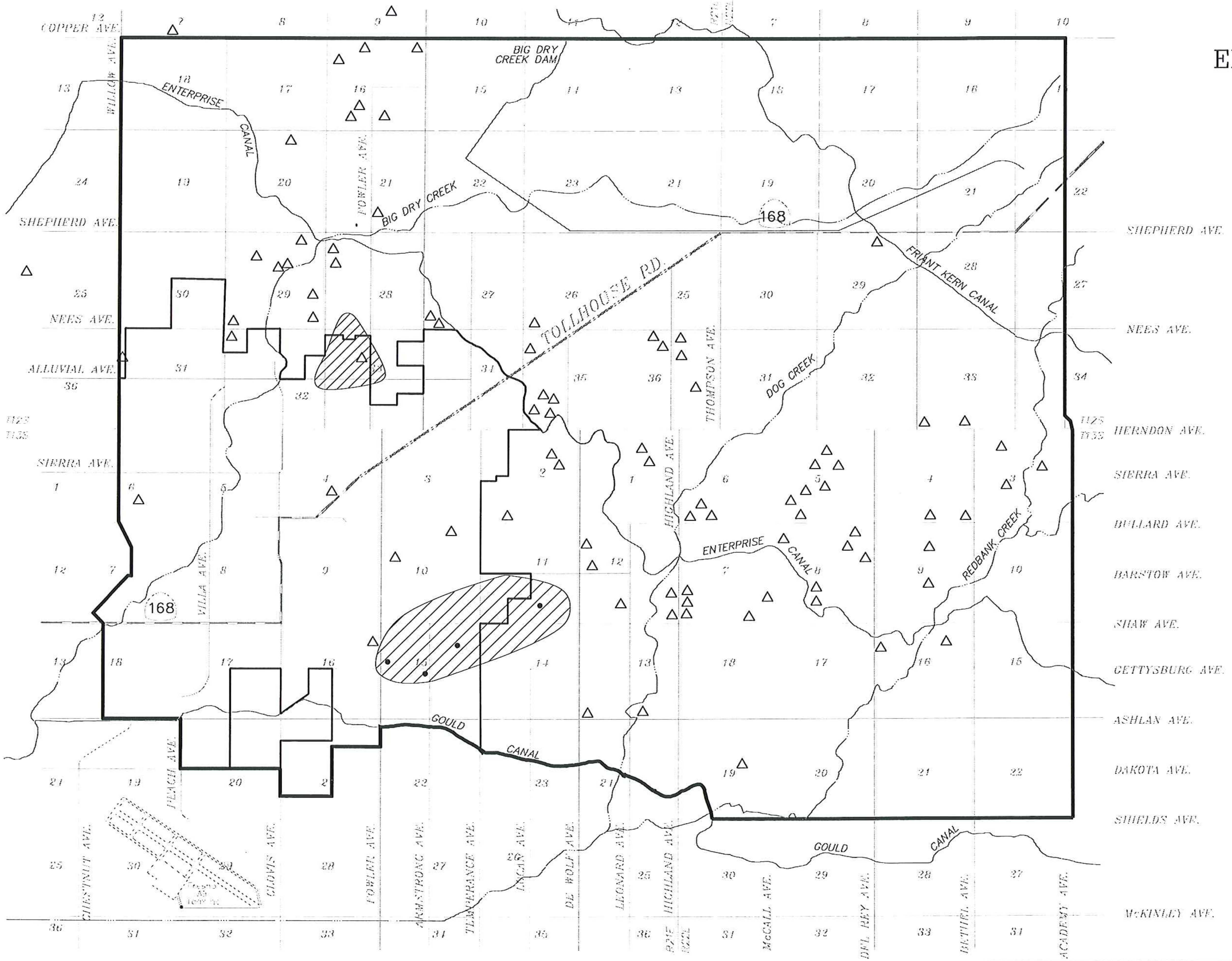
Print Date	02-22-95
Job No.	9405101
Dwg. No.	95-0030



Iron and Manganese Concentrations in Well Water
(1989-1992)
LEGEND
City Boundary
Section Line
State Highway
Creeks
Road
Conveyance Canal
Study Area Boundary
Fe & Mn < MCL
(Fe MCL=0.3 mg/l)
(Mn MCL=0.05 mg/l)
Fe & Mn Not Detected
Fe & Mn ≥ MCL
Fe ≥ MCL
Mn ≥ MCL
Fe ≥ MCL
Mn ≥ MCL
SCALE 1" = 1 Mile
Clovis Water
Master Plan Update
January 1995
Ken Schmidt & Associates
EST. 1968
PROVOST & PRITCHARD
ENGINEERING GROUP
Print Date 03-17-95
Job No. 9405101
Dwg. No. 95-0031
COPPER AVE.
SHEPHERD AVE.
NEES AVE.
ALLUVIAL AVE.
HERNDON AVE.
SIERRA AVE.
BULLARD AVE.
BARSTOW AVE.
SHAW AVE.
GETTYSBURG AVE.
ASHLAN AVE.
DAKOTA AVE.
SHIELDS AVE.
McKINLEY AVE.
WILLOW AVE.
FOWLER AVE.
THOMPSON AVE.
HIGHLAND AVE.
VILLA AVE.
PEACH AVE.
CLOVIS AVE.
ARMSTRONG AVE.
TEMPERANCE AVE.
LOCAN AVE.
DE WOLF AVE.
LEONARD AVE.
McCALL AVE.
DEL REY AVE.
BETHEL AVE.
ACADEMY AVE.
CHESTNUT AVE.
ENTERPRISE CANAL
BIG DRY CREEK DAM
BIG DRY CREEK
TOLLHOUSE RD.
FRIANT KERN CANAL
DOG CREEK
REDBANK CREEK
GOULD CANAL
168
T12S
T13S



Clovis Water Master Plan Update
January 1995



EDB Concentrations In Well Water

(1989–1994)

LEGEND

City Boundary	
Section Line	
State Highway	
Creeks	
Road	
Conveyance Canal	
Study Area Boundary	
EDB Concentration Equal to or Exceeds MCL (.02 ppb)	hatched
Nondetectable EDB	△
EDB Concentration In Public Supply Well ≥ MCL	•

SCALE 1" = 1 Mile

Clovis Water Master Plan Update

January 1995

Ken Schmidt & Associates

EST. 1969

PROVOST & PRITCHARD ENGINEERING GROUP

Print Date	02-22-95
Job No.	9405101
Dwg. No.	95-0033

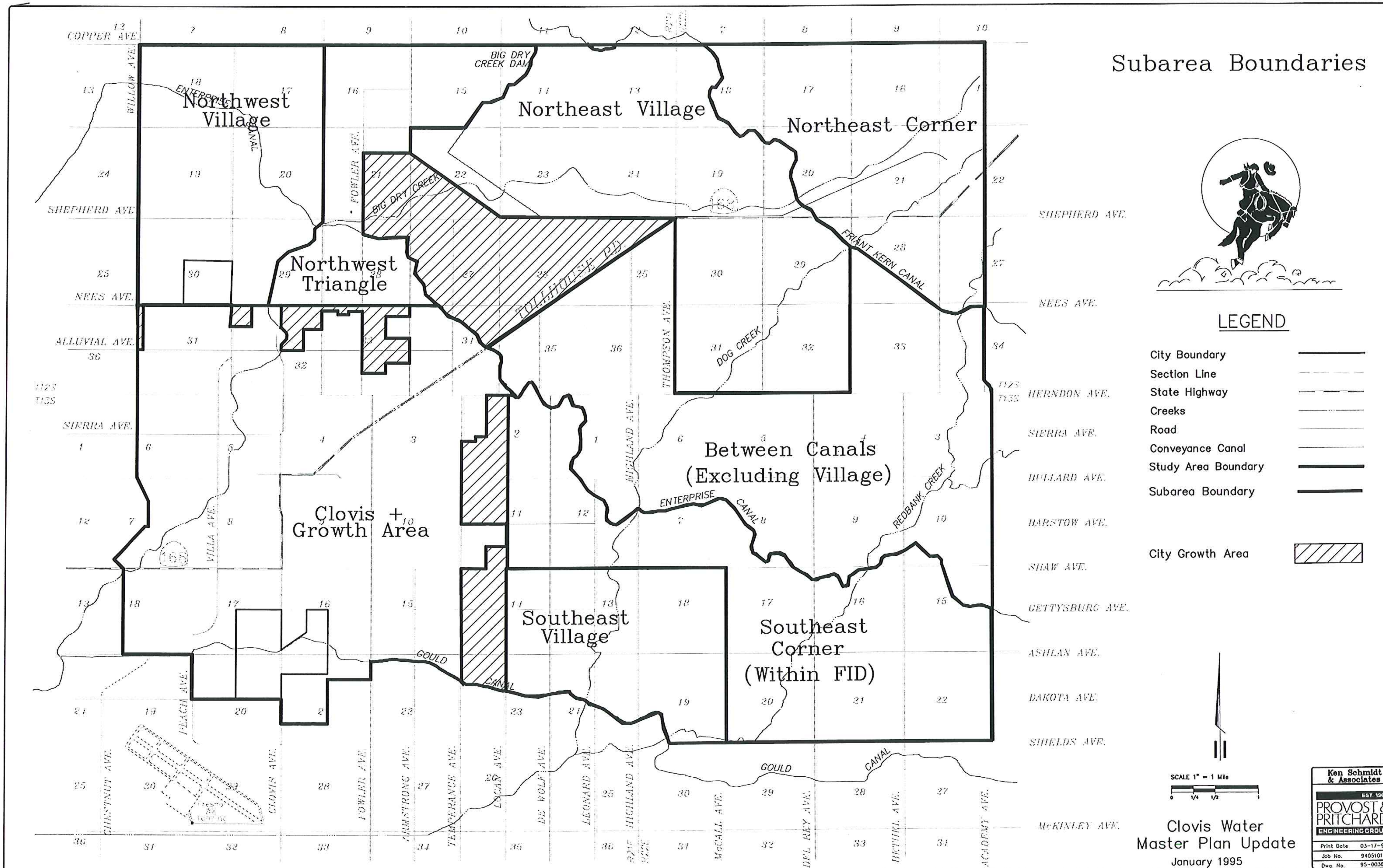
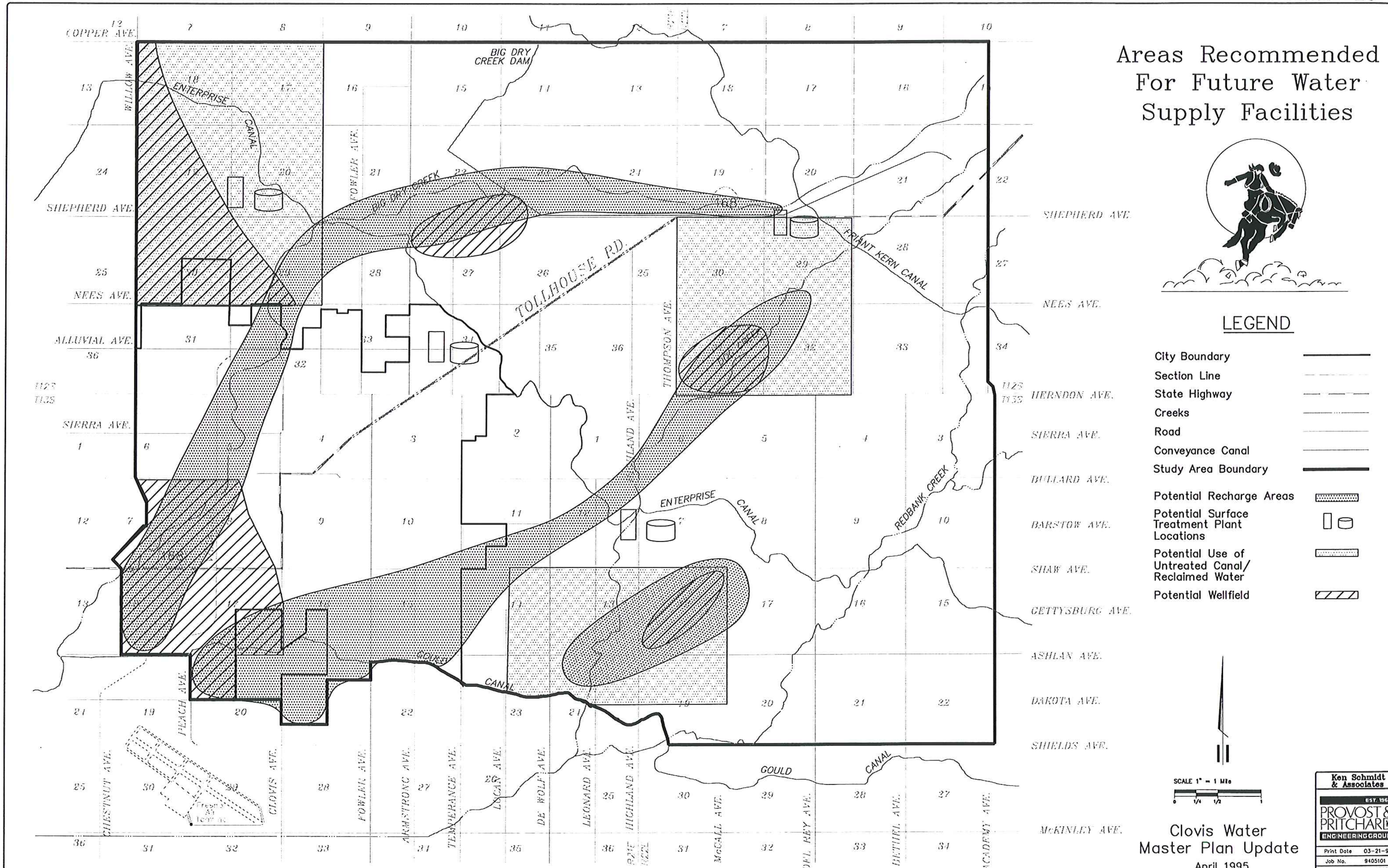
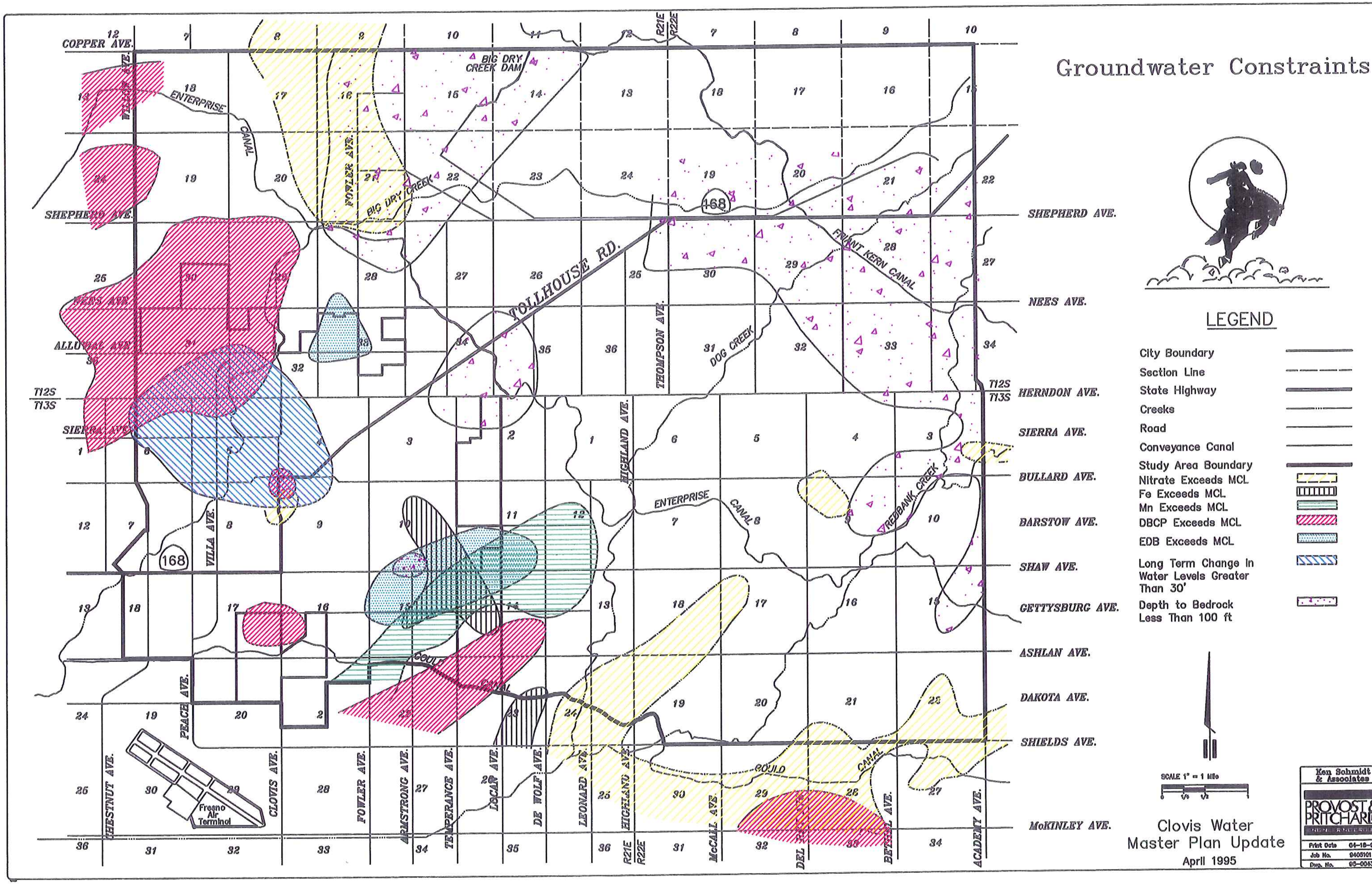

Subarea Boundaries
Northwest Village
Northeast Village
Northeast Corner
Northwest Triangle
Between Canals (Excluding Village)
Clovis + Growth Area
Southeast Village
Southeast Corner (Within FID)
BIG DRY CREEK DAM
BIG DRY CREEK
TOLLHOUSE RD.
FRIANT KERN CANAL
DOG CREEK
ENTERPRISE CANAL
REDBANK CREEK
GOULD CANAL
COPPER AVE.
SHEPHERD AVE.
NEES AVE.
ALLUVIAL AVE.
HERNDON AVE.
SIERRA AVE.
BULLARD AVE.
BARSTOW AVE.
SHAW AVE.
GETTYSBURG AVE.
ASHLAN AVE.
DAKOTA AVE.
SHIELDS AVE.
McKINLEY AVE.
WILLOW AVE.
FOWLER AVE.
THOMPSON AVE.
HIGHLAND AVE.
VILLA AVE.
PEACH AVE.
CHESTNUT AVE.
CLOVIS AVE.
ARMSTRONG AVE.
TEMPERANCE AVE.
LOCAN AVE.
DE WOLF AVE.
LEONARD AVE.
McCALL AVE.
DEL REY AVE.
BETHEL AVE.
ACADEMY AVE.
LEGEND
City Boundary
Section Line
State Highway
Creeks
Road
Conveyance Canal
Study Area Boundary
Subarea Boundary
City Growth Area
SCALE 1" = 1 Mile
Clovis Water Master Plan Update
January 1995
Ken Schmidt & Associates
PROVOST & PRITCHARD ENGINEERING GROUP
Print Date 03-17-95
Job No. 9405101
Dwg. No. 95-0036

PLATE 28

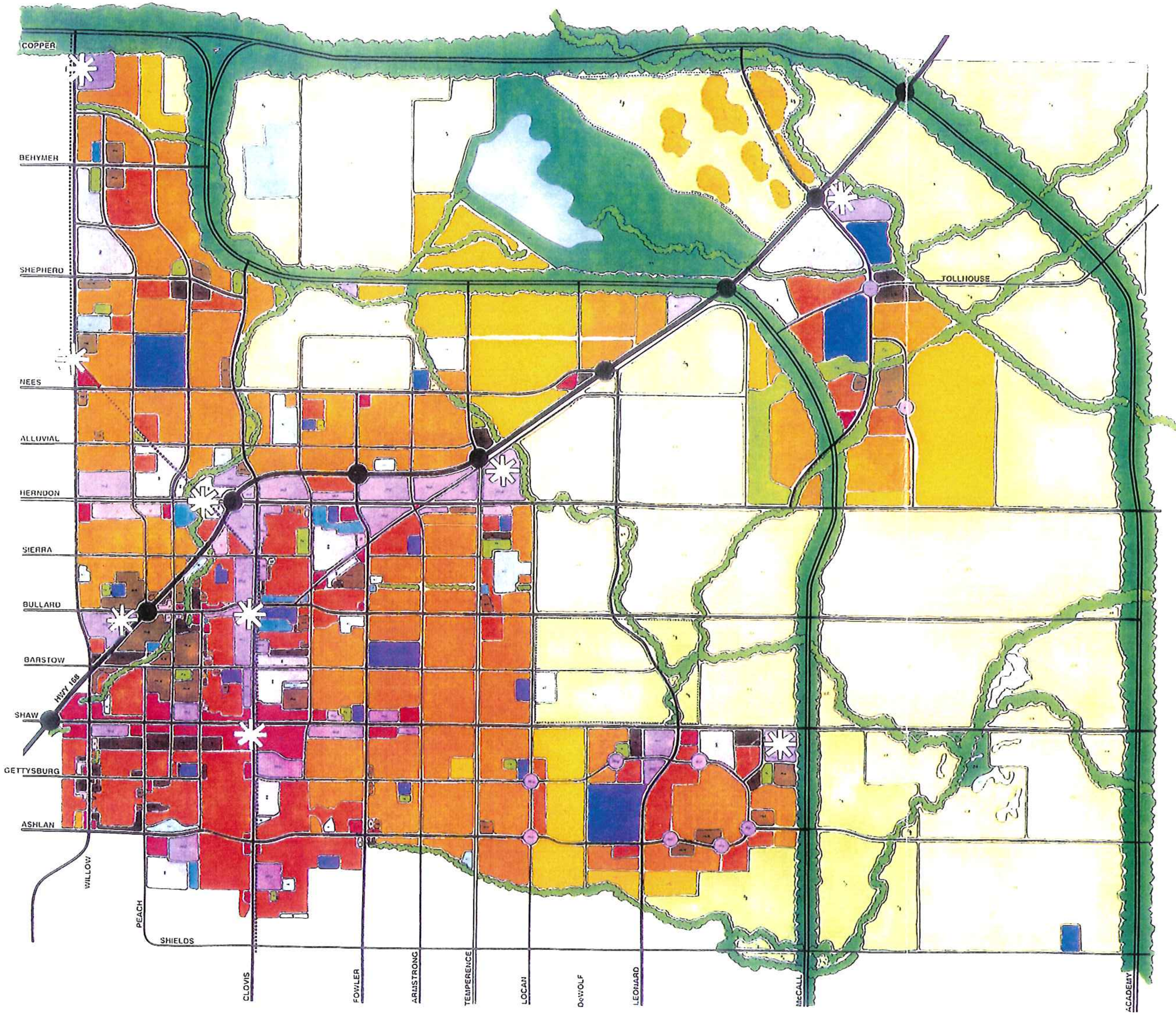

Areas Recommended For Future Water Supply Facilities
LEGEND
City Boundary
Section Line
State Highway
Creeks
Road
Conveyance Canal
Study Area Boundary
Potential Recharge Areas
Potential Surface Treatment Plant Locations
Potential Use of Untreated Canal/ Reclaimed Water
Potential Wellfield
COPPER AVE.
SHEPHERD AVE.
NEES AVE.
ALLUVIAL AVE.
HERNDON AVE.
SIERRA AVE.
BULLARD AVE.
BARSTOW AVE.
SHAW AVE.
GETTYSBURG AVE.
ASHLAN AVE.
DAKOTA AVE.
SHIELDS AVE.
McKINLEY AVE.
WILLOW AVE.
FOWLER AVE.
THOMPSON AVE.
PEACH AVE.
CHESTNUT AVE.
CLOVIS AVE.
ARMSTRONG AVE.
TEMPERANCE AVE.
LOCAN AVE.
DE WOLF AVE.
LEONARD AVE.
HIGHLAND AVE.
McCALL AVE.
DEL REY AVE.
BETHEL AVE.
ACADEMY AVE.
TOLLHOUSE RD.
BIG DRY CREEK DAM
BIG DRY CREEK
ENTERPRISE CANAL
FRIANT KERN CANAL
REDBANK CREEK
GOULD CANAL
SCALE 1" = 1 Mile
Clovis Water Master Plan Update
April 1995
Ken Schmidt & Associates
PROVOST & PRITCHARD ENGINEERING GROUP
EST. 1968
Print Date 03-21-95
Job No. 9405101
Dwg. No. 95-0063



Groundwater Constraints
COPPER AVE.
SHEPHERD AVE.
NEES AVE.
ALLUVIAL AVE.
HERNDON AVE.
SIERRA AVE.
BULLARD AVE.
BARSTOW AVE.
SHAW AVE.
GETTYSBURG AVE.
ASHLAN AVE.
DAKOTA AVE.
SHIELDS AVE.
McKINLEY AVE.
TOLLHOUSE RD.
ENTERPRISE CANAL
BIG DRY CREEK DAM
BIG DRY CREEK
FRIANT KERN CANAL
DOG CREEK
REDBANK CREEK
GOULD CANAL
THOMPSON AVE.
HIGHLAND AVE.
FOWLER AVE.
VILLA AVE.
PEACH AVE.
CHESTNUT AVE.
CLOVIS AVE.
ARMSTRONG AVE.
TEMPERANCE AVE.
LOCAN AVE.
DE WOLF AVE.
LEONARD AVE.
McCALL AVE.
DEL
BETHEL AVE.
ACADEMY AVE.
Fresno Air Terminal
168
R21E
R22E
T12S
T13S
LEGEND
City Boundary
Section Line
State Highway
Creeks
Road
Conveyance Canal
Study Area Boundary
Nitrate Exceeds MCL
Fe Exceeds MCL
Mn Exceeds MCL
DBCP Exceeds MCL
EDB Exceeds MCL
Long Term Change In Water Levels Greater Than 30'
Depth to Bedrock Less Than 100 ft
SCALE 1" = 1 Mile
Clovis Water Master Plan Update
April 1995
Ken Schmidt & Associates
PROVOST & PRITCHARD

FIGURE 1-2

Land Use Plan



Residential

- Agricultural (1 DU per 20 AC)
- Rural (.5 DU AC)
- Very Low (.6 - 2.0 DU AC)
- Low (2.1 - 4.0 DU AC)
- Medium (4.1 - 7.0 DU AC)
- Medium-High (7.1 - 15.0 DU AC)
- High (15.1 - 25.0 DU AC)

- Commercial
- Office
- Mixed Use
- Ind./Employment Center
- Public Facilities
- Schools
- Parks
- Open Space
- Water Basin
- Transit Center
- Beltway
- Village Center
- Special Study Area - to be included in Specific Plan Study

The City of CLOVIS General Plan Program

Note: Land use boundaries on this map are approximate and do not necessarily follow property lines.

THE PLANNING CENTER

0' 3000' 6000'

APPENDIX

Water Demand Summary

Clovis Water Demand Summary

Present Conditions, 1994

	Within FID* (52,572 ac-ft)			Other Districts** (8,151 ac-ft)				Outside Districts (18,295 ac-ft)					
	Urban	*R.R.*	*Ag*	*Urban*	*R.R.*	*Ag*	*Idle*	*Urban*	*R.R.*	*Dry Ag*	*Irr Ag*	*Idle*	***Total***
Acres	10,142	3,700	9.278	0	710	2,362	2,033	0	3,525	0	1,820	12,950	*46,520*
Ac-ft	19,188	5,550	27,834	0	1,065	7,086	0	0	5,288	0	5,460	0	*71,471*

Buildout Projections, 2030

	Within FID* (45,931 ac-ft)			Other Districts** (7,624 ac-ft)				Outside Districts (22,605 ac-ft)					
	Urban	*R.R.*	*Ag*	*Urban*	*R.R.*	*Ag*	*Idle*	*Urban*	*R.R.*	*Dry Ag*	*Irr Ag*	*Idle*	***Total***
Acres	16,820	4,220	2,080	2,820	815	250	1,220	3,620	5,870	3,750	1,900	3,155	*46,520*
Ac-ft	33,361	6,330	6,240	5,652	1,223	750	0	8,100	8,805	0	5,700	0	*76,160*

* Acreage Numbers includes FID exclusion.
** Other Districts consists of FID Annex, International and ½ of Garfield W.D.

LEGAL OPINION FROM GARY W. SAWYERS

LAW OFFICES OF
GARY W. SAWYERS
GARY W. SAWYERS
MELANIE J. ALDRIDGE
EAST SHAW COURT
1180 EAST SHAW AVENUE
SUITE 214
FRESNO, CALIFORNIA 93710-7812
TELEPHONE: (209) 228-8190
FACSIMILE: (209) 225-8955

January 30, 1995

Mr. James R. Provost
Provost and Pritchard, Inc.
286 West Cromwell
Fresno, CA 93711-6162

Re: City of Clovis
Our File No. 51477.004

Dear Jim:

Set forth below are our answers to the various questions you posed on behalf of the City of Clovis (the "City") in your November 28, 1994 letter. We have attempted to answer your questions as succinctly as possible; unfortunately, the complexity of the issues raised by your letter makes brevity difficult.

Introduction

All of your questions relate to the City's potential use of water supplies made available through the Central Valley Project. As you know, the administration of those supplies tends to be highly political and can vary dramatically with changes in Washington. The "new" Bureau of Reclamation (i.e., the Bureau under the Clinton Administration) has taken a very different approach to management of CVP water supplies from that of prior administrations, and many new regulations and policies now being developed could affect the City's plans.

Whether those new regulations and policies become effective will likely depend, at least in part, on the results of the 1996 elections and the Clinton Administration's reaction to the recent Republican takeover of Congress. Those political uncertainties cloud an already confused situation in Washington and impact the answers to several of your questions.

Many of our responses are also impacted by the Central Valley Project Improvement Act (the "CVPIA"), which became law on October 30, 1992 amidst substantial controversy and opposition from CVP water users. The Republican takeover of Congress is viewed by many as an opportunity to correct the perceived defects in the CVPIA, and an effort to amend the law can be expected in 1995. While no legislation has yet been prepared, it is likely that at least some of the CVPIA provisions relevant to the City's plans will be included in CVPIA reform legislation. We have tried to identify those issues impacting the City's plans which are most likely to be included in proposed CVPIA reform legislation.

Finally, it is important to note the possible role of the State Water Resources Control Board (the "SWRCB") in the City's plans to import new water supplies. As you know, if the City intends to use imported CVP water outside the SWRCB's permitted place of use for that water, it would be necessary to first obtain the SWRCB's permission to change the CVP place of use. It appears that all of the City's current service area is located within the CVP's permitted place of use, and thus the use of a new CVP water supply in the current City service area would probably not involve a SWRCB proceeding. However, the City's larger general plan area and/or its sphere of influence may not be entirely within the SWRCB's permitted place of use for the CVP. Delivery of water to annexed areas of the City outside the current CVP service area would require a change in the permitted place of use for CVP water permits. As a result, consideration should be given not only to what water will be acquired, but also where that water will be used. We have attempted to point out where possible SWRCB concerns might arise.

With those introductory comments in mind, we respond to your questions in the order you presented them:

Water Service Contract for the City

It is extremely unlikely that the City would be successful in obtaining a new water service contract from the Bureau in the near term. First, the CVPIA expressly precludes the Bureau from entering into any new long-term water service contracts until a variety of conditions have been satisfied. Those conditions include the completion of numerous environmental enhancement projects mandated by the CVPIA and the final implementation of Delta standards acceptable to both the SWRCB and the federal Environmental Protection Agency. Absent amendment of the CVPIA, it is likely that those conditions will take many years (if not decades) to satisfy, effectively precluding the execution of new long-term water service contracts in the CVP for the foreseeable future.

In addition, the CVP is already "oversubscribed," and existing CVP contractors would vigorously resist the dedication of CVP water supplies to new contractors until existing CVP demands have been satisfied. Even without opposition from existing CVP contractors, current environmental restrictions on CVP water make it extremely unlikely that the Bureau would commit itself to additional supplies via new long-term water service contracts.

Therefore, even if the CVPIA moratorium on contracting were lifted via amendment of the CVPIA (and there appears to be no motivation on the part of CVP contractors to pursue any revision in that aspect of the CVPIA), it is extremely unlikely that the City could acquire a long-term water service contract directly from the Bureau. It is far more likely that the City could acquire a Bureau water supply through an assignment or partial assignment of an existing CVP water service contract, or through a transfer arrangement with an existing CVP contractor.

Duration of CVP Water Service Contracts

In addition to prohibiting new long-term water service contracts, the CVPIA precludes the renewal of existing long-term water service contracts prior to the completion of a lengthy programmatic environmental impact statement. CVP water service contracts began to expire in 1989, with approximately 65 expiring on March 1, 1995. Among the districts with contracts expiring in 1995 are the Fresno Irrigation District (the "FID"), the International Water District (the "IWD") and the Garfield Water District (the "GWD").

Although the CVPIA requires the mandated EIS to be completed in late 1995, the enormous scope of that study renders that deadline unachievable. Moreover, it is inevitable that the sufficiency of the EIS will be the subject of litigation once it is completed, and it is fair to assume that any such litigation would continue for years. Therefore, because the completion of the required EIS is a precondition to long-term renewals of existing CVP water service contracts, it is likely that those long-term renewals will not occur for several years under the present statutory scheme.

In order to "bridge the gap" between the expiration of existing CVP water service contracts and long-term renewals, the CVPIA provides for a series of "interim" renewal contracts. Generally, the first interim renewal contract following the expiration of a CVP contractor's original water service contract will be for a term of three years. The FID, IWD and GWD have all negotiated interim renewals with three year terms.

After the initial three year interim renewal, the CVPIA allows subsequent interim renewals for up to two years each, continuing until a long-term renewal contract has been executed. Under the CVPIA, that long-term renewal is to be for a term of 25 years, which commences on the expiration of the last interim renewal

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contract executed by a contractor (rather than upon the expiration of the contractor's original water service contract).

Several provisions of the CVPIA relating to the renewal of water service contracts are troubling. For example, when describing the Bureau's obligation to enter into interim renewal contracts, the CVPIA provides that the United States "may" enter into interim renewals. The environmental community and some within the Bureau have interpreted the word "may" (as contrasted with the word "shall") to make interim renewal contracts permissive rather than mandatory. Similarly, while the CVPIA provides that the first long-term renewal contract is mandatory, it also implies that subsequent long-term renewal contracts (i.e., those that would be entered into after about 2025) are discretionary and not required.

Any suggestion that renewal contracts are not mandatory leads to uncertainty relative to the water supplies of CVP water service contractors. It also conflicts with both legislation enacted in 1956 which assured those contractors sequential renewals, and specific provisions contained in most original CVP water service contracts which expressly granted contractors the right to sequential renewals.

Because of concerns over contract certainty, the CVP contractors pursued and obtained an express commitment from the Bureau that the Bureau will provide successive interim renewal contracts for the entire period between the expiration of a contractor's original water service contract and the execution of its mandatory 25 year renewal. That commitment is embodied in provisions to be included in the first interim renewal contracts to be executed by CVP contractors in 1995, and hopefully will be carried forward in subsequent interim renewal contracts.[1] Additionally, the contractors reached agreement with the Bureau that the contractors would not waive their ability to later assert their rights to successive long-term renewal under either the 1956 legislation or their original water service contracts.

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[1] Interim renewal contracts are subject to a 60 day public comment period before they can be executed. The public comment period for the FID, IWD and GWD interim renewal contracts began on December 13, 1994. After the public comment period, the Bureau can propose revision of the negotiated form of interim renewal contract to respond to public comments, and can even decline to offer a contract which does not include those revisions. For purposes of this letter, it has been assumed that no such changes will be made. However, it may be that new or changed terms will be proposed prior to the execution of interim renewal contracts.

Thus, at the present time it appears that all CVP contractors will continue to have their contracts renewed through at least the year 2020, and more probably through at least 2025. It is, of course, impossible to predict what might happen when long-term renewal contracts expire three decades from now, although the CVP contractors have attempted to anticipate difficulties by preserving their asserted rights to successive renewals.

It is important to note that all contractual water quantities set forth in existing CVP water service contracts have been carried forward into the interim renewals. However, the Bureau has made it clear that it will revisit contract quantities when it negotiates long-term renewals, and will utilize information developed in the contract renewal EIS described above to determine whether any contract quantities should be reduced. The Bureau also intends to renegotiate many other provisions of its water service contracts based on the EIS at the time of long-term renewals. Undoubtedly, there will be substantial controversy if the Bureau attempts to cut contract supplies or radically change other contract provisions at the time of long-term renewals.

It is also important to note that contracting issues are among the highest priority for advocates of legislation amending the CVPIA. The expense and uncertainty associated with multiple interim renewal contracts is considered to be unacceptable, as is the Bureau's refusal to honor the 1956 contract renewal legislation or the rights of renewal contained in contractors' existing water service contracts. There has already been substantial discussion among contractors relative to possible CVPIA amendments which would "firm up" CVP water service contracts, and it is virtually certain that any CVPIA reform package will address the restrictions on contracting described above.

Provision of M&I Water

Bureau water service contracts all specify whether the water supply made available may be delivered only for irrigation, only for municipal and industrial ("M&I") use, or for both. Although many believe that contractual restrictions have largely been rendered moot in the context of water transfers under the CVPIA (see below), that is not entirely clear. Further, contractual restrictions on use would presumably continue to be relevant in the event of a partial or complete assignment of a CVP water service contract (again, see below).

The original CVP water service contract of the IWD permitted M&I deliveries, and that district's interim renewal contract continues to permit M&I uses of its CVP water supply. The original water service contracts of both the FID and GWD did not permit M&I water use; the GWD's interim renewal contract continues to permit only irrigation water deliveries. The FID's interim renewal contract has been amended to permit M&I water deliveries.

However, the Bureau takes the position that any conversion of irrigation water to M&I water is subject to Bureau approval, and that conversion must be accompanied by appropriate compliance with the National Environmental Policy Act, the Endangered Species Act, and other applicable federal statutes. By imposing these new requirements, the Bureau has essentially determined that it will be a participant in land use decisions involving the conversion of agricultural water to M&I uses. The Bureau's insistence on involvement in land use decisions is new, and there is no experience to suggest how onerous the Bureau's conditions for approval of conversions of irrigation water to M&I water will be. Nevertheless, this was a central issue for the Bureau in the negotiation of interim renewal contracts, and it is likely that the Bureau will seek to extract concessions from contractors seeking to make conversions.

As you know, there is a price differential between Bureau water delivered for irrigation purposes and M&I water. Prices vary district-by-district; however, in 1995, the cost of irrigation water delivered to the IWD will be approximately $22 per acre foot. By contrast, the M&I rate for 1995 to the IWD would be approximately $32 per acre foot. Any conveyance, storage or treatment costs incurred once the water has been delivered to the contractor must be added to those figures.

Assignment of Water Service Contracts

The Bureau has not yet approved any transaction in which water formerly delivered to a CVP water service contractor is to be delivered on a long term basis to another party. Most of the effort to move Bureau water from one entity to another has focused on water transfers, i.e., transactions in which a party retains its existing contractual relationship with the Bureau but agrees that a portion of its CVP water allocation may be delivered elsewhere. It is fair to say that the Bureau is still struggling with the administration of transfers (see below).

Permanent assignments of CVP water service contracts have been explored as an alternative to transfers. The Bureau presently views assignments as being different from transfers, in that a new party (the assignee) develops a direct contractual relationship with the Bureau and another party (the assignor) relinquishes that relationship. The Bureau has indicated that it would be receptive to pursuing assignments under appropriate circumstances; unfortunately, it is not clear what the Bureau considers to be "appropriate" circumstances, nor is it clear what requirements the Bureau would impose on an assignment.

At a minimum, it can be expected that the Bureau would insist on substantial environmental documentation under the National Environmental Policy Act, the California Environmental Quality Act, the Endangered Species Act and other applicable statutes. Further, as noted above, to the extent Bureau water would be delivered to annexed areas of the City outside the permitted place of use for CVP water under the Bureau's State water rights permits, it would be necessary to modify those permits in a proceeding before the SWRCB before any assignment could occur. Also, the Bureau would likely insist that all financial obligations of the assignor either be paid current or assumed in full by the assignee. Therefore, any unpaid operations and maintenance deficit of the assignor might have to be paid in a lump sum at the time of assignment (rather than amortized over the remaining term of the assigned contract as would be the case in the absence of an assignment) and any other past due amounts would probably be collected.

Perhaps most importantly, the assignee of a CVP water service contract would become subject to all provisions of Reclamation law, and would thus be required to develop a detailed conservation plan under the CVPIA, engage in Reclamation law reporting, and otherwise fulfill all obligations now imposed on existing CVP water service contractors. Nevertheless, an assignment would place an entity wishing to receive CVP water in a direct contractual relationship with the Bureau and eliminate the "middle man," i.e., a transferor.

The Bureau has also indicated its receptiveness to <u>partial</u> assignments of Bureau contracts. Therefore, it would not be necessary to assume <u>all</u> of an existing water service contract. Instead, an existing contract could be "fractionalized" and partially assigned to a willing assignee.

<u>M&I Shortage Provisions</u>

To the best of my knowledge, no M&I water is being delivered under Bureau water service contracts by the FID, IWD or GWD. As noted above, both the FID and the IWD will be able to deliver M&I water under their interim renewal contracts, and that ability will presumably continue in subsequent interim renewal contracts and in their long-term renewals. It is unclear whether the GWD will ever pursue M&I deliveries, although there is no reason to believe that the Bureau would object if the GWD sought to amend its contract in the future to permit M&I water use.

Historically, different Bureau M&I contractors have negotiated different shortage provisions for their water supplies. M&I contractors have asserted that they require more certainty than do agricultural contractors, and many M&I contractors have been successful in negotiating more favorable shortage provisions than those afforded to irrigation water contractors. Over the past few years, the Bureau has become more receptive to preferential treatment of M&I supplies, and has recently been quite willing to insert very favorable shortage provisions in M&I water service contracts. In addition, and perhaps most importantly, the Bureau has proposed (and has effectively adopted) a CVP-wide M&I shortage policy that now provides a maximum 25% shortage on M&I water supplies (as compared to a potential 100% shortage for irrigation water).

However, as irrigation water is converted to M&I use, preferential shortage provisions for M&I water pose a substantial operational problem for the Bureau. If water is made "firmer" simply by converting it from irrigation to M&I use, conversions will adversely affect remaining irrigation water users in times of shortage by dedicating additional water to satisfy M&I needs. As a result, the Bureau is attempting to develop a uniform protocol for administering conversion of irrigation water to M&I water to ensure that remaining irrigation water users are not adversely affected by conversions. No guidelines have yet been prepared, although several alternative approaches have been discussed by Bureau staff.

It may be that irrigation water converted to M&I water would remain subject to irrigation water shortages, thus making it less reliable than other M&I supplies but avoiding injury to remaining CVP irrigation water users. Another approach would be to develop a formula which, when taking into account historic CVP operations and the new preferential treatment of M&I water, would calculate the adverse impacts on remaining irrigation water users of a conversion of irrigation water to M&I water. The amount of M&I water made available as the result of a conversion would then be "discounted" to an amount which would leave remaining irrigation water users "whole" in times of shortage.

For example, if a CVP contractor proposed to convert 1,000 acre feet of irrigation water to M&I uses, the Bureau might determine that the effect on remaining irrigation water users of delivering 700 acre feet of M&I water with preferential shortage provisions would be the same as delivering the 1,000 acre feet of irrigation water proposed for conversion. If that determination were made, the CVP contractor wishing to make the conversion would no longer be permitted to deliver 1,000 acre feet of water for irrigation purposes, but could deliver 700 acre feet for M&I purposes with preferential shortage provisions. Effectively, the CVP contractor would lose 300 acre feet of allocation in years of full supply. Please note that the figures used in this example are fictitious, and actual "discounts" might vary significantly.

It is not clear when or how the Bureau will develop its M&I conversion policy. However, if the City is considering obtaining additional water supplies through conversion of existing irrigation water supplies, it would be well advised to participate in development of that policy. Moreover, it should be noted that the FID's Friant Division supply is entirely "Class 2" water, i.e., it is water which by definition is unstorable and is available only periodically. By contrast, the water supplies of both the IWD and the GWD are "Class 1" supplies, which are considered to be "firm" supplies. Therefore, regardless of the shortage provisions applicable to irrigation or M&I supplies, water derived through the IWD or GWD contracts will be firmer since Class 2 water develops only after all Class 1 needs have been satisfied. From the City's perspective, FID water, as Class 2 water, would be more appropriate for groundwater banking or for use as a supplemental supply.

San Joaquin River Study

As you know, the CVPIA requires the Bureau to develop a plan that is "reasonable, prudent and feasible" to address fish and wildlife issues on the San Joaquin River below Friant Dam. As now described in the CVPIA, the plan is to be comprehensive and will consist of a variety of features. However, the most widely publicized and controversial element proposed for inclusion in the plan is the restoration of an anadromous fishery (i.e., a salmon run) from the Delta to Friant Dam.

Water users throughout the Friant service area have strenuously argued that the amount of water required to support a salmon run makes the reestablishment of an anadromous fishery not reasonable, prudent or feasible. Secretary of the Interior Bruce Babbitt recently agreed, and has confirmed the Clinton Administration's belief that reestablishment of a salmon run on the San Joaquin River should not be a part of the restoration plan developed under the CVPIA.

Nevertheless, the CVPIA requires the development of a plan, including the study of alternatives for reestablishing an anadromous fishery on the San Joaquin River. Representatives of the Bureau and the United States Fish and Wildlife Service are actively developing the plan on a timetable that will see it finalized by the September 30, 1996 deadline set forth in the CVPIA.

Because of the uproar surrounding the reestablishment of a salmon run, little attention has been paid to other potential aspects of the plan. In all probability, a variety of restoration programs will be suggested, including riparian habitat enhancement and improved recreational facilities. Of course, the specifics of the plan will not be known for another two years; moreover, the CVPIA specifically provides that water will not be released from Friant Dam as a means of implementing any aspect of the plan (or any other element of the CVPIA) in the absence of a specific Act of Congress. Thus, because of the uncertainty associated with the plan development, the politics surrounding restoration of an anadromous fishery, and the potential for a legislative debate before Congress over key elements of the plan, it is difficult to predict what, if any, ramifications the plan will have for Friant Division water supplies.

Amendment of the San Joaquin River provisions of the CVPIA will undoubtedly be a top priority for Friant water service contractors in the new Congress. Especially in light of the Clinton Administration's announced opposition to restoration of a salmon run on the San Joaquin River, there will undoubtedly be a substantial effort to delete that aspect of the plan through CVPIA amendments and otherwise circumscribe the other elements which might be included in the final plan. To the extent those amendments are enacted, the threat posed by the CVPIA to Friant water supplies will be greatly reduced.

However, with or without legislation, it is entirely possible that the San Joaquin River plan will result in additional expenditures which could increase the cost of Friant water supplies. Those increases, especially when combined with the "Friant surcharge" assessed under the CVPIA in lieu of requiring releases of San Joaquin River water (presently at the rate of $4 per acre foot) and other price increases resulting from the CVPIA should be considered by the City in its long range planning.

While it is hoped and believed that the CVPIA will not result in any substantial dedication of Friant water supplies to environmental purposes, it must be remembered that there are other threats to those water supplies which should be monitored. For example, the new Delta water quality standards must be implemented, and the contribution of the Friant Division, if any, to achieving those new standards has not yet been determined. Similarly, Endangered Species Act considerations in the Delta and elsewhere will continue to require additional water; while Friant water supplies have yet to be implicated, future compliance activities should not be ignored.

Therefore, while Friant water supplies have historically been among the more dependable within the CVP (due principally to the Friant Division's hydrologic independence from the balance of the CVP), implementation of both the CVPIA and other environmental regulatory schemes must be carefully monitored. In short, Friant water supplies are like <u>all</u> existing water supplies in California in that they are subject to some level of uncertainty imposed by increased environmental demands.

<u>Contract Renewal Issues</u>

Although the theory of interim renewal contracts is to simply preserve the status quo until long-term renewal contracts are negotiated based on the EIS described above, the Bureau has utilized the interim renewal process as a vehicle to implement a number of new policy initiatives. For example, water deliveries under interim renewal contracts are conditioned on the development and implementation of a comprehensive water conservation program acceptable to the Bureau. Each Bureau contractor must comply with rigorous water conservation guidelines in the context of its conservation program and adopt a number of "best management practices." In addition, the water conservation guidelines imposed under the interim renewals require the development of groundwater management programs under AB 3030, the consideration (and in most cases implementation) of a tiered pricing program, and substantial water measuring and reporting requirements.

The Bureau has also required all CVP contractors with "operations and maintenance deficits" arising prior to 1986 to repay the full amount of those deficits over the three year term of their interim renewal contracts (rather than amortizing the amount through the year 2030 as had originally been promised by the Bureau). The Bureau's insistence on accelerated repayment of these deficits is typical of the new Bureau attitude that water prices should be increased substantially to reflect the "true value" of the water.

Perhaps the most noticeable shift in direction displayed in the interim renewal contracting process relates to an internal memorandum prepared by Bureau Commissioner Dan Beard in July 1994. In his memorandum (which was released to CVP contractors in the Fall), the Commissioner set the new Bureau policy relative to contracting. Under that policy, the Bureau is to make as few commitments to contractors as possible, and is to limit any commitments which must be made to the shortest term legally allowed. According to the Commissioner's memorandum, he believes that the Bureau must reserve for itself as much flexibility and power as possible to alter its management of water supplies. That general philosophy was evident throughout the negotiations with the Bureau on the interim renewal contracts, and can be expected to continue until a change occurs in the Clinton Administration.

As one example of the Bureau's effort to implement this policy, the shortage provisions originally proposed by the Bureau for interim renewal contracts would have allowed the Bureau complete discretion to <u>unilaterally</u> determine how to allocate shortages among contractors. The Bureau negotiators were quite candid about the Bureau's desire to make those allocations from year-to-year based on the Bureau's determination of the "worthiness" of a particular contractor for water supplies. While that shortage provision was negotiated out of the interim renewal contracts by the contractor negotiating team, it is indicative of the Bureau's new attitude towards contractual certainty.

It should also be noted that historically, all CVP water service contracts have been "take or pay" contracts. Under a "take or pay" contract, a contractor must pay for all water made available to it whether it takes the water or not. All interim renewal contracts in the CVP, with the exception of Friant interim renewal contracts, will be "take and pay" contracts, meaning that contractors will pay only for that water made available to them which they actually receive. The CVPIA mandates that all long-term renewals of CVP contracts be "take and pay" in character because the CVPIA mandates the imposition of tiered water pricing on CVP contractors once long-term renewals are executed; the underlying theory of tiered water pricing (i.e., that it promotes conservation by discouraging contractors from taking more water than they can economically utilize) is defeated if long-term renewal contracts remained "take or pay" contracts. The Bureau wanted to "get a head start" on conversion of contracts to "take and pay" contracts by converting interim renewal contracts.

Because of the two class system of water in the Friant Division, Friant contractors requested that their interim renewal contracts remain as "take or pay" contracts pending a study of the ramifications of converting Friant water service contracts to "take and pay" status. That request was granted by the Bureau, but Friant water service contracts will ultimately be converted to "take and pay" contracts absent a revision of the CVPIA. When CVPIA amendments are pursued, it is likely that an effort will be made to delete tiered water pricing provisions, meaning that it may be possible to retain "take or pay" contracts indefinitely. To the extent contracts are "take or pay" in nature, it may mean that contractors will be anxious to dispose of water in wetter years if they cannot use it since they will be required to pay for it.

CVPIA Water Transfers

The CVPIA contains lengthy water transfer provisions which allow, for the first time, water to be transferred outside the CVP service area over the objection of a CVP contractor. These transfer provisions were hailed by some as a breakthrough for California water management. However, the reality has not matched expectations, and the Bureau can fairly be characterized as confused in its handling of water transfer requests under the CVPIA.

No long term transfers of CVP water have yet been approved. As a result, it is difficult to describe all of the aspects of the transfer process with certainty. Thus, while from a purely legal standpoint transfers are now possible under the CVPIA provided the applicable conditions are satisfied, the requirements for transfers are still unclear.

In an effort to clarify its CVPIA transfer procedures, the Bureau has developed interim transfer guidelines to implement the water transfer provisions of the CVPIA. The guidelines will remain in effect until final rules and regulations are promulgated, which are not expected for at least another eighteen months. One Bureau contractor has asserted that the interim guidelines must comply with NEPA prior to becoming effective; however, the practical impact of that argument is that the interim guidelines are invalid, leaving parties to a transfer with no guidance as to implementation issues. The guidelines are subject to revision by the Bureau, and transfers under the interim guidelines will also be subject to compliance with any final rules and regulations.

Under the CVPIA, a transfer may be made by either a CVP contractor or by an individual water user who receives a water allocation from a CVP contractor. Prior to the CVPIA, it was not legally possible for an individual water user in California to transfer its water allocation without the cooperation of the water supplier. However, the CVPIA expressly provides that water users receiving water from the CVP may transfer their water allocations over the objections of the water supplier, subject to specified conditions.

A transfer under the CVPIA requires approval by the Bureau, but <u>does not</u> require approval by the contractor holding the water supply unless more than 20 percent of the total CVP water supply of that contractor is proposed to be transferred. Although the statutory language is somewhat unclear, it is generally agreed that the 20 percent figure refers to the collective water supplies of all water users within the contractor, not 20 percent of the supply available to <u>each</u> water user.

The CVPIA limits the amount of water available for transfer to that which would have been consumptively used or irretrievably lost to beneficial use in the absence of the transfer, i.e., a crop's consumptive use, amounts resulting from transportation losses, return flows, or deep percolation to usable groundwater basins. The determination of the portion of the water supply which would have been consumptively used must be approved by the Bureau. In order to determine the consumptive use limitations on a proposed transfer, historical usage of water will be examined.

All transfers under the CVPIA must be "consistent with State law," including the California Environmental Quality Act. No one, including the Bureau, is quite sure of the definition of "consistent with State law." Clearly, certain consents from the SWRCB and compliance with CEQA will be required (see below). However, there is no right under State law for a water user to transfer its individual allocation, and it is unclear how this conflict between State law and the CVPIA will be resolved.

Nevertheless, the Bureau believes the CVPIA allows for water user initiated transfers, and that view is almost certainly correct.

Transfers outside of the CVP service area are subject to a right of first refusal by entities within the CVP service area. Thus, if the City is able to negotiate a transfer and the intended delivery area is outside the CVP service area, the transfer could be subject to a right of first refusal in favor of entities within the CVP service area. The right of first refusal may only be exercised for a period of 90 days from the date notice of the proposed transfer is published. The Bureau's existing transfer guidelines require that a public notice of intent to transfer be published in various major newspapers throughout the CVP service area and also be provided to all CVP associations, e.g., the Central Valley Project Water Association, Friant Water Users Authority, etc. If this right of first refusal is successfully exercised, the CVPIA provides that the transferee must be reimbursed for the total costs associated with the development and negotiation of the transfer.

Transfers under the CVPIA will not be approved unless they do not have any significant long-term adverse effects on groundwater conditions. Because the consumptive use requirements imposed on transfers under the CVPIA mandate that any water that would have reached the groundwater be "left behind," additional restrictions on a proposed transfer as the result of this provision of the CVPIA are not likely. However, the transferor would need to show that it would not resort to groundwater to replace the transferred water, or that substitution of groundwater would not have a significant long-term adverse effect on the groundwater supply. Although the CVPIA requires a determination that there will be no significant effect on the groundwater, the interim transfer guidelines developed by the Bureau apparently only require that a groundwater study be provided if groundwater is to be substituted for the transferred water.

A transfer would not be approved by the Bureau if the Bureau believed that it would have an unreasonable impact on the water supply, operations or financial condition of the contractor or its water users. In fact, the Bureau's transfer guidelines require a statement from the contractor that such an impact will not occur.

If the use of transferred water would be outside of the existing CVP service area, the greater of the cost of service rate or the M&I rate for CVP water would have to be paid for all water transferred. In addition to those higher water rates, a $25 per acre foot surcharge would be imposed on all water used for M&I purposes outside the existing CVP service area.

The Bureau will also require any proposed transfer to comply with the National Environmental Policy Act. It will be up to the Bureau and involved state agencies to determine what level of NEPA/CEQA documentation (as well as documentation under the Endangered Species Act and other environmental statutes) would be required in connection with a proposed transfer. While the CVPIA requires that all transfers be consistent with federal and state laws (including NEPA and the Endangered Species Act), the Bureau's current transfer guidelines expressly provide that transfers must also be consistent with the Fish and Wildlife Coordination Act and the California Endangered Species Act. Compliance with those laws is the responsibility of the transferor, and documentation of compliance must be attached to the transfer application filed with the Bureau.

The CVPIA requires that the Bureau approve or deny a transfer within 90 days of the submission of a completed transfer proposal. The Bureau takes the position that a proposal is not "received" by the Bureau until it has been completed to the Bureau's satisfaction. As a result, the Bureau asserts that a number of transfer proposals which have been in the Bureau's possession for more than a year have not been "received" for purposes of the CVPIA. The Bureau's transfer guidelines provide a checklist to determine whether an application is complete. The checklist is quite extensive and requires attachment of CEQA compliance documentation, a groundwater study if applicable, and other materials.

All costs associated with the review and processing of a transfer application by the Bureau must be reimbursed. The guidelines currently require a deposit with the submission of an application. If the costs are less than the deposit, the excess deposit will be refunded. Costs in excess of the initial deposit will be billed to the transferor. The transferor is also responsible for the cost of preparation of all environmental documentation and any mitigation measures required as a result of the environmental review.

The guidelines require that all approved transfers be reviewed annually to ensure that the water quantity transferred is consistent with the quantity available and that no adverse impacts on the environment or CVP operations would occur if a long-term transfer continued. The Bureau reserves the right to terminate the transfer if such conditions occur. No guidance is given as to what rights, if any, a transferor or transferee would have under these circumstances.

In addition to approval by the Bureau, any proposed transfer to the City would require a number of other governmental consents. First, it would be necessary to obtain a modification of the place of use restrictions in the water rights permit issued to the Bureau by the SWRCB if any transferred water would leave the CVP permitted place of use. Permission to change the place of use for the transferred water would be pursued via the filing of an application with the SWRCB. In the absence of material protests, the SWRCB would likely approve the application without a hearing. However, if protests were received, a hearing on the advisability of allowing the change in place of use would occur. The SWRCB process would require compliance with CEQA, but that compliance would be coordinated with the NEPA compliance required by the Bureau.

The costs associated with pursuing a transfer would vary depending upon the difficulties encountered and the number of parties with whom the City would deal. For example, uncontested proceedings before the SWRCB would be relatively simple and inexpensive, while a contested hearing could prove to be quite costly. Of course, the Bureau, the SWRCB and other agencies with which the City would deal will charge processing fees. A critical cost factor would be the cost of an environmental impact statement/environmental impact report, as the preparation of those documents would undoubtedly be expensive. Any direct costs incurred by the City for pumping the water and/or the expense of building facilities to convey that water also should be considered.

Like costs, the timeframe in which a transfer might be consummated would depend upon the complexities and opposition encountered. Based on the confusion displayed by the Bureau to date, I would expect that it would take a minimum of two to three years to obtain final approval for a proposed transfer.

Some of the uncertainty now associated with CVPIA transfers will be eliminated as more transfers are processed and standards are developed. Moreover, the Bureau is about to embark on formal rulemaking relative to transfers, and more guidance may be forthcoming. In addition, it can be anticipated that water transfer legislation will be enacted in California within the next few years, which could facilitate transfers under the CVPIA by providing additional guidance and experience with respect to many of the issues described in this letter. Finally, clarification of the CVPIA transfer provisions will likely be a part of any CVPIA reform package submitted to Congress in 1995.

City of Clovis/Fresno Irrigation District Cooperative Agreement

The Cooperative Agreement between the City and the FID provides that the FID will furnish the City that water which would have otherwise been delivered to City landowners within the FID's boundaries. Although the literal language of the Agreement excludes both CVP water and Kings River water which has been stored behind Pine Flat Dam, we understand the Agreement has been interpreted to mean that it excludes only CVP water and that the City may receive any Kings River water, including that stored behind Pine Flat Dam. Nevertheless, any plan to provide CVP water to the City would require amendment of the Cooperative Agreement.

As noted in the Agreement, the FID is party to a similar agreement with the City of Fresno. However, the Agreement with the City expressly provides that in the event there is insufficient water to meet the needs of both the City and the City of Fresno, the FID will meet the needs of the City of Fresno first. It is unclear based on our limited review of the Agreement what actions the City could take to improve its position with respect to obtaining water supplies from the FID.

The Agreement excuses the FID from furnishing water from September 1 to March 1 of any year. This may not be a significant limitation if the City uses the water it receives from the FID for recharge purposes only.

In the event the City obtains a supplemental supply of water from a source other than the FID, the Agreement provides that the FID will reasonably cooperate with the City in conveying the supplemental water through the FID's facilities. However, Section 8 of the Agreement expressly provides that the FID is not bound to convey that supplemental water, nor to enter into an agreement to deliver it to the City. To the extent the City foresees obtaining a supplemental source of water, it should consider obtaining more firm wheeling rights from the FID. However, the ability of the FID to grant those wheeling rights, even if it were otherwise so inclined, may be limited if its facilities are already fully utilized.

Groundwater Banking

Assuming all of the physical and economic issues associated with a groundwater banking arrangement with the FID are addressed, physical deliveries out of the Enterprise Canal raise at least two legal issues.

First, both the Bureau and the SWRCB take the position that the restrictions on place of use imposed on water supplies follow those supplies, even if they are delivered as part of an exchange. Therefore, restrictions imposed by the SWRCB on the place of use of the CVP and Kings River water transported through the Enterprise Canal would continue to apply to that water, even if it were to be delivered as part of a banking program.

As a result, to the extent water delivered to the City as part of a banking program is intended for use outside of the permitted places of use for that water, the consent of the SWRCB would be required, just as if that water had been transferred directly to the City by the holder of the underlying water right. Although there are efforts underway to convince the SWRCB and the Bureau that "tracking molecules" in this way is illogical in the context of an exchange or groundwater banking program, both agencies remain adamant in their positions. Consequently, it is possible that a banking program like the one described in your letter could involve a SWRCB proceeding unless all water to be delivered to the City remained inside the permitted place of use for that water. While such a proceeding would be time consuming, it probably would be successful.

In addition, use of Kings River water to supply the City could be prohibited by the Kings River Blue Book Agreements, which preclude delivery of Kings River water outside the Kings River Service Area. Because the FID's CVP supply is a Class 2 supply, there could be times when the only surface water available in the Enterprise Canal for delivery to the City would be Kings River water. Absent the consent of all 28 signatory agencies to the Blue Book Agreements, the FID could be contractually precluded from delivering Kings River water to the areas of the City outside the Kings River Service Area. Consequently, at times when the only surface water available to the FID was Kings River water, the FID might have to pump stored groundwater to deliver to the City.

I hope the foregoing is helpful. If you or the City wish to discuss any of our answers in more detail, please feel free to give me a call.

Very truly yours,

Gary W. Sawyers

GWS:dt

COST ESTIMATE DESCRIPTION

General

The costs provided in this report are based upon a variety of sources and assumptions and should be considered "order of magnitude" estimates. This is due to the broad nature of the estimates and the avoidance of any site specific planning. Actual costs incurred will vary.

In order to provide a consistent basis for comparisons, the costs for each element of the plan have been estimated for a 40 year life cycle. In many cases, items described in the plan are generally considered to have a useful life of only 20 years. For each of these cases the replacement costs have been included in the analysis by calculating the present worth of the replacement cost, and adding that value to the initial capital cost which must be financed. The present worth of these items was calculated using an effective interest rate of 3%. The effective rate is the real interest rate less the inflation rate, estimated as 6% and 3% respectively. The effective rate is used to reduce the exposure to inflation for items that will be purchased for the same project but at significantly different times. Failure to account for inflation in future purchases results in underestimating the actual life cycle costs. In reality, these items will likely be financed through individual bond sales in the future, or through regular budgetary process, thus reducing the initial capital requirements.

All costs are estimated in 95 dollars, and excepting the estimate of inflation for calculating the effective interest rate, there is no other correction made for inflation. Thus for any long term capital budgeting purposes, the amounts presented must be corrected to allow for the time value of money and inflation. In order to calculate the annual costs, a discount factor (or cost of capital) value of 6% was used. This value was chosen to reflect the estimated interest which would be paid for municipal bonds. Of course this value may vary depending upon prevailing market factors at the time of bond sales. Financing costs were not included in these estimates but may constitute a significant portion of project costs funded through bond sales.

Other factors which may influence costs are environmental and regulatory issues which are subject to change. In particular the implementation of projects to treat wastewater for reclamation or surface water for municipal use are subject to stringent and dynamic criteria which are sometimes unpredictable. No attempt has been made in this report to quantify the risks associated with these or any other environmental issues which may have significant impacts on the ability of the city to proceed.

Individual Element Descriptions

Artificial Recharge

The costs for constructing a single use recharge facility are based upon the assumptions listed of which the most critical elements are; land price, infiltration rate, and proximity to the water supply. Significant changes to any of these would cause substantial changes in capacity or price.

The cost of converting existing basins for recharge purposes are broken down each basin and should have a higher degree of accuracy given the site specific nature of the expenses. Still these costs could be impacted by the requirements imposed by the FMFCD which maintains the basins.

Well Construction and Wellhead Treatment

The cost of well construction and treatment is based in part upon cost data provided by the city. The cost elements which are not always considered but which are included in the estimate are the cost of adding disinfection units and treatment with granular activated carbon (GAC). The use of disinfection units is not presently required but widely expected to become mandatory within the near future.

The cost of wells and treatment is largely impacted by the estimated operating levels of the well. For this report the wells are expected to operate at a design capacity of 1500 gpm for 30% of the time. Using an increased operation level could substantially reduce the estimated unit cost but a 30% level is more realistic from a sustained operational perspective. For wells that must be retrofit, an allowance is made for condemning sufficient property to place the units. It is assumed that new well sites would include sufficient property.

Small Package Surface Water Treatment Plant

The price for the small package plant is based upon the price for a recently constructed plant of similar character (four 1/2 MGD units in parallel). The use of multiple units builds in some redundancy which makes operation variations easier. The price does not include any storage facilities as it is assumed that demand fluctuations would be handled by the existing storage facilities and operating levels of the wells in the system.

Regional Surface Water Treatment Plant

The costs for the plant are based in large part upon estimates made originally by Montgomery Engineers in 1990 and quoted by CH2M Hill (in the FWRMP 1994). Some changes have been made to more closely reflect the conditions present.

Again the operational level impacts the unit cost, and for this and all the water treatment plants, the operational level is taken to be 90% of capacity, operating 11 months a year. The 11 months is a reflection of the water supply, which may require maintenance periods on an annual basis, during which time the plant would not operate. Location of the plant is assumed to be adjacent to one of the canals, but should consider the location also of storage facilities. Location of the plant adjacent to a recharge basin could alleviate demand fluctuations and operational issues associated with the nature of the water supply.

Dual System for Conveyance of Untreated or Reclaimed Water

The use of untreated canal water for landscape purposes in the rural portions of Clovis is a viable alternative which could reduce the use of groundwater during the times of peak demand. The principle costs of such a system are the distribution system which would have to be constructed throughout the service area. It is assumed for this estimate that this would only be cost effective in areas where there is large portions of Rural residential, Low density housing, and schools or parks which consume large amounts of water. Because much of the area is already developed and current land owners have developed their own supplies, there is little control of demand unless their is considerable incentive for the users. Hence a large distribution area is assumed. Three different specific sites are broken out to allow for further site specific breakdown in the future. For this estimate, only water mains are included, which would provide service only to the main existing roads. Further additions are assumed to be provided as development progresses.

Another issue which is addressed in other parts of this report is the source of water. Because Kings River and FID water is only allowed to be used within FID, the lands estimated are all within FID.

The prices presented for the use of reclaimed water include only the distribution system. The collection and treatment are not included in this category. Three separate breakdowns are provided. The first is for Landscape water in the Southeast quadrant. This area is primarily outside FID and thus assumes that the original water source is groundwater or unrestricted surface water. The limiting factor in this sector is the supply of wastewater. With the existing users primarily relying upon septic systems, the amount of wastewater generated upgradiant from the area may be limited and require an additional cost to pump the waste from more densely populated areas down gradient of the plant and disposal area.

The use of reclaimed water for agricultural purposes is limited by both area for application, supply, and allowable use. The other consideration that must be made for such application are the regulations which are currently under revision by the State DHS. Costs are generally lower than those for landscape use, as it is assumed that ag users are on larger parcels which are able to access the water at a greater distance than those required for landscape of smaller parcels.

The last component of a dual system is a distribution system for reclaimed water in the Northwest sector. This area already has a defined capacity problem and represents a good potential for dual use. The distribution system is estimated to move the reclaimed water to the future alignment of the beltway where the water would be applied for landscape purposes. One of the advantages of this scenario is that it would allow greater control over the use of the reclaimed water, thus allowing less in distribution system requirements.

ADDITIONAL DATA NEEDS

Some data deficiencies have been noted. None of these are critical to the completion of the present study. In the interest of more accurate assessments in the future, as the plan is updated, the following suggestions are presented.

Surface Water

- Better records of stormwater flows into and out of the retention/detention basins are needed.
- Flow records from the FID canals near the study area boundaries are needed for future water budget calculations.
- Accurate and consistent land use and population projections are needed.
- An improved data management system for both surface water and groundwater would be helpful.
- Additional data on the quality of surface waters, specifically the San Joaquin and Kings Rivers and Fresno County streams, are needed.

Groundwater Data Gaps

Several data gaps should be addressed to facilitate water management efforts in the project area. This data should be developed as time permits and as development proceeds. Others are more long-term. Essentially, these gaps include non-public supply well pumpage in the urban area, water-level records, pesticide concentrations in the surrounding area, and improved data management.

Pumpage

All active large-capacity, non-public supply wells in the study area should be identified, and pumpage should be estimated from metered measurements, power records, irrigated acreage with crop type, or other factors. Better and more accurate data will help to make more accurate water budgets in future years.

If possible, water use records should be obtained on large public facilities such as the

Buchanan complex. This could be obtained by installation of a temporary meter to develop better information for future use.

Water Levels

The former County of Fresno northeast water-level measurement program provided useful data northeast and upgradient of the urban area. This program should be re-implemented, using the same wells, if possible, and continued into the future. Wells in this network and the FID with long term water level hydrographs should be kept up so as to document long-term trends.

In addition the city should institute a program to measure static levels on a monthly basis. It should be noted that static water levels are the single most important representation of the state of groundwater resources. By obtaining information from City wells, better mapping can be prepared in the urban areas. Also, historical hydrographs for the City wells may be maintained.

Aquifer tests are necessary to better estimate the amount of groundwater flow out of the area which is one the main outflow items.

Water Quality

In the area North of Shepard and East of Locan, there needs to be greater analysis of potential DBCP and EDB contamination. Test wells constructed in the area should test for these contaminants to try and define not only levels of contamination but vertical, as well as horizontal distribution. In addition, in the Northeast Village, there is limited water quality information. It can be expected that some agricultural suitability analysis have been performed. More involved testing, specifically those items listed under Title 22 regulations for safe drinking water, needs to be completed prior to development of groundwater for urban uses.

Geologic Information

There is a need for additional information in all of the future villages. When new wells are being constructed in these growth areas, test holes should be undertaken to obtain information on deeper alluvial deposits. In addition the city should prepare new subsurface cross sections periodically as new data becomes available.

If new recharge activities are to take place, additional testholes in proposed areas should be undertaken to determine if soils are conducive to the percolation of water and whether there are limiting soils at depth.

KINGS RIVER DIVERSION SCHEDULE

AMENDED KINGS RIVER MONTHLY DIVERSION SCHEDULE
- March -

River at Piedra	Main River and North Fork	Laguna Dist.	Murphy Slough Assn.	Fresno Dist.	Lemoore Canal	Peoples Canal	Last Chance Canal	Consolidated Canal	Alta Canal	Liberty Canal	Crescent Canal	Stinson Canal	Burrel Ranch	James Main Canal	Beta Main Canal	Lakelands Canal	South Fork	Clark's Fork	Upper San Jose	Whalen Canal	Empire No. 1	Empire No. 2	Lovelace	Water at Empire W.No.2	River at Piedra
100	100	15	15	70																					100
200	200	15	15	100	70																				200
300	300	15	15	100	85	85																			300
400	400	15	15	100	90	180																			400
450	450	15	15	100	91	183	46																		450
500	500	15	15	150	91	183	46																		500
600	600	15	15	250	91	183	46																		600
700	700	15	15	350	91	183	46																		700
800	800	15	15	450	91	183	46																		800
900	900	15	15	550	91	183	46																		900
1000	1000	15	15	650	91	183	46																		1000
1100	1100	15	15	750	91	183	46																		1100
1200	1200	15	15	850	91	183	46																		1200
1300	1300	15	15	950	91	183	46																		1300
1400	1400	15	15	1050	91	183	46																		1400
1500	1500	15	15	1150	91	183	46																		1500
1600	1600	15	15	1200	93	185	92																		1600
1700	1700	15	15	1200	118	235	117																		1700
1800	1800	15	15	1200	130	260	130	50																	1800
1900	1900	15	15	1200	143	285	142	100																	1900
2000	2000	15	15	1300	143	285	142	100																	2000
2100	2100	15	15	1300	167	285	168	150																	2100
2200	2200	65	65	1300	167	285	168	150																	2200
2300	2300	90	90	1300	167	285	168	200																	2300
2400	2400	90	90	1300	167	285	168	200	100																2400
2500	2500	90	90	1300	167	285	168	200	200																2500
2600	2600	90	90	1300	167	285	168	300	200																2600
2700	2700	90	90	1300	167	285	168	400	200																2700
2800	2800	90	90	1300	167	285	168	500	200																2800
2900	2900	90	90	1300	167	285	168	500	300																2900
3000	3000	100	100	1300	200	300	200	500	300																3000
3100	3100	100	100	1300	200	300	200	500	400																3100
3200	3200	113	112	1300	225	325	225	500	400																3200
3300	3300	113	112	1300	225	325	225	500	500																3300
3400	3400	163	137	1300	250	325	225	500	500																3400
3500	3500	200	175	1300	250	325	225	500	500	25															3500
3600	3600	200	175	1300	250	325	225	500	500	50	75														3600
3700	3700	204	179	1300	255	332	230	500	500	50	75	75													3700
3800	3800	208	182	1300	287	339	234	500	500	50	100	100													3800
3900	3900	208	182	1300	337	339	234	550	500	50	100	100													3900
4000	4000	258	182	1300	337	339	234	600	500	50	100	100													4000
4100	4100	268	197	1300	345	344	235	619	531	52	103	100		2	4										4100
4200	4190	277	211	1300	352	348	236	636	559	53	106	100		5	7		10	10							4200
4300	4250	284	220	1300	357	350	237	647	577	54	108	100		6	10		50	30	20						4300
4400	4310	290	229	1300	362	353	238	658	595	55	110	100		8	12		90	30	50	10					4400
4500	4370	296	238	1300	367	356	239	669	614	56	112	100		9	14		130	30	50	50					4500
4600	4430	302	247	1300	372	359	239	681	632	57	114	100		10	17		170	30	50	70	20				4600
4700	4490	308	256	1300	377	362	240	692	650	58	116	100		12	19		210	30	50	70	60				4700
4800	4550	314	265	1300	382	364	241	703	669	59	118	100		13	22		250	30	50	70	100				4800
4900	4620	321	276	1300	388	368	241	716	690	60	121	100		15	24		280	30	50	70	100	25	5		4900
5000	4690	328	287	1300	393	371	242	729	712	62	123	100		16	27		310	30	50	70	100	50	10		5000
5100	4760	335	297	1300	399	374	243	742	734	63	125	100		18	30		340	30	50	70	100	75	15		5100
5200	4830	342	308	1300	405	377	244	755	755	64	128	100		20	32		370	30	50	70	100	100	20		5200
5300	4900	350	318	1300	410	380	245	768	777	65	130	100		22	35		400	30	50	70	100	106	20	24	5300
5400	4970	357	329	1300	416	384	245	781	799	66	132	100		23	38		430	30	50	70	100	106	20	54	5400
5500	5040	364	340	1300	422	387	246	794	820	68	134	100		25	40		460	30	50	70	100	106	20	84	5500
5600	5110	371	350	1300	427	390	247	807	842	69	137	100		27	43		490	30	50	70	100	106	20	114	5600
5700	5180	378	361	1300	433	393	248	821	863	70	139	100		28	46		520	30	50	70	100	106	20	144	5700
5800	5250	385	371	1300	439	396	249	834	885	71	141	100		30	49		550	30	50	70	100	106	20	174	5800
5900	5310	391	381	1300	444	399	249	845	903	72	143	100		32	51		590	30	50	70	100	106	20	214	5900
6000	5370	397	390	1300	449	402	250	856	922	73	145	100		33	53		630	30	50	70	100	106	20	254	6000
6100	5430	403	399	1300	454	405	251	867	940	74	147	100		34	56		670	30	50	70	100	106	20	294	6100
6200	5490	408	414	1300	461	409	251	886	940	75	150	100		37	59		710	30	50	70	100	106	20	334	6200
6300	5550	408	436	1300	461	409	251	914	940	75	155	100		40	61		750	30	50	70	100	106	20	374	6300
6400	5610	408	459	1300	461	409	251	942	940	75	160	100		44	61		790	30	50	70	100	106	20	414	6400
6500	5670	408	482	1300	461	409	251	970	940	75	165	100		48	61		830	30	59	70	100	106	20	454	6500
6600	5730	408	525	1300	461	409	251	975	940	75	175	100		50	61		870	30	50	70	100	106	20	494	6600
6700	5790	408	575	1300	461	409	251	975	940	75	185	100		50	61		910	30	50	70	100	106	20	534	6700
6800	5850	408	624	1300	461	409	251	975	940	75	196	100		50	61		950	30	50	70	100	105	20	574	6800
6900	5900	408	665	1300	461	409	251	975	940	75	205	100		50	61		1000	30	50	70	100	106	20	624	6900
7000	5950	408	706	1300	461	409	251	975	940	75	214	100		50	61		1050	30	50	70	100	106	20	674	7000
7100	6000	408	747	1300	461	409	251	975	940	75	223	100		50	61		1100	30	50	70	100	106	20	724	7100
7200	6050	408	795	1300	461	409	251	975	940	75	225	100		50	61		1150	30	50	70	100	106	20	774	7200
7300	6100	410	823	1303	463	410	252	981	943	75	226	100		51	62	1	1200	30	50	70	100	106	20	824	7300
7400	6150	413	826	1310	467	413	255	994	950	76	227	101	1	52	63	2	1250	30	50	70	100	106	20	874	7400
7500	6200	416	828	1318	470	416	258	1007	958	77	228	102	2	52	64	4	1300	30	50	70	100	106	20	924	7500

City of Clovis