URBANIZATION AND WATER IN THE NORTHERN SAN JOAQUIN VALLEY

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ABSTRACT

Much of California would not be recognizable to someone who witnessed statehood in 1850; the natural landscape has been transformed. Unfinished, the continuing transformation at the end of the 20th century was driven by the resource needs of expanding urbanization. As an essential resource for urban growth, the sale, acquisition, and use of water are analyzed in the context of the urban relationship with both agriculture and the natural environment. These relationships change with comprehension of the natural world and as population pressures multiply, they are important because they determine the present and future landscape. The City of Tracy, located just south of California's water hub, the Sacramento - San Joaquin Delta, is used for the analysis because of the recent rapid growth and expected future expansion, as well as the geographic location relative to major federal and state water facilities. In the midst of supplemental water supply acquisition, the City of Tracy is confronting the physical and legal limits inherent to a fully allocated water system. As a vital commodity without substitution (except desalinated seawater), the re-allocation of water forces such confrontation as long as non-urban water uses are valued.

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An introduction and discussion of general ideas, perceptions, and questions surrounding the expansion of urban areas in California.

The urbanization experience of one California city is analyzed from the resource perspective, particularly the water resource.

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Continuous urbanization changes the relationship between the city and the rest of the region and tests the sustainability of the water resource system.

1. GROWING URBANIZATION……….general ideas, perceptions, and questions

During one of his yearly visits to California, my father-in-law remarked, "It will be a nice place, if it ever gets finished". A work in progress, under constant construction and not quite defined, is how he sees the State. Carey McWilliams[1], in his 1949 analysis of California, described the same phenomenon as caused by governmental services lagging behind population growth, "the state is always off balance, stretching itself precariously, improvising, seeking to run the rapids of periodic tidal waves of migration". From the discovery of gold and the argonaut influx to the widely distributed handbills which lured the Joads (Steinbeck, 1939) and other Dust Bowl refugees in search of employment, California purposely projected a self-image as a “Land of Promise”. Practices which might diminish this image were discouraged. There were even suspicions in the 19th century that the wide spread adoption of irrigation technology would undercut the perception of California as an agricultural paradise (Kahrl, 1982). Despite the apparent end of state boosterism by 1949 (McWilliams), California still beckons. Natural increase has surpassed migration since 1990, still, a quarter of a million people migrated to California in 1999 (DOF, 2000).

State boosterism from 1850 to 1950 encouraged population growth to over 10 million people; cities were laid out and infrastructure built. In the 1960s a master plan for higher education was instituted, an extensive network of highways constructed, and a nearly statewide system stored and conveyed water for use when needed (Bradshaw, 1992). During its first 120 years as a state, infrastructure was shaping urban growth patterns in California. More recently, the sufficiency of infrastructure and resources has been questioned as well as whether there has been a role reversal. Are the demands of population growth now forcing urban planning? The annual addition of people has accelerated; from 1850 to 1950 California's population increased by an average of 100,000 each year, during the last 50 years the annual increase averaged 460,000. The California Department of Finance estimated a population increase of 571,000 between January 1999 and January 2000.

Table 1. The Population of California

Date (January)	State population	Increase decade to decade	Percentage change
1850	92,597		
1860	379,994	287,397	310%
1870	560,247	180,253	47%
1880	864,694	304,447	54%
1890	1,213,398	348,704	40%
1900	1,485,053	271,655	22%
1910	2,377,549	892,496	60%
1920	3,426,861	1,049,312	44%
1930	5,677,251	2,250,390	66%
1940	6,907,386	1,230,135	22%
1950	10,586,223	3,678,837	53%
1960	15,717,204	5,130,981	48%
1970	19,953,134	4,235,930	27%
1980	23,667,902	3,714,768	19%
1990	29,760,021	6,092,119	26%
2000	33,871,648	4,111,627	14%

Sources: California Department of Finance Website, http://www.dof.ca.gov and U.S. Census website, http://www.census.gov .

Encouragement of population growth was replaced by concern about related impacts as the 20th century progressed. Suburban sprawl, the rapid disappearance of productive farmland in coastal and southern California, and increasing roadway congestion were

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[1] Carey McWilliams reported social, political, and economic development in California for the national press. He was California's Commissioner of Immigration and Housing for four years. Beginning in 1945,

sufficiently alarming to inspire various essays, editorials, and a challenge for state planning during the 1960s and 1970s. Alfred Heller, Samuel E. Wood and other California Tomorrow[2] participants coined the term "slurb" to describe the "sloppy, slovenly, slipshod, semi-cities" they observed proliferating on treasured California soil. They charged that there was no coordinated state policy, no general land development plan and that the basic planning questions: How do we want to live our lives in this state?, How do we manage our lands toward those ends? were not approached by state planners. McWilliams (1949) noted that the idea of population growth was well favored but the reality feared. This inconsistent sentiment was echoed on a bumper sticker I noticed in Victorville, California in the mid 1980s: “Welcome to California, Now Go Home”. Hospitality, fairness, and perceptions of democracy have apparently collided with new, daily frustrations and changes caused by the accommodation of more people, population growth. The idea that people should be able to live where they want can be practically difficult.

Presuming population growth is inevitable, the type of development rather than the growth itself could be creating more problems than necessary (Fulton et al., 1995; Felsenthal, 1995; Landis, 1995; Kunstler, 1996). Faults with the suburban type of development are commonly listed and studied, for this has been the predominant housing choice since World War II. James Howard Kunstler (1996) notes the suburban house is perceived as entitlement, a part of the American Dream that should be available to all.

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he was contributing editor of *Nation*.

[2] The purpose of the California Tomorrow group (1961-1983) was to raise an outcry about the assault on the California environment, and to push the idea of better planning and better governmental machinery as

Changing the design of new and existing housing developments from suburbs to towns or towns within cities, and from automobile oriented to people oriented is a proposed solution for some population growth impacts. Sandy Felsenthal (1995) reported on Anton Nelesson's (Rutgers University) surveys conducted to determine urban preferences; people want "green open space in the middle and at the edge of town, narrow streets, a small traditional neighborhood". Drivers might slow down on narrow streets, hiding the garage would lessen the commuter-front look of the homes, and mixed housing with selected service and retail businesses could eliminate "the absurdity of a 5 mile trip for a loaf of bread". From my single-family residential area home, the nearest store is about ¾ of a mile away, if you go through a hole in a fence then across two sets of railroad tracks and through an opening in the shopping center back wall. If you don't want to or can't climb over railroad tracks and through holes in fences, the distance is doubled. The Local Government Commission (1992) cites a study solicited by the American Society of Civil Engineers (published in March 1990) which compared vehicle miles likely to be traveled by residents of conventional suburban neighborhoods and more walkable, mixed use neighborhoods. Their conclusion was that walkable communities reduce total vehicle miles traveled by 43 percent. The Ahwahnee Principles, developed by architects and planners of pedestrian and transit oriented communities in October of 1991, stresses community design that is esthetically pleasing and walkable, where daily life is within walking distance or accessible with transit options (The Local Government Commission, 1992). Curiously, although the onslaught of cars in the mid 20th century was a factor in driving people out of the city, the suburbs to which they fled were usually designed for

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the means of turning things around. They produced and published the *Cry California* (later *California Tomorrow*) periodical.

cars (Kunstler, 1996). Accommodation was surely the motive, but wide streets, housefront garages, segregated land uses, large parking lots, and easy freeway access have succeeded mainly in increasing automobile dependency. Moving away from the problem spread it over a larger area. William Fulton et al.'s (1995) list of sprawl costs begins with the maintenance of highways, decreasing air quality, and the inevitable commuting present in single zoning development. Suburban life takes more individual time and more personal and public money, although the perception is that suburbs are cheaper places to live (Fulton et al., 1995).

California needs more housing and much more choice in type of neighborhood and housing style, testified John D. Landis (1995) to the Little Hoover Commission[3]. The first argument is based on the dynamics of supply and demand, Landis argues the price of a single-family home is high because there is not sufficient housing supply. The need for more choice is obvious to any recent homebuyer. Most newer housing styles and neighborhood structure are safely similar "the exact center of the marketplace" (Landis, 1995). Once a general location is chosen, comparison shopping is often done on the basis of square footage, the lowest common denominator. Landis envisions more housing of much greater variety located on environmentally suitable land, preferably initiating the revitalization of central cities. Prerequisites to realizing this vision are a clear designation of where housing developments belong and a commitment to environmental protection. To Landis, the reduction of development uncertainty through prioritization of lands for

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[3] The Little Hoover commission is an independent state oversight agency created in 1962. The Commission's mission is "to investigate state government operations and--through reports, recommendations and legislative proposals--promote efficiency, economy, and improved service" (Little Hoover Commission website).

future development, urban limit lines, the codification of development and zoning conditions of approval, and the use of formal impact standards in the CEQA review process, will increase housing choice and promote environmental enhancement.

To approach environmental protection and enhancement, assessment of natural systems needs to occur at a relevant scale in space and time. Project specific regulations (Landis specifies CEQA in his criticism) may not operate at a useful scale. Such regulations have “distracted us from the need for large-scale, long-term ecosystem and habitat planning, statewide long-term water planning, and regional land conservation” (Landis, 1995). Landis recommends centralized control and vision as more effective than local, decentralized decisions. The modern lack of limiting local feedback complicates the perception of the human impact on the environment and lends strong argument to more centralized environmental planning. Modern growth began with the industrial revolution which “changed the relationship between people and resources in at least two fundamental ways: scale and intensity” (UNEP, 1995). The driving force of the industrial revolution, fossil fuels, opened the world as a marketplace and decoupled people from the local ecosystem. The sustenance and products on which we survive are not only local, the soils and air and water of other regions are bought and sold in the finished products of food processors and manufacturing. The proportion of *ecosystem people*[4], those who depend on local resources and for whom local feedback is a mediating force in overexploitation of local resources, continues to decrease while *biosphere*

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[4] The work of R.F. Dasmann, *Toward a Biosphere Consciousness,* in Worster, D. (ed.) The Ends of The Earth, is cited by UNEP. Dasmann divides people into two simple types, *ecosystem* and *biosphere*, to distinguish their level of resource usage. Although a great simplification, UNEP found this classification useful "for understanding different relationships between people and biodiversity".

people, those who are dependent on much larger systems and typically insulated from the consequences of their own use of resources, become common (UNEP, 1995). Perhaps it is the disconnection from the environment that is the greater problem. Solutions which distance individuals and communities from environmental impacts ignore the social connection to the environment, centralized planning could further disconnect people from their local environment.

Although Malthusian arguments have generally been tossed aside, especially with the transcendence of local and regional resources, the idea that human occupation can reach some crisis quantity has become common. This idea is expressed as carrying capacity, limits to growth, full world economics, and sustainability. All of these consider the human impact on the natural environment and propose arguments or methods for estimation of reasonable and/or maximum population. There is sometimes a difference in scale among the arguments, some can be regionally focused while others are global. There can also be a difference in focus, from species specific to the inclusion of all life forms and natural processes.

Carrying capacity usually refers to a region, but can (and perhaps must) be generalized to encompass the world. Kenneth Arrow et al. (1995) define carrying capacities in nature as changing, complex, and dynamic relations contingent upon both environmental and human factors. These environmental and human factors are all variable and some are interdependent: changes in preferences, technology, the structure of production and consumption, and interaction changes between the physical and biotic environments.

Quality air and water, a bank of diverse life (biodiversity is a sort of immune system husbanded by previous generations (Srivastava, et al., 1996)), soil formation, other resources and raw materials, energy, nutrients, and wildness all make possible human survival. These are environmental and economic services: inputs necessary for economy, sinks to absorb and recycle wastes, and an irreplaceable life support function (ASCE, 1996). Goodland and Daly (1995) define carrying capacity as "a measure of the amount of renewable resources in the environment in units of the number of organisms these resources can support". This definition reduces the problem to a function of the area and the organism, some requiring a greater or smaller area than others. The problem is not so simple when considering people, human resource usage is complicated and variable. Using energy consumption as "a crude surrogate for environmental impact…A baby born in the United States represents twice the impact on the Earth as one born in Sweden, three times one born in Italy, 13 times one born in Brazil, 35 times one in India, 140 times on born in Bangladesh or Kenya, and 280 times one born in Chad, Rwanda, Haiti, or Nepal" (Goodland and Daly[5], 1995). Reducing resource usage to approximate resource needs would yield the maximum number of supportable people, but Goodland and Daly (and many of us!) find the maximum number of people to be far from the optimum.

Edward J. Kaiser et al. (1995) see carrying capacity analysis as a way to determine the amount of development an area can support without causing irreversible ecological damage. They divide potential limiting factors into three groups: environmental (air and water quality, ecosystem stability, soil erosion) physical (infrastructure capacity) or

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[5] Goodland and Daly are citing Ehrlich and Ehrlich, 1989, when comparing energy usage across countries.

psychological (perception of crowding or esthetics). How can it be known when the range of irreversible ecological damage is approached? On a local or regional level, where environmental decisions become specific, allocation of resources to urban, rural, and wildlife needs requires some division of what is available. The quantification of portion size estimates what is necessary to remain on the survival side of the "threshold" for species of concern, while simultaneously satisfying as many urban and rural needs as possible. Considerable scientific disagreement exists about the locations of thresholds in ecosystems and about whether particular species are crucial in determining the location of thresholds. Scientific prediction of thresholds in ecosystem behavior are poorly developed, despite the realization that ecosystems driven across thresholds to undesirable states can result in long-lasting or even permanent losses (UNEP, 1995). Determination and application of thresholds of environmental significance is done every time an Environmental Impact Report (EIR) or Statement (EIS) is drafted. The California Environmental Quality Act (CEQA) authorizes local governments to translate available data, standards, and local values into qualitative and quantitative thresholds (Governor’s OPR website2, 2000). Whether deliberately or by chance, resources are divided among demand sectors. For instance, the allotment of water to urban, agricultural, and environmental needs is an attempt to quantify a commonly comfortable distance from thresholds. The usefulness of carrying capacity analysis, according to Kaiser et al. (1995), is the determination and necessary mitigation of human impacts on ecosystems as well as “allocation of predetermined amounts of growth…specification of performance standards for development, and determination of consequences of various levels of resource utilization”.

UNEP (1995) asserts we have been more successful in simplifying than in reconstructing complex ecosystems. A poorly understood factor in attempting ecosystem support or replication is natural selection. How does this seemingly random process work? We know how to produce nutritious crops and beautifully landscaped areas and ample livestock. But these have all been genetically altered, at least through controlled reproduction and predatory protection. They are bred for desired attributes, such as sirloin steaks or bigger heads of wheat or docility. Paul Shepard (1982) describes domestication as “infantalized” animals and “nature at a new, cruder level”. Following Shepard’s description, as soon as humans make most of the decisions, the direction is toward a managed system or domestication. How important is natural selection in ecosystem health? How far away from the process should we be for natural selection to proceed? Richard Norgaard (1994) might argue that we should be closer, for the coevolution of environments and societies has been detrimentally altered during the last century and a half of fossil fuel consumption when, “Neither system has coevolved in response to direct signals from the other”. The UNEP (1995) notes our lack of success in ecosystem restoration and suggests that great caution should be exercised in reducing biodiversity through management practices because of the potential loss of goods and services in the long term.

Timothy Beatley (1994) describes the current science and technology of creating wetlands as “crude at best”. Uncertainties about the functioning system of wetlands have resulted in a range of mitigation ratios. The Western Water Policy review Advisory

Commission (1998) notes, "…after years of research on the Bay Delta [California's Sacramento-San Joaquin Delta], a model of an undisturbed ecosystem the size of the Bay Delta did not exist, and the CALFED[6] process has not established 'the ecosystem baseline'". When an environmental impact report or statement reveals the habitat of some species of concern will be affected by development, mitigation with some other acreage in trade is usually recommended. Although the California Environmental Quality Act (CEQA) has always required mitigation of adverse environmental effects, before 1988 there was no stipulation for mitigation monitoring. Since passage of California Assembly Bill 3180, projects relying on a mitigated negative declaration or an environmental impact report (EIR) must establish monitoring programs (Governor's OPR website1, 2000).

Limits to growth have already been reached, according to Robert Goodland (1992). For evidence Goodland cites the Peter Vitousek et al. (1986) calculation that the human economy uses, directly and indirectly, approximately 40 percent of terrestrial biomass. Extrapolation to a doubling of global population would mean an amazing 80 percent appropriation of the net primary product of terrestrial photosynthesis. Goodland suggests a global population doubling time of 35 years, California's population doubling time[7] over the last 150 years has been about 18 years. From 1850 to 1900, the doubling time was about 12 years, over the last 50 years it has been about 30 years. Global warming,

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[6] The CALFED program, composed of both state and federal participating agencies, began in May of 1995. Their mission is to develop a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta System.

[7] Population doubling time: California population is from Table 1, the basic calculations are
population (year 2000) = population (1850) times exp(rate of increase times 150 years)
doubling time = natural log of 2 divided by the rate of increase

ozone shield rupture, mining of groundwater, land degradation (erosion, salination, desertification), and loss of biodiversity are commonly listed warning signs that the human enterprise is nearing the end of exponential growth. Paul and Anne Ehrlich (1996) have observed a decrease in biodiversity accompanying urbanization in California, butterfly populations one after another have disappeared, apparently as a result of various land developments. The Department of the Interior, through the Central Valley Project Improvement Act, declared the decline in anadromous fish population due to diversion and use of instream flows to be unacceptable in the Central Valley of California. An acceptable fish population level was quantified as twice the 1967-1991 fishery population levels (DWR, 1998). The UNEP (1995) lists indicators that suggest ecosystem and resource limits have been reached: the fish harvest peaked in 1989 and grain harvests in 1984, by 2010 the per capita availability of rangeland will drop by 22% and the irrigated land by 12%, cropland and forestland per person will decrease by 21% and 30%, respectively.

“How many people can live on earth from a water resources viewpoint, or at what stage does water become a critical issue for further development?”(Hoekstra, 1998) Hoekstra uses Shiklomanov’s[8] calculation of total annual water withdrawal by the human economy as 8 to 9 percent of the total yearly continental runoff, which is estimated at $40\text{-}47\text{x}10^{15}$ kilograms per year (32 to 38 billion acre-feet per year). Among the human factors which can influence water availability, Hoekstra lists: consumptive use, evaporation from artificial surfaces, untreated (or inadequately treated) wastewater, fertilizer and pesticide

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[8] Shiklomanov, I.A. (ed.), 1997, *Assessment of water resources and water availability in the world; Scientific and Technical Report*, State Hydrological Institute, St. Petersburg, Russia.

use, soil erosion, artificial groundwater recharge, reservoirs, wastewater treatment, and land use changes. Other factors which can influence water availability are: proximity of runoff to urban areas, flooding and/or flood control, and environmental requirements. There are various opinions on the maximum global population if freshwater is a limiting factor. Depending on assumed per capita requirements and the measure of potential water supply, the calculated range is from 4.5 to 25 billion people (Hoekstra, 1998). Even higher populations are supportable if the entire global runoff is considered potential supply. With desalination, water limits are stretched yet further.

Although there may be no water shortage from the global perspective of volume of water per person, this global view does not quite reflect regional, current reality. Natural water distribution and urban growth are not positively correlated. The state of California receives about 70 percent of its annual runoff in the north while approximately half of the population lives in the southern coastal region (DWR, 1998). This natural water resource allocation is mitigated by the state's water storage and conveyance system which makes water regulation and redistribution possible. Although it enhances supplies, the physical capability of managed water allocation does not guarantee all demands will be fully met.

Table 2. California's Water Budget for Average and Drought Years (maf)

Year	Available supply (ave./drought)		Total demand (ave./drought)		Urban demand (ave./drought)		Agricultural demand (ave./drought)		Shortage (ave./drought)	
1995	77.90	59.64	79.49	64.79	8.77	9.01	33.78	34.54	1.59	5.15
2020	78.08	59.75	80.50	65.96	12.02	12.36	31.50	32.33	2.42	6.21

Notes: Environmental demand is the difference between total demand and urban plus agricultural demand. Amounts are applied water.
Source: DWR, 1998

California's last Water Plan Update (DWR, 1998) shows the demand for water is generally greater than the available supply. In an average year at a level of development expected for the year 2020 (DWR, 1998) the ratio of population (47.5 million) to available supply is equal to 490 people per million meters cubed of water (0.6 people per acre-foot of water). According to Hoekstra[9] (1998) this indicates a region where only general management problems occur. In a drought year the same ratio yields 640 people per million meters cubed of water (0.8 people per acre-foot of water), a region with water stress but not water scarcity. This scarcity index is very general, environmental water requirements are not specifically addressed, and the application has been modified from total runoff as potential supply to available supply as listed by the California Department of Water Resources (DWR). Of the three major sectors of water demand, (urban, agricultural, and environmental) the Water Plan Update shows urban demand increasing, environmental demand remaining nearly constant, and agricultural demand falling. Water has become a limiting factor for the expansion and maintenance of agriculture but not for urban growth.

California has always been highly urbanized (McWilliams, 1949; Hundley, 1992). In 1870, twenty years after statehood, California was one of the ten most urban states in the country. By 1949, 75% of the population lived in seven metropolitan districts (McWilliams, 1949). In 1978, 94% of the state population (22 million) was urban as was 2.5% of the land (Weiss, 1980). The 1990 census recorded more than 80% of the population lived in urban areas of more than one million (95% of state's 30 million lived in metropolitan areas (Bradshaw, 1992)), making California the most urbanized state in

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[9] Hoekstra is using Falkenmark’s Scarcity Index: 600 people/1million cubic meters of water per year indicates a region without water stress, 600-1000 people per the same amount of water indicates water stress, 1000-2000 people indicates chronic water scarcity, and 2000+ people means absolute water scarcity.

the nation (Fulton et al., 1995). California is listed as the most populous state in the nation by both the 1990 and 2000 census.

Urbanization has been an ongoing process since the practice of agriculture began. Hunting and gathering, or foraging, do not provide adequate food production or storage for urban populations. It is pastoralism and farming that make possible the concept and reality of the city (Shepard, 1996). Agriculture promotes the growth of towns and cities and supports that growth with productive abundance for which the city is a market. William Cronon (1991) examines the strength of the tie between city and country, "Each had created the other, so their mutual transformations in fact expressed a single system and a single history… Regarding them as distinct and separable obscured their indispensable connections". Having inextricable pasts and futures means to ignore or to harm one is to injure both. The use of prime farmland for urban growth bewilders many who recognize this connection, "The state [of California] has not addressed the issue of supplying food for the increased populations anticipated in the 21st century" (Senate Select Committee, 1998).

There are approximately 27 million agricultural acres in California with 13.6 million acres in the Central Valley (Senate Select Committee, 1998). Between 1982 and 1987, there was a permanent loss of agricultural land in the Central Valley of nearly half a million acres to urbanization (Fulton et al., 1995). The California Department of Conservation reports the San Joaquin Valley lost 21,500 acres to urbanization during the

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For the calculation in the text: 47.5 million people/78.08 million af (available supply, average year), for a drought year the available supply is 59.75 million af (amounts are from DWR, 1998).

drought years 1990-92, and the valley ranked number one in converting lands from agricultural to urban uses (McClurg, 1995). Hundley (1992) records some 60,000 acres of farmland per year was converted to urban use in California during the 1950s and about 44,000 acres annually by the 1990s. Scott Hudson, the San Joaquin County agricultural commissioner, ponders the economic impact of San Joaquin County suburbanization, “At what point do the scales start tipping away from agriculture as land becomes converted” (Fujii, 2000)? The American Farmland Trust (1989) has suggested at least 32 policy options to better cope with urbanization of the Central Valley. These policy options ask for protection of the practice of farming and careful evaluation prior to farmland conversion. Strengthened Right-to-Farm ordinances, regional air quality standards, reduced constraints on water marketing, and a state groundwater policy are policies offered to enhance farming viability. Consideration of farmland conversion as a "significant environmental impact" and various local, state, and county tools to conserve farmland are also proposed. The Great Valley Center (1998), organized to support the economic, social and environmental well being of California's Central Valley, presents farmland conservation options that provide an alternative to the all or nothing choice of either farming or selling the land. These efforts recognize there is no longer a next valley in California to recommence the practice of agriculture. It is in this Central Valley that urban and rural interests will determine how to share the resources of California.

Agriculture and urban areas have a complex relationship of mutual need and mutual competition. The basic natural resources of air, water, and land are increasingly in dispute as the quest for the suburban ideal is driven over the coastal ranges and into the

Central Valley of California. The competition over resources includes quality issues and waste disposal, for both cities and agriculture contaminate air and water, resources essential to both. Demment et al. (1990) found some of California agriculture's most pressing issues involve disposal: drainage water, contamination of groundwater, dairy waste, crop residue burning, and pesticide residues. The conveyance of agricultural and municipal pollutants by surface water in the Sacramento and northern San Joaquin Valleys converges in the Sacramento-San Joaquin Delta. Water from the Sacramento-San Joaquin Delta that does not exit through the San Francisco Bay is then conveyed to various cities and irrigated farmland, mainly through the California Aqueduct and the Delta Mendota Canal. The transport of urban pollutants by air initiated the Howitt and Goodman (1989) assessment of ozone standards (the largest single source of ozone is the automobile); economic impacts of various levels of ozone regulation on agricultural production were quantified. Estimates of 1986 crop losses due to ozone were over 20% for beans, melons, and grapes and from 1% to 15 % for alfalfa, cotton, lemons, oranges, and potatoes (Winer et al., 1990). The effect of ozone on plants is similar to the effect of farmland conversion to urban uses on farming. Farmland conversion does not immediately replace farming in an area with other industry, but it does reduce the regional viability of conventional farming. Ozone doesn't kill plants immediately, it damages them by reducing their synthesis of chlorophyll (AFT 1989).

Protection of natural productive processes is usually implied in studies of sustainable resource use and environmental sustainability. Goodland and Daly (1995) define environmental sustainability as a variable, one that changes so slowly (perhaps at the speed of evolution) that it is constant as a first approximation. Certainly, assimilation capacity of wastes (sinks), stocks of nonrenewables, and regeneration of renewable stocks are fairly constant. The ASCE (1998) describes water resource sustainability as a philosophical concept and not a precise state of being, defying precise definition. A general definition is then proposed: "sustainable water resource systems are those designed and managed to fully contribute to the objectives of society, now and in the future, while maintaining their ecological, environmental and hydrological integrity". Furthermore, sustainability implies a condition in which the frequency and severity of threats to society are decreasing over time. Sustainability, as defined by the ASCE, is an increasingly resilient equilibrium where extreme events may temporarily disturb but not destroy the managed system.

Guiding principles for the sustainable development and use of water resources were produced in 1992 at the International Conference on Water and the Environment. The Dublin Statement presented four guiding principles from the conference. These principles were intended to guide water policy at all levels (Hoekstra, 1998).

Table 3. Water Resources and Sustainable Development

Four principles of the Dublin Statement	Glieck's seven sustainability criteria
A holistic approach to water management, linking social and economic development with protection of natural ecosystems	Human actions should not damage the long-term renewability of freshwater stocks and flows. Sufficient water guaranteed to restore and maintain the health of ecosystems.
Water management should be based on a participatory approach, involving, users, planners, …at all levels.	Institutional mechanisms to prevent and resolve water conflicts. Water planning and decision making should be democratic.
The central role of women in the provision, management, and safeguarding of water.	Minimum water quality standards.
Water should be considered an economic good…basic right of all humans to clean water and sanitation.	Guaranteed minimum water quantity for all humans.
	Collection of data on water resources availability.

Source: Hoekstra, 1998

In his discussion of the Dublin Statement, Hoekstra included a description of Peter Gleick’s seven water sustainability criteria as further insight into the key issues. Gleick’s criteria and the Dublin Statement are broad enough to allow significant regional or local interpretation. A ‘guaranteed minimum water quantity for all humans’ or the ‘basic right of all humans to clean water and sanitation’ do not quantify an amount of water necessary to meet the goal of providing a water lifeline. Neither is the amount of water required for healthy ecosystems specified. Quantifying water allocations can be challenging, acceptance of specified amounts is not assured. The Department of the Interior quantified the amount of water to be returned to the environment in the Central Valley Project Improvement Act of 1992, but the past eight years have been an ongoing discussion about implementation of that directive. Where should the water be accounted for, what, if any, other uses of the water, either upstream or downstream, are allowable, what are the necessary quality considerations, and what are the designated sources? The questions reflect an awareness of water scarcity. Broad, guiding principles for the use and development of water resources increase in importance and controversy as water abundance decreases with population growth.

The worldwide influence of people is distilled into a full world thesis by Herman E. Daly (1992). “Perhaps the clearest policy implication of the full world thesis is that the level of per capita resource use of the rich countries cannot be generalised to the poor, given the current world population” (Daly, 1992). Daly proposes a transition has been made from empty world to full world economics. He explains, using Vitousek et al.’s calculation of terrestrial biomass usage, human endeavor could previously be described by empty world economics because the world was relatively empty of human beings and human-made capital. By directly and indirectly using about 40 percent of the net primary product of terrestrial photosynthesis, the world has become relatively filled with humans. Full world economics recognizes natural capital and human-made capital are complements, not substitutes. Either can be a limiting factor. In empty world economics the limiting factor has often been human-made capital, in full world economics it is natural capital. Furthermore, Daly discerns economic policy should be designed to increase the productivity of natural capital and its total amount, since natural capital is now the limiting factor, rather than increasing the productivity of manmade capital. Carrying capacity is exceeded when people are living on natural capital rather than natural interest (Ehrlich and Ehrlich, 1996). So, natural capital is the stock of environmentally provided assets (soil, atmosphere, forests, water, wetlands, groundwater, fisheries, biodiversity, etc.) and environmental sustainability is the maintenance of natural capital. A full world thesis warns we cannot grow our way into sustainability. Growing implies a quantitative increase, on the other hand, development implies a qualitative change, usually (hopefully) for the better (Goodland and Daly, 1995).

To an urban planner, sustainability is defined with an emphasis on development, preferably sustainable development. Scott Campbell (1996) explores sustainable development with a triangular model. Each triangle corner positions a distinct development priority: economy, environment, and equity. The economic development planner considers overall economic growth and efficiency as the priority, the environmental planner's goal is environmental protection, and the equity planner seeks social justice, economic opportunity, and income equality. In this model conflict arises because each type of planner has different goals and a unique view of the city. Property is the conflict between the economic and the equity planners, resources are the conflict between the economic and environmental planners, and development itself is the conflict between the equity and environmental planners.

Table 4. Planning Priorities and Sustainable Development

Planning priority	**The City**	**City Competition**	**City Space**
Economy	As a location of production, consumption, distribution, and innovation	In competition with other cities	Is the economic space of highways, markets, …
Environment	As consumer of resources and producer of wastes	In competition with nature for scarce resources	Is the ecological space of greenways, river basins, …
Equity	As a location of conflict over distribution of resources, services, and opportunities	Is within the city	Is the social space of communities

Source: Scott Campbell, 1996

Sustainable development is the middle of the triangular model, the balance of all three goals. Having sustainable development as a long-term goal, and moving incrementally in that direction seems the most realistic course of action to Campbell. At what level is sustainability immediately important, the global level of Daly's full world thesis or the local (each local urban area?) level of Campbell's urban area? A pre-ordained path to sustainability in the planner's triangle, constructed in "the hermetic isolation of universities and environmental groups", is rejected by Campbell. He insists negotiation, conflict resolution, and the promotion of creative solutions at the planning table will define stakeholder's vision of a sustainable city. This process defines sustainable development as a social construct.

Larger than local influence may be required to cover the costs unaccounted for in the growing urbanization of California. According to William Fulton et al. (1995), “no one in California is unaffected by the cost of sprawl”, taxpayers, businesses, residents of both new and old suburbs as well as central cities, farmers, and the environment all pay for costs not included in the market transactions of urbanization. Central cities and older suburbs are sometimes abandoned, agricultural land is converted to urban use, wildlife habitat is taken or adversely impacted, and traffic impacts are multiplied; the quality of life is changed. Fulton et al. suggest ways to correct the market failure: identification of potential development areas, efficient use of already developed land, and establishment of a legal and procedural framework “to create the desired certainty and send the right economic signals to investors.” The intended result of these suggestions is that development will simultaneously be more streamlined, less risky, and pay for itself. In addition, local governments probably need some security about the actions of neighboring cities in order to offer developers and citizens a more secure local planning environment.

Learning new ways of staying in business has been a prerequisite for local governments since the passage of Proposition 13 in 1978. Proposition 13 decreased local rule by increasing local dependency on the state for funding as it halved the property tax support of local government. Raising property taxes to support bond issues and infrastructure has since been difficult for local governments because of the two-thirds vote requirement. As result, William Fulton (1991) observes, “they [local governments] turned to the only source of funds they had any leverage over: developers”, and planning became “fiscalized”. This ‘fiscalization’ of planning tends to separate local government’s interest in planning from that of its citizens (Fulton, 1991).

Constant tinkering takes place within California’s planning system legal structure. Challenges to legislative Acts update planning law as circumstances, application of the law, and priorities change. "Land use regulations are a manifestation of the local police powers conferred by the State Constitution", police powers based on the protection of public health, safety, and welfare (Curtin, 1998). The main urban planning document is the general plan. Daniel J. Curtin, Jr. (1998) describes a city's general plan before 1971 as “advisory” and today as “the constitution for development”, a blueprint of the future. Before projects outlined in a general plan can begin, the California Environmental Quality Act (CEQA) demands a review if there may be significant environmental effects. The four major purposes of CEQA, providing information, identification of mitigation or avoidance of adverse environmental effects, prevention of significant and avoidable environmental effects, and disclosure of reasons for project approval despite significant environmental effects, also address public health, safety, and welfare. Although CEQA documents describe and determine local conditions, the extent of significant environmental effects is, in part, defined by the federal interest in endangered species, wetlands, air and water quality, and land use.

Table 5. California's Basic Planning System Legal Structure

Core Legal Structure	First date	Description
Planning, Zoning, and Development	?	Lays out the legal basis for the state's interest in planning and establishes the requirement for local planning agencies.
The Subdivision Map Act	1907	Local regulations to guide subdivisions
The Community Redevelopment Law	1950s	Gives cities and counties power to redevelop blighted areas.
The Cortese-Knox Local Government Reorganization Act (LAFCO)	1963	All annexations, incorporations, and other boundary changes processed through the Local Agency Formation Commission.
General Plan	1927	All local governments prepare a general plan.
Specific elements	1950s	Seven mandatory elements: land use, circulation, housing, conservation, open space, noise, and safety.
Consistency doctrine	1971	Zoning and subdivision approvals must be consistent with the general plan
The California Environmental Quality Act (CEQA)	1970	Local environmental review on virtually all public and private development.
The Coastal Act	1972	Establishes special planning requirements for coastal areas.

Sources: Fulton, 1991; Weiss, 1980; Curtin, 1998

Various local and regional agencies are included in urban planning. In 1963, the California legislature responded to urban sprawl by establishing a local agency formation commission (LAFCO) in each county except San Francisco (Weiss, 1980). Annexations, incorporations, special district formation, and city planning "spheres of influence" must have LAFCO approval. William Fulton (1991) predicts air quality districts and regional water quality control boards may become more directly involved in planning as the impacts of urban pollutants and corresponding federal concern increase. Regional planning is by voluntary councils of governments (COGs), the Association of Bay Area Governments (ABAG) is a COG. COGs are limited by a lack of revenue producing authority and a specific mandate, so they must rely on good will and cooperation since unpopular decisions can mean the withdrawal of dissenting communities (Bradshaw, 1992). A COGs only real power comes from administering federal and state grants (Fulton, 1991), often their primary purpose is as an information source for regional problems. The local and regional control of urban planning in California is a source of criticism. Ted Bradshaw (1992) wants more planning control at a higher level, he defines growth as a statewide issue but, "the tools to manage it are all in the hands of county and city officials who have generally failed to consider the statewide and regional implications of their actions". Instead of regulating urban sprawl, Daniel J. Curtin (1998) suggests cities concentrate on solving the infrastructure problems that motivate growth control measures. Further, using infrastructure to shape urban growth and to protect or enhance quality of life does not allow population growth to control planning. A common test of local and regional efficacy in urban planning and infrastructure development in California is the acquisition of a firm water supply for proposed projects.

How firm does the water supply for a new development need to be? Chapters 330 and 850 of the Statutes of 1995 (California Legislature) require local agencies to make a specified assessment of the reliability of their water supplies for varying water year types (DWR, 1998). A reliability assessment could give local agencies a measure of their current water supply that might aid in defining the firmness level necessary to supply old and new customers. Chapter 881, also of the Statutes of 1995, "requires that cities and counties making specified land use planning decisions, such as amending a general plan, consult with local water agencies to determine if water supply is available" (DWR, 1998). Chapter 881 amends general plan elements and CEQA reporting on water supply assessment (SB901, 1995). The possibility of linking decentralized land use planning with the more centralized process of state water resources planning has incited both proponents and dissenters. The California Department of Water Resources opened the door for Chapter 881 in 1994 by recommending, “Local land use planning and resulting General Plans should be coordinated with water resources planning agencies to insure compatibility between land use plans and water supply plans to make optimum use of the State’s water resources”. Implementation of such a suggestion raises questions regarding authority over local land use and impacts of urban growth. Proponents argue water purveyors cannot be expected to simply provide water for all development as has been done historically. Dissenters claim a formal link is unnecessary, local use of the CEQA process is sufficient to assure supply. With or without a formal link between city planning and water supply, urbanizing California continues to be transformed by visionaries, by hard work, by default, and by water.

Like the flow of water, urbanization in California is a dynamic process. In the next two chapters, population growth and water issues in Northern San Joaquin Valley, reveal a situation as complex as the land and the people involved. Although we are mostly *biosphere people* in California, it is often difficult to think in the large terms of our global impact. In this mostly arid region, consideration of direct water use may be local enough to form some reciprocal connection with the environment we depend upon. At least there is a history of water related dialogue, "nothing will weld disparate elements into a more cohesive force than a common concern over water” (McWilliams, 1949). This is where I will begin, with a look at a growing city and its water.

2. THE URBANIZATION OF TRACY, CALIFORNIA….land, water, and opportunity

“Before the city, there was the land” (Cronon, 1991). Not that the land was uninhabited, simply void of "permanent" settlement. The unsettled land of the present city of Tracy was described in mid-autumn of 1861 and early summer of 1862 by William H. Brewer [10]. As a member of the J.D. Whitney California State Geological Survey from 1860 to 1864, Brewer “recorded in his notebooks with minute punctiliousness everything he saw” (Farquhar, 1949). In October of 1861, Brewer described the journey along the Diablo Range foothills, just west of the Tracy area from Zimmerman’s Mountain House at the entrance of Livermore Pass to the mines near Corral Hollow Creek, as almost treeless, the ground extremely dry, and the air sultry. The San Joaquin Valley appeared desert-like, “a tedious plain”, except along the San Joaquin River where ferocious marsh mosquitoes harassed anything warm-blooded. The heat, the barrenness, and the apparent lack of water (except at a distance, in the river) for nine to ten months of the year caused Brewer to declare the western San

Map 1. The Tracy Area in the 1860s

Source: Farquhar, 1949

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[10] William H. Brewer was Professor of Agriculture in the Sheffield Scientific School (Yale) from 1864 to 1903. Journals of his work with the California State Geological Survey were edited by Francis P. Farquar and the first edition published in 1930 by Yale University Press. All references to Brewer are from the second edition, published in 1949.

Joaquin Valley, “most Godforsaken, cheerless, inhospitable, [and] comfortless…Such an immense region, such it must ever remain, supporting a scanty population”.

When the Central Pacific Railroad brought their Sacramento to San Francisco Bay at Niles[11] line through Tracy in 1869, sheep, herding dogs, and shepherds were the transient population. Sheep crossed paths with the State Geological Survey in the spring of 1862 frequently enough for Brewer to comment, after travelling south from Corral Hollow Creek to Orestimba Canyon (halfway between Del Puerto Canyon and Pacheco Pass), "Here we were on a cattle ranch, away from the infernal sheep" (Farquhar, 1949). Railroaders saw the Tracy area as an ideal stopover before climbing over the Diablo range and continuing to coastal cities. The Southern Pacific Railroad built one line in 1878, another in 1887, and is credited with founding the town of Tracy. The intersection of transportation lines established Tracy and continues to define the city. Before the present freeway triangle surrounded Tracy, major highways, especially Routes 50 and 33, allowed nonstop travel times of less than 30 minutes to Stockton and an hour to the San Francisco Bay area (Livingston et al., 1959). Being well connected to the rest of the region initiated and stimulates the growth of Tracy first as a town and now as a city.

From just before Tracy’s incorporation in 1910 until the late 1930s, Harry Hammond promoted the cities and countryside of the Delta and Diablo Valley with his publication, *Byron Times*. In the publication’s twelfth special edition, the *San Francisco Examiner* was quoted as describing the biennial publication, “California’s outstanding classic in development literature”. Sections on each town and city included pictures of prominent industry, downtown areas, adjacent or nearby waterways, and productive farmland. The 1930-31 edition labels Tracy a “Marvel Town”, and the Tracy Chamber of Commerce invites you to come to “a City where opportunity awaits”. With an estimated population of 5000, the city of Tracy boasted consistent growth and offered four contributing factors: “development of rich agricultural land close to the San Francisco Bay area…; an abundance of cheap water for irrigation and domestic purposes; transportation of the best by rail, water, highway, and air; industries that manufacture the raw products of the community”. The 1932-33 edition has the Tracy Chamber of Commerce promising Tracy is the city “where an assurance of prosperity awaits”.

The language of boosterism in the *Byron Times* was intended to answer common concerns while exuding assurance that this was the finest location with the best opportunities. The abandonment of Tracy’s precursor, the town of Ellis, and the gradual transition back into farmland of nearby San Joaquin City were recent enough to require the reassurance of words like “consistent growth” in a prospective town’s description. The town of Ellis grew quickly for about ten years (1868 – 1878) before relocating to the railroad junction, Tracy. San Joaquin City was started in 1849, once boasted a population of over 1000 and considerable river traffic along the Stockton – Visalia river road, only to be plowed back into a farm by 1911 as circumstances changed (Williams, 1973-74). Farmland conversion was not necessarily permanent in the 19th and early 20th centuries. The *Byron Times* also promised opportunity and prosperity in the towns and cities it promoted. Tracy’s Chamber of Commerce claimed “resources are assurance of

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[11] Niles is now inland several miles, the connection to the city of San Francisco was by ferry (Grunwald, Crawford & Associates, 1969).

prosperity" and listed its prosperity in crops grown, schools, industry, transportation, dairies, irrigation districts, and fame as the "Baby Lima Bean center of the north" (Hammond, 1932-33).

The city's 1959 General Plan identified agriculture as Tracy's primary economic element. Agricultural production in the area had changed from sheep and cattle ranches before 1900 to beans and alfalfa in the 1920s, then to a 1959 mix of tomatoes, alfalfa, sugar beets, asparagus, and a few orchards. In 1969, agriculture and food manufacturing still dominated Tracy area employment by providing over a third of the jobs tabulated in the technical appendix of the 1970 General Plan (Grunwald, Crawford & Associates, 1969). Since then, the importance of other employment sectors has increased. Several large food manufacturing operations have closed, Laura Scudder's in 1988, Heinz in 1998, and now the Holly/Spreckels Sugar Plant, an odoriferous city mainstay for over 80 years, may soon cease processing sugar beets.

Table 6. Tracy Area Employment

	1965	**1980**	**1990**
Agriculture	3028	2810	260 (includes mining)
Construction	519	180	650
Food manufacturing	2846	1050	2860 (all manufacturing)
Misc. manufacturing	291	750	
Wholesale & warehouse	1341	360	520
Retail	1645	1400	1950
Other	1763	1130	4030
Transportation & utilities	NL	760	390
Education	749	NL	NL
Government	2463	4300	2340
Total	16,198	12,740	13,000
Population	14,724	18,428	32,701
Employment/population	1.1	.69	.40
Employment/households	2.4	1.4	1.2

Notes: NL = not listed, possibly in another category. 1965 Population and households are for 1970.
Households: 1970 & 1980 census -based, Tracy Planning Area. 1990, the Tracy Chamber of Commerce
Employment: 1965, census tracts S52, S53, S54, S55. 1980 (1982 General Plan).
1990 (1993 General Plan) City estimates-beginning of 1990 plus new employment during the year.
Sources: Grunwald, Crawford & Associates, 1969; Blayney-Dyett, 1982; Gruen Gruen & Associates, 1992

Tracy was not always a bedroom community. In 1911 and 1912, as the first municipal water and sewer systems were being installed, builders hustled to meet the housing demand of local Southern Pacific Railroad workers (Tracy Press, 12/98). Livingston et al. (1959) described Tracy as “ a relatively independent city with few persons commuting into or out of the area to their jobs”. People became Tracy residents for the employment opportunities in or near the city. There was considerable optimism in 1959 that sufficient jobs for even high projections of population growth would be forthcoming, especially as the planned freeway triangle was constructed. Easy access in every direction would be available to interested industry and their employees, “Tracy will become a giant traffic island surrounded by three freeway legs” (Livingston, et al., 1959). By 1970, Interstate 5 and state freeways 580 and 205 were completed or nearing completion, current maps of the new construction did suggest city boundaries. Taking “full and creative” advantage of this remarkable transportation network was the undercurrent of the 1970 General Plan. In 1970, Tracy had a high ratio of employment to population and number of households. Hundreds commuted to Tracy from Stockton, Modesto, Livermore, and other areas within a 30-mile radius. Many were forced to commute due to the lack of housing in Tracy (Grunwald, Crawford & Associates, 1970). Although Tracy was still “relatively self-reliant in terms of maintaining its own economic base” (Grunwald, Crawford & Associates, 1969), and industrial space needs were expected to increase faster proportionately than urbanization (Grunwald, Crawford & Associates, 1970), it was realized that the freeways would not only facilitate industrial and commercial connections but also the movement of people. The potential for becoming a bedroom community was speculation in the technical appendix to the 1970 General Plan (Grunwald, Crawford & Associates, 1969). Commuting to a job out of the city was estimated at 1000 people in 1982, about one-third of those commuting to Tracy (Blayney-Dyett, 1982). Tracy is now associated with commuting; approximately 70%[12] of the work force drives to a job somewhere else (Tracy Press, Partridge, 3/4/00).

"The dull roar of Interstate 205 can be felt as much as heard…" (Stockton Record, Nickles, 3/14/99), as commuters from Tracy and nearby cities and towns begin the day, on the road. Nickles refers to economists when listing the two nearly unstoppable forces that drive the commuter phenomenon: the need for affordable housing and the quest for high paying jobs. A City of Tracy survey conducted in the fall of 1999 reflects these forces. Identification of available employment skills in the community was the intent of the survey, commuters were targeted, and the response rate was 7.3% (City of Tracy, 1/13/00). Of all the respondents, 86% commuted at least 30 minutes one way, 89% of the respondents said they would take similar jobs in Tracy if they were available. The State Department of Finance reports the San Francisco and San Jose metropolitan areas have added one home for every three jobs this past decade (Tracy Press, Sams, 3/20/00), 205,000 jobs were created in the Silicon Valley while 63,000 homes were constructed (Tracy Press, Brownne, 3/4/00). Stephen Levy, Director of the Palo Alto based Center for the Continuing Study of the California Economy, concludes the San Joaquin Valley is underwriting job growth in the Bay Area since jobs are a net benefit to a local tax base while housing is usually a drain (Stockton Record, Nickles, 3/14/99). Eric Parfrey, a

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[12] 70% is a 1990 census based estimate (City of Tracy, 1997)

county planner and Sierra Club activist, agrees with Levy by describing the housing boom in cities like Tracy a misapplication of pressure that should be on East Bay cities (Tracy Press, Brownne, 3/4/00). State lawmakers are questioning whether California can sustain an economy that depends on 90-minute commutes. The Assembly Housing and Community Development Committee approved a bill on April 26, 2000 that would create incentives for developers to bring jobs to the housing rich Central Valley and houses to the job rich Bay Area (Tracy Press, Sams, 4/27/00). Assembly Bill 2054 passed the Assembly May 31, 2000 and was read for the first time in the Senate on June 1, 2000 (CA Legislative website).

Agriculture came over the Altamont Pass before commuters considered such a trek. In the 1950s, expanding orchards in the Tracy area were often planted by displaced Bay Area growers. The choice of relocation made sense as all of the land in the 1993 Tracy Planning Area is classified as Prime farmland by the Soil Conservation Service (City of Tracy et al., 1993). Protecting the prime agricultural land south of Schulte Road (1 mile south of downtown) from urban encroachment was suggested in 1959, but it was also recognized that the land eventually would be developed. By 1970, the new General Plan was encouraging Tracy to shed its small agricultural town image for its destiny as an urban center. Planners predicted the valleys west of the Altamont Pass would be full around 1980 and the next housing move would be to Tracy.

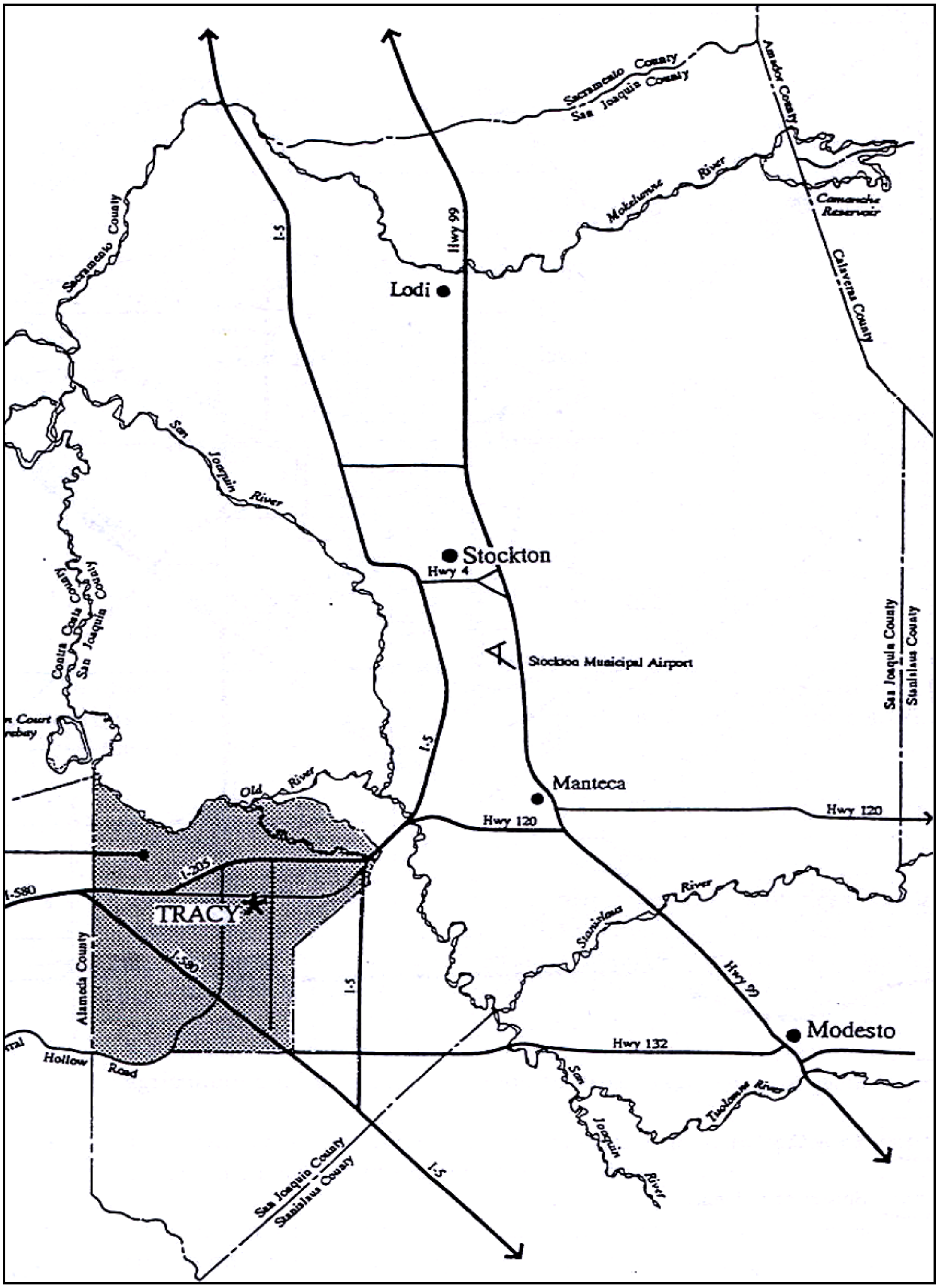
Table 7. The Size of Incorporated Tracy

Year and Information source	Urban area	Urban density
1883 town plan, described in 1982 General Plan	Bounded by East, West, South and Eleventh Streets ~ 169 acres	
1910, Water Conservation Plan 1994	730 acres/ 1.1 square miles	877
1959 General Plan	2350 acres/ 3.7 square miles	3074
1970 General Plan	3680 acres/ 5.8 square miles	2561
1982 General Plan	4400 acres/ 6.9 square miles	2680
1993 General Plan	7600 acres/ 11.9 square miles	2754
1995, Tracy website	8960 acres/ 14 square miles	3179
1999, Assistant City Planner, Yoschak	13,180 acres/ 20.6 square miles	2442

Notes: Urban density is population/square miles of urban area. Population is from Table 9, the year closest to the year of the urban area description is used.

Tracy has always expected to grow. Discussion in the first General Plan (1959) included reserving land for industrial expansion, enlarging the Central Business District, and influencing the placement of proposed freeways. Residential expansion was north of the downtown railroad junction before the 1970s (Poticha, 1986), since then city expansion has been mainly to the west and southwest. The 1982 General Plan specifically directed growth (except infill) to the south and west of the city to economically provide services and to minimize conflicts between urban and agricultural uses of the land. This policy is continued currently. General constraints to city growth have been recognized for each major compass direction. To the North expansion is limited by the Delta and floodplain, to the West is the Diablo Range, to the East Interstate 5 and the 450 acres (Livingston et al., 1959) of the Defense Logistics Agency form a barrier, Southward development is interrupted -but not stopped- by the Delta Mendota Canal, the California Aqueduct, the airport and gravel pits, and Site 300 of the Lawrence Livermore National Laboratory (Tracy Tomorrow, 1989). The freeway triangle has been outgrown, especially north and southwest of town. Less visible constraints are the preservation of agriculture, development of new water resources, and disposal of wastes. These usually limit growth temporarily, until circumstance, technology, or public sentiment change.

Map 2. San Joaquin County and the City of Tracy



Source: The City of Tracy and The Planning Center, 1993

Each of Tracy's General Plans involved citizens in the planning process. Deciding what the city should look like over the planning horizon has been the major task of successive citizen committees. The most recent was the 1989 Tracy Tomorrow process when 120 citizens participated in 30 weekly meetings. This form of planning process was used with specific benefits in mind; citizen-based participation reverses the traditional legislative process, decentralizes decision making, is less bureaucratic, and improves communication. Perhaps most importantly, a common vision for the future of Tracy could be developed (Tracy Tomorrow, 1989). Recommendations of the Tracy Tomorrow process included facilitating development to increase the number of available homes. Rapidly escalating housing prices were believed to be the result of insufficient supply. The Tracy Tomorrow vision and effort was incorporated into the 1993 General Plan.

As was discovered in the 1999 commuter survey of Tracy (Table 8) and implied in population records (Table 9), most current Tracy residents lived elsewhere during the 1989 Tracy Tomorrow process. The vision of 11 years ago has been challenged, particularly the part of the Growth Management Ordinance (GMO)[13] that limits residential growth to an average of 1200 units per year (maximum of 1500). An expression of disenchantment with the results of the 1989 vision, Measure T was drafted by the Tracy Region Alliance for a Quality Community [14]. The initiative slowed the rate of residential growth to a maximum of 750 units per year (an average of 600). Even if

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[13] Origin of GMO number of housing units is a best estimate from planning commission, city council, city staff, consultants, school district, and citizens. (Tracy Tomorrow, 1989) The Gruen Gruen & Associates (1988) analysis of the GMO: "Given the estimated average annual demand between now and the end of the century, the 1200 to 1320 annual allotment is sufficient to maintain a competitive housing market over the next 13 years." Poticha (1986) estimated Tracy's share of the near future (<10 years) housing demand to be approximately 1200 units per year. Poticha's assumptions: 65% of the Tri-Valley housing demand will be met outside the region, Tracy's share is two thirds.

long-term community goals are agreed upon and a clear vision of the future appearance and character of a city is seen, there is no guarantee those goals and vision will go unchallenged, especially when the city and its residents change. In March of 2000, Measure T was presented to voters. While older neighborhoods favored the initiative, newer neighborhoods rejected the attempt to slow growth (Tracy Press, Brownne, 3/10/00). Measure T failed 48.7% to 51.3% (Tracy Press, Brownne, 3/27/00).

Table 8. 1999 Tracy Commuter Survey

YEARS LIVED IN TRACY	PERCENT OF RESPONSES	CUMULATIVE
Less than 1 year	15.8%	15.8%
1 – 3 years	20.2%	36.0%
3 – 5 years	12.7%	48.7%
5 - 10 years	27.7%	76.4%
> 10 years	20.1%	96.5%
All my life	3.5%	100%

Source: Tracy Press, Brownne, 1/14//00

There were many arguments for and against Measure T, perhaps the most engaging was the promise (almost) of coming high-tech jobs if the Growth Management Ordinance was not changed. The Tracy Blue Ribbon Committee[15] reports, "Tracy is poised to become an economic powerhouse. The combination of its location, transportation access, and solid employee base ensure that Tracy will continue to build a strong mix of jobs. Tracy will broaden its traditional base of agricultural and blue-collar jobs to include a significant number of high salary technology jobs in the near future... Recently, technology companies have begun to locate their assembly operations in Tracy's light industrial centers. This trend will continue as the City and the San Joaquin Partnership[16] pursue these targeted companies. *Tracy is establishing a reputation as a viable*

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[14] TRAQC: Tracy area residents concerned about the city's growth policies and quality of life

[15] The Tracy Chamber of Commerce sponsors Blue Ribbon Committee. They describe themselves as having been formed to "study and disseminate information about the current plans for Tracy's future."

*alternative to expensive Bay Area locations." (*Tracy Chamber of Commerce, 2000) The Chamber of Commerce presents Tracy as on the brink of attracting well paying jobs. Skeptics question whether jobs are forthcoming, or would be affected by an initiative such as Measure T (Tracy press, Brownne & Partridge, 3/1/00). An analysis of Measure T found a reduced residential growth rate in Tracy would not have a major effect on the regional economy (Economic & Planning Systems, Inc., 1999). The analysis concluded the spillover housing would be picked up by nearby communities, and "major employers are more likely to locate in Tracy on the basis of regional labor force characteristics rather than the specific attributes of Tracy's labor force". Opponents to Measure T, like the Blue Ribbon Committee, offer a future Tracy of varied employment opportunities and city stature, an expected result of the 1989 Tracy Tomorrow process and the 1993 General Plan. Proponents of Measure T argued those positive characteristics can be achieved with less transitional pain in the present by slowing the rate of growth, with the added bonus of more planning time. One of Tracy's residents, perplexed after months of reading Measure T discussions in the local newspaper, captured the need for a current Tracy Tomorrow process by asking both sides of the debate: Why did you move here? What did you want to see happen to Tracy then? What kind of town do you want to live in 10 years from now? (Tracy press, letters to the editor, 12/15/99)[17]

Of all the growth issues, the availability of water may actually pace the rate of development in Tracy. Farmers, city and rural residents, environmentalists, and others

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[16] San Joaquin Partnership: a nonprofit corporation created in 1992 as a marketing entity to promote the county to business. Mike Locke (former Tracy city manager) is president and CEO.

attending City Council meetings have given various water-related reasons why Tracy should slow its current housing boom. The stormwater drainage system has been criticized for fouling Old River and contributing to Delta degradation. The increasing number of detention basins have been described as indicators the drainage problem is unsolved. Sewer and water capacity are questioned in light of continuous city expansion. Between city incorporation and the 1960s, water supply in the Tracy Area was generally considered more than sufficient. “A practically unlimited supply of water at low cost” was offered to industry, to ease the uncertainties of farming, and to support the desired urban growth of Tracy (Hammond, 1932-33). A 1943 USDA study on the suitability of the Tracy-Newman area for the production of guayule[18] found the local irrigation districts believed their water supply was “ample for the area now irrigated” (Ewing, 1943). The 1959 General Plan for the city of Tracy stated only that system expansion of the municipal groundwater source was planned. Concerns about water supply sufficiency are not evident until the 1970 General Plan when recommendations are made to expand and improve the current supply with surface water from the California Aqueduct or the Delta Mendota Canal (Grunwald, Crawford & Associates, 1969 and 1970). Since then, the procurement of water, adequate in both quantity and quality, has become part of the planning process for the Tracy area.

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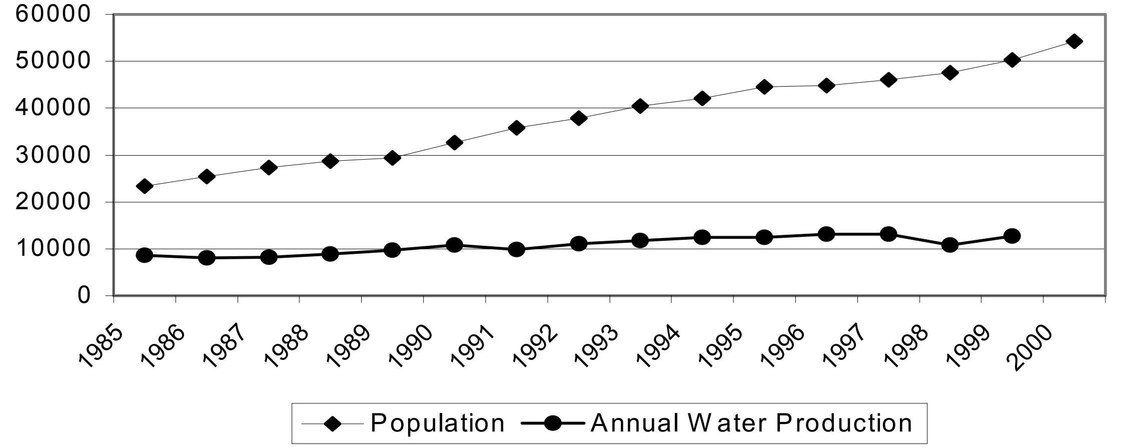
[17] A new Tracy Tomorrow process is in progress as of the Fall of 2000. Measure T was modified by TRAQC to address only the number of allowable residential units per year (600 ave./750 max), renamed Measure A, and passed in November, 2000 by 56.1% to 43.9%.

[18] a wartime emergency rubber source, the small shrub is currently grown for rubber in parts of the southwest U.S.

Chart 1. Tracy: Water Production and Population



Source: Bayley, 2000 for most of the water production data and the idea for the graph. Population and other data is from Table 9.

The demand for water in the City of Tracy has increased with the population, but at a slower rate. Water production has increased gradually from 8,589 acre-feet in 1985 to 12,754 acre-feet in 1999; the population meanwhile has more than doubled. The citywide use of water (municipal and industrial) per person has decreased over time. In 1980, 370 gallons of water production was supplied per person each day, by 1999 production had decreased to 226 gallons per capita (Table 9). Water production since 1985 has increased an average of 3.3% per year, population 5.8%.

Table 9. Tracy Population, Water Source, and Water Production

Date	Population (Jan. 1, except 1910, 1950)	Water Source [amount]	Water Production (city total, acre-feet)		
			Surface water	Groundwater	Total
1910 to	1000	Groundwater, upper and lower zones			
1950	8410				
1960	11289	Groundwater, upper and lower zones			
1962				4750	4750
1963				4860	4860
1964				5120	5120
1965				5380	5380
1966				5660	5660
1970	14724	Groundwater, upper and lower zones			
1974				4794	4794
1975	15816			5850/5382	5850/5382
1976				5041/5639	5041/5639
1977				4784/4648	4784/4648
1978				5045/4885	5045/4885
1979			903	5012/4993	5915/5896
1980	18428	Groundwater, lower zone mostly and USBR contract [up to 10,000 af/yr]	5676	1980/1438	7656/7114
1981			5513	1421/1330	6934/6843
1982			6108	1602/456	7710/6564
1983			6295	1594/579	7889/6874
1984			6276	1310/1150	7586/7246
1985	23381		5733	2856/2504	8589/8237
1986	25436		5954	2150/1872	8104/7826
1987	27279		6421	1841	8262
1988	28762		5936	2970	8906
1989	29403		4946	4788/4480	9734/9426
1990	32701	Groundwater, lower zone [6,000 af/yr yield] and USBR contract	4967	5837	10804
1991	35760		4995	4815	9809
1992	37875		7023	4002	11024
1993	40507		7572	4126	11698
1994	42082		7471	4980	12451
1995	44507		8241	4246	12487
1996	44850		8631	4468	13098
1997	46047		7267	5817	13083
1998	47544		6089	4699	10787
1999	50300		7260	5495	12754

Notes: The source of surface water is the Central Valley Project through the Delta Mendota Canal, the groundwater is local. The decrease in water production in 1998 is due to the closing of the Heinz plant. Water production amounts represent the amount that enters the municipal distribution system from municipal wells and the Delta Mendota Canal. af = acre-feet. USBR=U.S. Bureau of Reclamation

Sources:
The population from 1910 to 1950 is from Livingston et al., 1959; from 1960 to 1999 (except 1996) is from the Tracy website, 1996 is from the California Department of Finance website (DOF website).
Discussion of the USBR contract is in Blayney-Dyett, 1982 and in the text.
Discussion of the groundwater basin yield is in Kennedy/Jenks/Chilton, 1990, and in the text.
Groundwater pumpage for 1962-1966 is from Hotchkiss and Balding, 1971.
Groundwater pumpage 1974 – 1989 Kennedy/Jenks Consultants, 1994a & Kennedy/Jenks/Chilton, 1990.
Groundwater pumpage for 1990 – 1992 is from Kennedy/Jenks Consultants, 1994a.
Surface water diversion for 1979 to 1992 is from Kennedy/Jenks Consultants, 1994a.
Groundwater and surface water for 1993 is from Kennedy/Jenks Consultants, 1994b.
Total water production for 1990 to 1999 is from Bayley, 2000.
Groundwater and surface water from 1994 to 1999 is from City of Tracy Water Quality Reports, (monthly percentages of groundwater and surface water are given for 1996 – 1999, yearly for 1994 and 1995).

In 1974, a 40-year contract between the city of Tracy and the United States Bureau of Reclamation for up to 10,000 acre-feet per year was signed. Delta Mendota Canal delivery of Central Valley Project water to the city of Tracy began in 1979. Water production increased following delivery of the surface water, especially during the first full year, municipal water production in 1980 was 30% higher than in 1979. The 1974 contract between the United States and the City of Tracy specified cumulative minimum deliveries over 30 years (Kennedy/Jenks Consultants, 1994b). In the year following the initial delivery date (1979) the minimum delivery was 1000 acre-feet, actual surface water production for 1980 was 5,676 acre-feet. By the tenth year (1989) at least 33,250 acre-feet should have been delivered, surface water production from 1979 through 1989 totaled 59,761 acre-feet. Today, minimum deliveries seem a curious article to include in a contract, at the time water purveyors, including the Bureau, sought customers. Groundwater briefly became the supplemental and emergency supply, since surface water quality was superior to that of local groundwater. In the mid 1980s strategies to use municipal groundwater in conjunction with surface water supplies to increase reliability were evaluated. Four new wells were drilled near the water treatment plant, adjacent to the Delta Mendota Canal (Kennedy/Jenks Consultants, 1994b), pumpage increased again. During the last drought the percentage of surface water to groundwater varied with surface water availability. Blending groundwater with Delta Mendota Canal surface water was chosen by the city as a method of lessening the objectionable taste of the total dissolved solids and sulfates in the groundwater as well as reducing the potential for trihalomethane (and other disinfection by-products) formation in the treated surface water

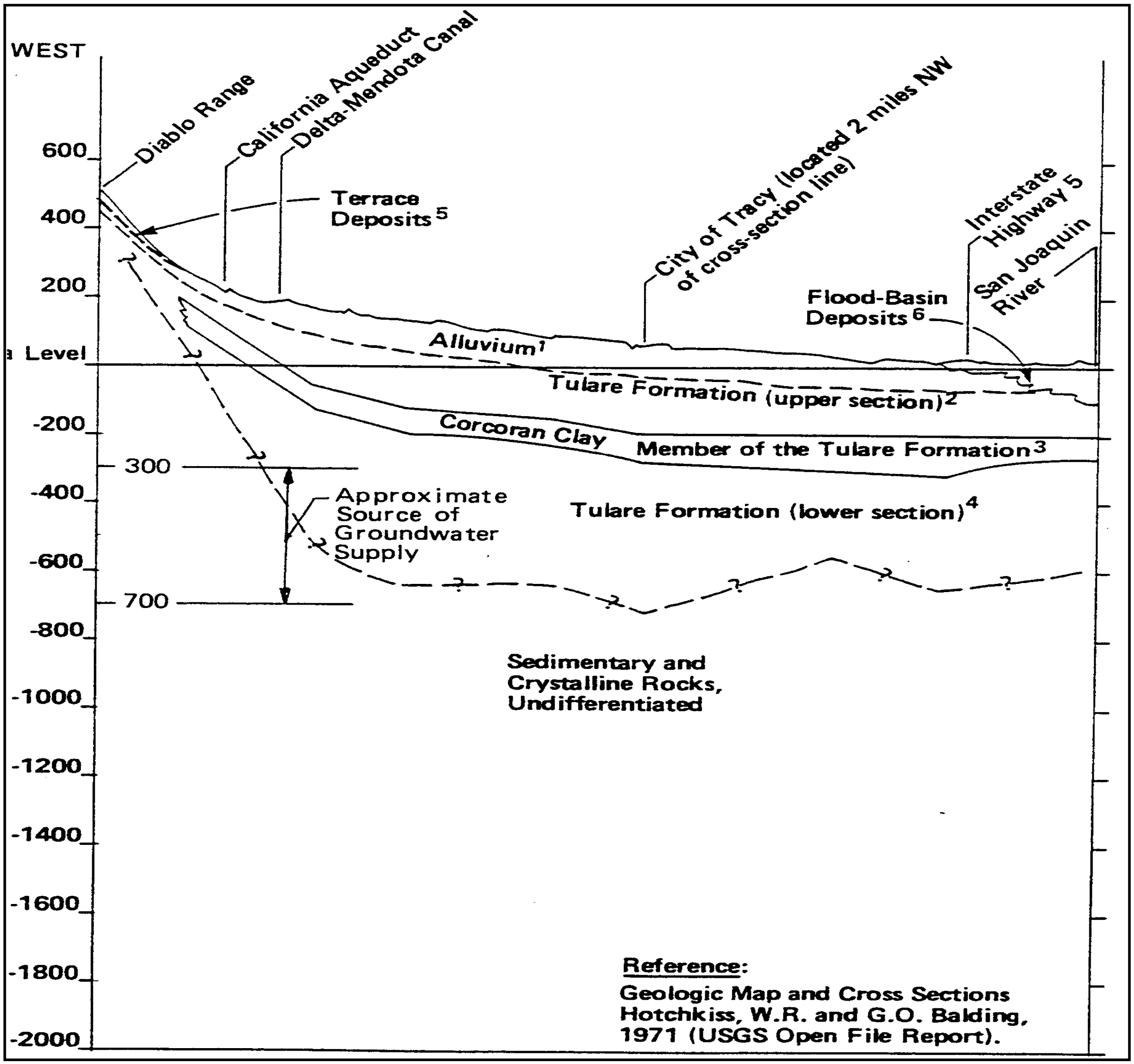
(Kennedy/Jenks Consultants, 1994b). Currently, a blend of 60% surface water to 40% groundwater is desired to achieve water quality goals (Bayley, 2000).

The quality of local water has been remarkable for over a century, regardless of water year type (wet or dry). For instance, although the extremely wet water year of 1861-1862 has become part of California weather legend, Tracy area water quality was reportedly unaffected. The flooding was so tremendous that in June of 1862, William H. Brewer recorded, “all ferries across the San Joaquin were still impassable, up to Firebaugh, eighty miles up the River” (Farquhar, 1949). The previous fall, Brewer noticed the ephemeral nature of many streams in the Diablo Range and how the streambed of Corral Hollow Creek (southwest of Tracy, see Figure 1) told of a large flow at times. In early 1862 his observation was demonstrated, “A torrent like a river, had swept down the canyon last winter, destroying the road.” Water near Corral Hollow, near everywhere, was more abundant in 1862 than in 1861, but the California State Geological Survey mules were still disgusted with the “poor and alkaline” quality in the Corral Hollow Creek area. A local resident described the water from her well as good for cooking some things and making coffee, “but it spiles tea”. Brewer found the local spring water better than the “*awful*” streamwater coming from the Corral Hollow mines, but still “too bad to drink alone”. He longed to “get a drink of *good* water. I assure you the last is no little item” (Farquhar, 1949).

Groundwater development began in the Central Valley about 1880 (Bertoldi et al., 1991), following development of drill rigs and engine-driven pump technology in the 1870s

(CVPIA PEIS, 1997). During the 1880s, artesian wells were constructed throughout the San Joaquin Valley (CVPIA PEIS, 1997). The early abundance of artesian flow in the San Joaquin Valley gave credence to the idea of at least a two-aquifer system separated by a layer of confining clay. In a study of groundwater from Tracy to Dos Palos (bounded by Old River, the Diablo Range, the Merced/Fresno county lines, and the San Joaquin River), Hotchkiss and Balding (1971) describe two general water bearing zones. Corcoran Clay confines the lower zone, the upper zone ranges from confined to unconfined and is above the Corcoran Clay member of the Tulare Formation. The Corcoran Clay is a lacustrine and marsh deposit (Hotchkiss and Balding, 1971; Page, 1986), evidence of ancient Lake Corcoran which is estimated to have occupied the western half of the San Joaquin Valley about 600,000 years ago from the Stockton arch to where the San Joaquin River turns north (Norris and Webb, 1990). Kennedy and Jenks (1994) estimate the lower zone source of municipal groundwater supply for the city of Tracy is located between 300 and 700 feet below mean sea level. Prior to groundwater development on the western side of the San Joaquin Valley, there were lower zone flowing wells from the Delta to Buena Vista Lake. Near Tracy, the area of flowing wells was about 7 miles wide (Hotchkiss & Balding, 1971). Under this predevelopment pressure gradient, “water from the lower zone also must have had the tendency to move upward toward the upper zone” (Hotchkiss and Balding, 1971). By 1967 pumping depressions near Tracy and southwest of Dos Palos caused the pressure head of the lower zone to be less than that of the upper zone, “water now has the tendency to travel downward from upper to lower” (Hotchkiss and Balding, 1971). In comparison, the absence of a widespread confining bed was demonstrated in the Sacramento Valley by the lack of flowing wells during early groundwater development (Page, 1986).

Chart 2. Geologic Cross Section of the Tracy Area



Source: Kennedy/Jenks Consultants, 1994b

1. Alluvium: permeable to moderately permeable; unconfined

2. Tulare Formation (upper): highly to variably permeable; unconfined, semi-confined, and confined.

3. Corcoran Clay Member: impermeable confining stratum.

4. Tulare Formation (lower zone): highly to variably permeable; confined.
5. Terrace Deposits: highly permeable to permeable; unconfined; generally above the water table.

6. Flood-Basin Deposits: moderately to poorly permeable; unconfined.

Kennedy/Jenks Consultants (1994b) identify the confined lower zone of the aquifer as having superior water quality to the upper zone, especially when considering sulfates and total dissolved solids. Although described as confined, the lower zone is not isolated. Water quality in the lower zone can be affected by cross-zone wells, whether the wells are functioning or incorrectly abandoned. Perforated casings that connect several aquifer layers greatly increase the vertical hydraulic connection through the aquifer system (Bertoldi et al., 1991). Kennedy/Jenks/Chilton (1990) associate localized “islands” of poor quality water in the lower zone with cross-zone wells. The DWR (2000) lists 152 wells in the Tracy Basin, of these the number of cross-zone wells is not documented and the extent of the contamination of lower zone water by upper zone water constituents is not known. Of 78 wells (in the Tracy to Dos Palos area) identified by Hotchkiss and Balding (1971) as yielding water with excessive[19] iron, fluoride, nitrate and boron concentrations, 71% are upper zone wells and 21 % are cross zone wells. The base of freshwater, the bottom of the lower zone, in the San Joaquin Valley is underlain by a saline water body[20]. Depths to the base of freshwater range from less than 100 to greater than 3500 feet below the land surface (Bertoldi et al., 1991). Bertoldi et al. identify the most probable source of high chloride in the shallow groundwater along the San Joaquin River as the upward flow of the saline groundwater. In addition to possible upwelling of saline water, naturally occurring salts in the soil can degrade groundwater in the northern Delta Mendota Canal Service Area (Stoddard & Associates, 1996).

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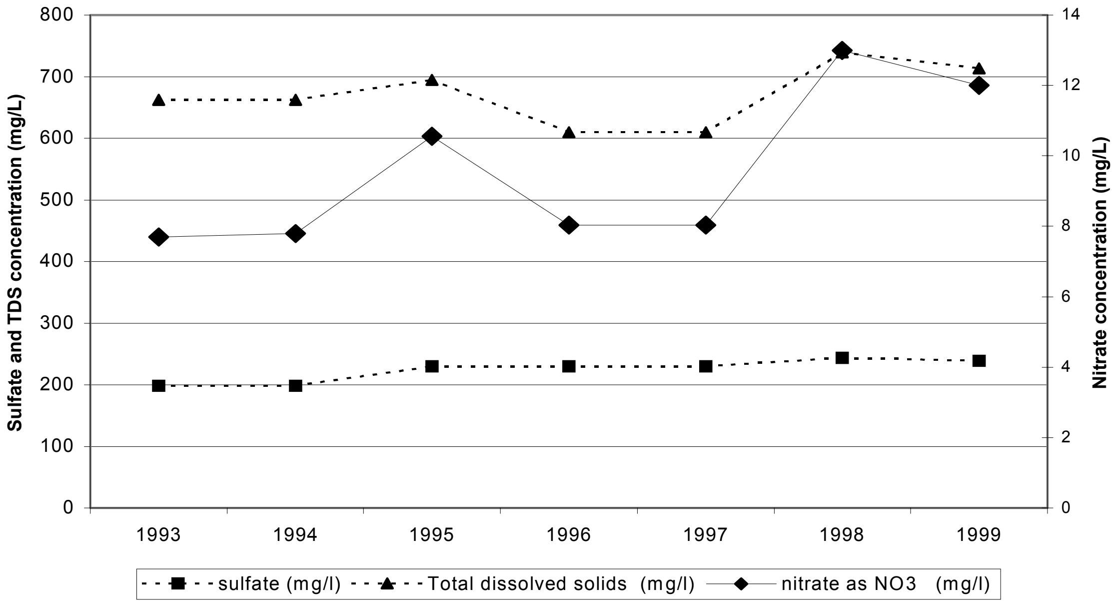
[19] 1962 Department of Health Services standards

[20] Prior to the Pleistocene (~2 to 3 million years ago), the Pacific Ocean flowed through various areas of the Central Valley, retreating gradually as the Coast Ranges rose (Bertoldi et al., 1991).

Groundwater quality is highly variable across the Tracy area. The lowest concentrations of sulfate (~100mg/L) and total dissolved solids (~600 mg/L) were found in wells between the City and the airport to the southwest (Kennedy/Jenks/Chilton, 1990). An isoconcentration line of 1000 milligrams total dissolved solids per liter of water follows the western and southern boundaries of the Tracy planning area. Most of the wells sampled[21] contained sulfate concentrations between 100 and 300 milligrams per liter of water, a few along the Diablo Range tested at 500 to 600 mg/L (Kennedy/Jenks/Chilton, 1990). Although groundwater quality varies spatially, well data from 1953 to 1984 did not indicate any significant trend in total dissolved solids concentration over time (Kennedy/Jenks, 1985). More recent data also fails to show a trend over time[22].

Chart 3. Tracy Groundwater Quality



Sources: City of Tracy, 1993 to 1999, Water Quality Reports

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[21] The wells sampled tapped either the upper or lower zones or both, but the specific zone of a well is not noted.

[22] The recent data cannot be compared directly with the older data (1953-1984) because the wells are not the same and the recent data is a composite of municipal wells while the older data compared the water quality of each well with itself over the time period.

Tracy's groundwater does meet the Environmental Protection Agency's primary water quality standards; some secondary standards are exceeded. Excessive constituents include sulfates and total dissolved solids, plus the groundwater is very hard (hardness is >180 mg/L – measured as concentration of calcium carbonate) (Kennedy/Jenks Consultants, 1994b). Secondary standards are not federally enforceable or believed to compromise health if exceeded, but they do affect the aesthetic qualities of water and public acceptance. Local groundwater quality was motivation for acquiring a surface water supply in the 1970s, despite believing the groundwater supply was adequate and reliable for the city's long-term requirements (Creegan & D'Angelo-McCandless, 1970). The Department of Water Resources ranks the quality of Tracy groundwater as "tolerable" (Grunwald, Crawford & Associates, 1969).

In response to local water quality and quantity questions, an AB 3030 groundwater management plan, initiated by local water supply districts[23] and the City of Tracy, was drafted. The Groundwater Management Plan For the Northern Agencies in the Delta-Mendota Service Area and a Portion of San Joaquin County (referred to here as the Groundwater Management Plan) includes part of the Tracy Basin[24] plus part of the Delta Mendota Basin; portions of Merced, Stanislaus, and San Joaquin Counties are included in the Groundwater Management Plan. The basic goal of the Groundwater Management

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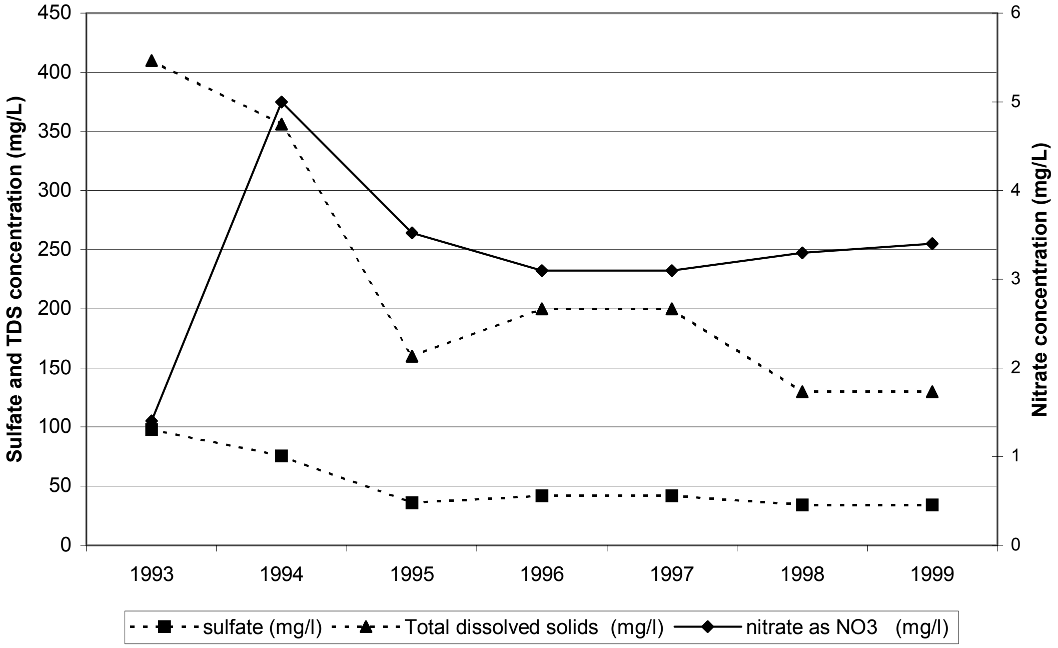
[23] Banta-Carbona ID, West Side ID, west Stanislaus WD, Plain View WD, Patterson WD, Del Puerto WD, located from the Delta (North) to the Del Puerto Water District (South), and from the Coast Ranges (West) to the San Joaquin River (East), nondistrict lands in San Joaquin County are represented by the San Joaquin County Flood Control and Water Conservation District.

[24] The California Department of Water Resources (1980) describes the Tracy Basin as including all San Joaquin Valley older and younger alluvium in Contra Costa and Santa Clara Counties and the portion of San Joaquin County west of the San Joaquin River.

Plan is to "provide the means for collection of the necessary groundwater monitoring data needed to assess the impacts of…activities that affect the groundwater basin such that sustained use of groundwater can be optimized without adverse impacts to the water quality and yield" (Stoddard & Associates, 1996). Collection of groundwater data is necessary. While addressing the 21st Biennial Ground Water Conference, Carl Hauge (1998) stated, "It is difficult, if not impossible to "manage" groundwater with only two-fifths of the data that is available to manage surface water".

Kennedy, Jenks, and Chilton (1990) discovered the lack of data for the Tracy area groundwater basin limited quantification of basin yield to an historical trend analysis. Since it was not possible to construct a water budget without data to define the hydraulic connection to the surrounding water bearing deposits and flows in and out of the area, a maximum groundwater withdrawal calculation was devised. This calculation was based on maximum total pumpage (1974 – 1989), and resulted in the recommendation that the city of Tracy not exceed 6000 acre-feet per year groundwater withdrawal (Kennedy/Jenks/Chilton, 1990). Of course this estimate of safe yield has been criticized, and with reason, the number does not reflect comprehension of the aquifer system only that past pumpage was survived. Still, in 10 years a better estimate has not yet surfaced. The City of Tracy has recently initiated a yield study on the local portion of the lower zone groundwater basin. Water levels are being monitored and annual municipal groundwater production is targeted to range from 5500 to 5800 acre-feet (Bayley, 2000).

Chart 4. Tracy Treated Surface Water Quality



Sources: City of Tracy, 1993 to 1999, Water Quality Reports

The water Tracy receives from the Central Valley Project has a different history than local groundwater, and different quality concerns. This surface water requires treatment for exceeding primary and secondary maximum contaminant levels for color, odor, turbidity, and concentrations of aluminum and iron (City of Tracy, 1993 to 1999). Surface water from the Delta Mendota Canal enters the Tracy Water Treatment Plant for flocculation, sedimentation, filtration, and disinfection prior to municipal distribution (Kennedy/Jenks Consultants, 1994b). While removal of suspended materials and infectious organisms has been routinely achieved, this success has been accompanied by formation of disinfection by-products. Disinfection by-products are the result of chlorine or ozone combining with organic compounds and bromide. The Delta, where Central Valley Project water conveyed by the Delta Mendota originates, is a source of both organic soils (organic compounds) and seawater intrusion (bromide). Since groundwater has low potential for forming disinfection by-products, blending groundwater and surface water has been one strategy for staying below the minimum concentration level, another has been the use of chloramines instead of chlorine for the final disinfectant (Kennedy/Jenks Consultants, 1994b).

Consideration of future need prompted the comparison of two potential water supply sources for the City of Tracy (CH2Mhill, 1997). Costs and advantage of the acquisition of water conveyed through the Delta by local water districts were contrasted with participation in the South San Joaquin Irrigation District's (SSJID) South County Surface Water Supply Project (referred to here as the Project). Water quality and the reliability of pre-1914 water rights to the Stanislaus River earned SSJID the recommendation of CH2MHill. High quality Stanislaus River water could improve both the City's drinking water quality and conjunctive use options (CH2MHill, 1997). Alternatively, CH2MHill did not expect water from a Delta source conveyed through the Delta Mendota Canal to improve municipal water reliability or quality. Since the Central Valley Project was designed as an agricultural water source, the Delta Mendota Canal is not as well protected as the California Aqueduct. During winter maintenance of the Canal[25] an amazing assortment of vehicles is usually dragged up from the Canal bottom. Uniformly sandy-tan colored and packed with silt and sediment, the cars, trucks and occasional motorcycles await identification in an empty lot across from the old Heinz plant on 11th

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[25] The San Luis & Delta Mendota Water Authority has maintained the Delta Mendota Canal for the past 5 years. Winter maintenance is not on a regular schedule, it is done whenever pumping can be stopped and the water outlook is favorable. The vehicles stacked in the Tracy lot are from the northern half (approximately) of the Canal (telephone conversation , 5/25/00).

Street in Tracy. In 1997, there were over 175 such vehicles (CH2MHill, 1997), accidental, stolen, unwanted, nefariously involved; all contributed to the constituent mix of the Central Valley Project water. CH2MHill (1997) suggested this sort of addition to the water supply would not occur with Stanislaus River water.

In an editorial, Cheri Matthews (Tracy Press, 7/26/99) recalls Tracy missed a chance to tap into Hetch Hetchy water half a century ago and warns, “don’t blow it this time with SSJID”. Planning for the SSJID Project began in the late 1980s, Tracy was invited to join the Project in 1993 (Tracy Press, Brownne, 7/16/99). The purpose of the Project is to supplement the municipal water supply of the growing cities of Manteca, Escalon, Lathrop, and Tracy. A water treatment plant is planned just west and downhill of Woodward Reservoir, an offstream storage facility of SSJID. Tracy’s share of the Project is 10,000 acre-feet of water per year (Environmental Science Associates, 1999). Rick Martin, general manager of SSJID, estimates the project will require a year of planning prior to two years of construction (Tracy Press, Brownne, 1/18/00). The Final Environmental Impact Report was released in May of 2000 and approved by the SSJID board at the end of the same month. Some Tracy subdivisions have begun the development process with SSJID as their water source, their development fees are structured to fund the water project (Tracy Press, Brownne, 12/23/99). Can SSJID’s Project be considered a firm enough source of water supply? “The whole issue of water supply has been shunted off to too late in the process”, according to Eric Parfrey, “the public is being told ‘Don’t worry they won’t get a building permit until they have water.’ But the city shouldn’t be approving subdivisions and specific plans without water” (Tracy

Press, Brownne, 12/23/99). The city's General Plan states that new annexations need to bring their own water supplies. However, the Planning Commission sometimes agrees on annexation without a water supply because the city's Growth Management Ordinance assures that no project can gain building permits without a water supply (Tracy Press, Brownne, 1/18/00). How closely connected should development planning and construction be with the certainty of a specific water supply? How firm is firm enough at the planning stage of development?

Despite the nearly tripled population since 1980, Tracy's water supply has been sufficient. The estimated annual groundwater basin yield of 6,000 acre-feet has not been exceeded and the city has yet to demand the maximum annual Central Valley Project delivery of 10,000 acre-feet. The difference between Tracy's annual allotment and the amount delivered has usually gone to carryover storage to be reallocated the next year among Central Valley Project contractors. In recent years the City of Tracy has sold between 1400 and 2300 acre-feet of their allotment to other Project contractors when there has been a market (Bayley, 2000; USBR, 2000). Within another 20 to 40 years the City population is expected to triple again, to around 160,000. The estimated potable water demand for this future city is 39,000 acre-feet of water annually, 23,000 acre-feet over the current total supply. Major water suppliers, the Central Valley and State Water Projects, have already allocated their supplies (DWR, 1998). Water reallocation occurs at a different level, from district to district or district to municipality or vice versa. Each secured or potential water source carries concerns, balancing those concerns to achieve quality and reliability is the challenge. Nick Pinhey, Tracy's Director of Public Works wants to diversify, he feels it is essential for Tracy to have 4 or 5 sources of water (Tracy Press, Matthews, 3/4/00).

One of the first places to look for new water is nearby. Tracy has been an agricultural center for most of its existence; irrigation and water districts surround the city, each with different advantages and challenges to offer. If district water accompanied urbanized land in the same percentage as land area (Table 10), at build-out of the current Urban Management Plan over 25,000 acre-feet of agricultural water would be added to the City's supply. All of the irrigation districts listed in Table 10 were organized by 1921 (Division of Water Resources, 1931). Plain View Water District organized after the arrival of Central Valley Project water in the early 1950s. Tracy's current Urban Management Plan (1993) includes most of West Side Irrigation District and over a third of Naglee-Burk Irrigation District, annexation to the city of either district's lands means cessation of district water deliveries. A recent evaluation of Tracy's water supply options addressed this local loss of water by recommending the development of institutional arrangements with local water districts to transfer water to the city as district land is urbanized (Water Transfer Associates, 1996). The water agreement between the Solano Irrigation District and the city of Vacaville was included in the report as an example. In exchange for greenbelt/buffer zones, annexation and development restrictions, and negotiated charges, the Solano Irrigation District agreed to provide a specified quantity of water to the expanding city of Vacaville. Since the agreement covers water supply for new residential areas, health and safety concerns are expected to mitigate effects of any future reduction in the district's entitlement to water from the Solano Project. Plain View

Water District has communicated the intention "to work with the City to assure the reliability of the supply" (PVWD, 1998). The Central Valley Project contract with Plain View Water District is for agricultural use water, except for about 400 acre-feet, (Water Transfer Associates, 1996), but the District offers internal supply redistribution during dry years to support a water commitment to the City. Unlike West Side and Naglee-Burk Irrigation Districts, Plain View Water District maintains its service area even after city annexation. The water entitlement stays with the land.

Table 10. Water Supply and Urbanization of Local Districts near Tracy

Local District	Supply	Urbanization Impact
West Side ID	1916 water right – Old River up to 82.5 cfs April 1-Oct. 31 7,500 af/year CVP	After annexation, land is de-annexed from WSID and water deliveries cease. ~ 70% within Tracy's UMP
Naglee-Burk ID	Pre-1914 right – Old River About 3.5 af/acre, about 2650 acres ~ 9,300 af/yr	After annexation, land is de-annexed from NBID and water deliveries cease. ~35% within Tracy's UMP
Plain View WD	20,600 af/yr CVP	After annexation, land remains within the service area of PVWD. ~60% within Tracy's UMP
Banta Carbona ID	25,000 af/yr CVP 2 San Joaquin River licenses on an irrigation schedule ~40,000 af/yr	~10% within Tracy's UMP
Byron-Bethany ID	Pre-1914 right – 40,000 miner's inches under 4-inch pressure 60,000 af/yr historic use Old River-diversion at CCFB	District recently annexed part of Tracy Hills planning area. Supply up to 6,000 af/yr
South San Joaquin ID	Pre-1914 and post-1914 rights – Stanislaus River, 300,000 af/yr	South County Surface Water Supply Project Tracy's share = 10,000 af/yr.

Notes: ID = irrigation district, WD = water district, CVP = Central Valley Project,
af/yr = acre-feet per year, UMP = Tracy's 1993 General Plan /Urban Management Plan,
cfs = cubic feet per second, CCFB = Clifton Court Forebay.

Sources: Water Transfer Associates, 1996; CH2MHill, 1997; Environmental Science Associates, 1999; CH2MHill et al., 1999

Even if the water always remained with the land, not all planning areas are currently irrigated. The Tracy Hills Project, a southwest Tracy location of the future for homeowners and business, has 364.6 acres in the Plain View Water District (Nolte and Associates, 1997,2), but the remaining 5810 acres do not belong in any district. The developable portion of Tracy Hills (about 2700 acres) was annexed to the city in 1998 with an array of potential water sources and the apparent certainty of Widren Water District. The Tracy Hills development group bought Widren Water District in 1997 (Tracy Press, Brownne, 9/1/99) with the intention of using the District's water for their development. The Widren Water District is adjacent to the Delta Mendota Canal just west of Firebaugh on the San Joaquin River. In 1958, the U.S. Bureau of Reclamation filed a report on Widren Water District's request for Central Valley Project water and assessed the District's land and local water. Groundwater in the district was described as meager and of poor quality, the report recommended the district receive up to 2990 acre-feet per year to become a productive agricultural unit. It was anticipated that drainage might become a problem with the application of irrigation water to the land (USBR, 1958).

Table 11. Widren Water District Land Assessment in 1958

Land Class	Limitations for Irrigation Farming	Area (acres)	Percent of Area
3	Smooth, fine textured soils with moderate concentrations of soluble salts. Can be worked within a limited moisture range. Limited to alkali-tolerant crops.	286	34.2
4	Smooth, fine textured soils with strong concentrations of soluble salts. Can be worked within a limited moisture range. Limited to a very narrow range of salt-tolerant crops.	509	61.0
	SUBTOTAL - IRRIGABLE ACREAGE	795	95.2
6	Non-irrigable land in stream beds, reservoirs, roads, etc.	40	4.8
	TOTAL – GROSS AREA	835	100.0

Source: USBR, 1958

The Draft Environmental Assessment of the proposed water transfer issued a Finding Of No Significant Impact (FONSI) on the permanent assignment of the Widren Water District contract of up to 2990 acre-feet of water per year to the City of Tracy (Montgomery Watson, 1998). The Assessment also indicated the transfer would be beneficial to the Widren Water District by increasing upland habitat and improving drainage water quality and quantity. After the FONSI was challenged by Fresno County, a second Assessment was issued. The same finding was recorded, with the added stipulation that 50 acre-feet of water per year remain with Widren Water District. The city of Tracy could take delivery of up to 2940 acre-feet per year, subject to agricultural water supply allocation criteria (Montgomery Watson, 1999). However, the County of Fresno disputes the legality of the Tracy Hills development group's actions; the group bought all of the land in a water district, installed new directors, and voted to transfer the district water out of the county for a different use (Tracy Press, Brownne, 9/1/99). This dispute is still in court.

The estimated annual water demand for the annexed Tracy Hills planning area (potable and nonpotable) is 5000 acre-feet (Nolte and Associates, 1997). Plain View Water District supplies district land within the Tracy Hills project with about 870 acre-feet annually. In December of 1999, the San Joaquin Local Agency Formation Commission voted unanimously to allow the Byron-Bethany Irrigation District to annex 2006 acres of the Tracy Hills planning area (Tracy press, Brownne, 12/11/99). The annexation will bring up to 6,000 acre-feet per year to Tracy Hills and the City. This is water reallocation at perhaps a new level, between developer and district. District general manager, Rick Gilmore, told the Commission that Byron-Bethany, whose board approved the annexation in August, can spare 6000 acre-feet because of increased irrigation efficiency (Tracy press, Brownne, 12/11/99). Delivery of Byron-Bethany water can be through the Delta Mendota Canal.

The concept of an adequate supply can be considered on another level; how much water does the City of Tracy consume? Urban consumptive use of water production quantities can be estimated if irrigated acreage, evapotranspiration, and system losses and accretions are known, assumed, or can be derived. Several estimations support the calculated consumptive use for the City of Tracy (Appendix). Indoor water use can be estimated from water production using the Minimum Month Method (DWR, 1994). Consumptive use of water used indoors is low, possibly around 2% (DWR, 1983), most of the water used indoors has the second job of waste transport. Almost all outdoor water use involves irrigation of landscaping. Urban irrigation is usually averaged to the evapotranspiration needs of local irrigated pasture, although landscaping can consist of a variety of trees, bushes and smaller plants, in addition to grass. To check the validity of this simplification for Tracy I surveyed the 233 homes I see most often and found over 94% have front yard lawns. Tariq Kadir (1991) suggests 25% of urban land area is irrigated, but the City of Tracy has annexed thousands of acres that await development. An estimate of urban irrigation in Tracy is 1,400 acres (Appendix, Table A-6).

The sum of these estimations reveals from 37% to 40% of water delivered in the City of Tracy was used consumptively in 1997, 1998, and 1999, returning about 60% as wastewater, drainage, or otherwise irretrievably lost. Indoor consumptive use of water was about 2.5% of total consumptive use.

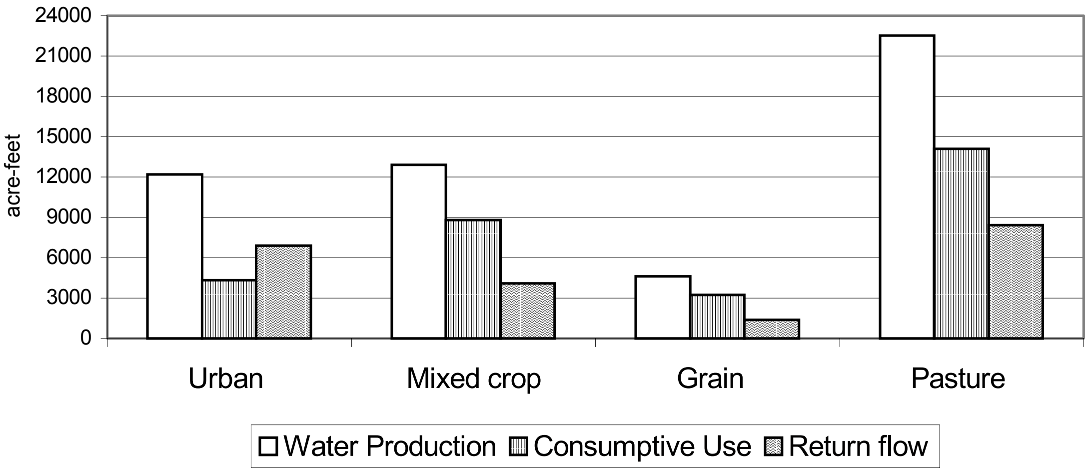
Table 12. Urban Consumptive Use of Water in Tracy

	estimated Indoor CU	1997 Water Delivered	1997 estimated Outdoor CU	1998 Water Delivered	1998 estimated Outdoor CU	1999 Water Delivered	1999 estimated Outdoor CU
JAN	3.2	181	0	176	0	189	0
FEB	2.9	173	0	145	0	163	0
MAR	3.2	284	108	170	14	192	17
APR	3.1	353	192	205	146	251	147
MAY	3.2	401	184	239	108	387	183
JUN	3.1	409	224	338	217	443	222
JUL	3.2	490	270	434	270	491	270
AUG	3.2	467	250	449	251	465	251
SEP	3.1	420	183	379	179	407	178
OCT	3.2	340	84	297	57	362	80
NOV	3.1	233	0	202	0	253	19
DEC	3.2	177	0	204	0	225	24
(MG)	38	3926	1495	3237	1241	3828	1391
(AF)	116	12047	4589	9933	3809	11745	4269

Notes: AF = acre-feet, MG = million gallons, CU = consumptive use
The noticeably lower water use in 1998 was due to a very wet year.
Indoor consumptive use is for all years.
Source: Calculations and sources are in the Appendix.

If the Tracy area was not urbanized, growers might be tending irrigated pasture (most water intensive) or grain (least water intensive), or a mixture of crops. If the main urban area, about 4,700 acres, was actually irrigated pasture then around 14,100 acre-feet of water would be consumptively used annually (Chart 5). Many crops require less water than irrigated pasture; if grain were grown on the 4,700 acres, then consumptive use of irrigation water applied from January through June each year would be about 3,300 acre-feet, or about 75% of the annual estimated urban consumptive use of water (the Appendix presents the basis for these comparisons). Water applied per acre of land irrigated can be similar for cropland and urban land, regional irrigated pasture and urban landscaping are often given the same estimated monthly evapotranspiration rate (Kadir, 1991; CVPIA PEIS, 1997). In the model used (Appendix) to estimate urban consumptive use of water there is one calculation of effective precipitation per unit of land, whether many continuous acres of farmland or the sloped suburban front lawn.

Chart 5. Water Use of Land Scenarios for Urban Tracy



<u>Notes</u>: Urban irrigated (landscaped) area = 1400 acres
Core urban area = 4700 acres = crop area irrigated for comparison.
<u>Source</u>: See the Appendix for more assumptions and the calculations.

Runoff coefficients are higher for urban areas than farmland, storm hydrographs before and after urbanization demonstrate higher urban runoff during these events. The difference between dry season urban drainage and farm return flows may not be as dramatic. The range of average annual farmland return flows for an 4,700 acres Tracy farm is about 8,400 acre-feet for irrigated pasture to 1,400 acre-feet for grain, assuming respective irrigation efficiencies of 63% and 70%, and no deep percolation, reuse, or other irretrievable losses. Urban return flows include both indoor wastewater and drainage from landscape irrigation. The average annual return flow estimate for the City of Tracy is 6,900 acre-feet, more than the midpoint of the range for 4,700 acres of crops grown in the Tracy area. The difference between indoor water use, calculated using the

Minimum Month Method, and the consumptive use of water used indoors is wastewater, about 5,700 acre-feet annually for the City of Tracy. However, there are significant accretions and losses to urban return flows.

Morning curbside water, residential and municipal drainage from urban irrigation, evaporates and percolates as it glides down the urban runoff collection system. Outdoor water use that is not lost to evapotranspiration or on-site percolation in Tracy flows down a stormwater drainage pipe or channel, often to a detention basin, and ultimately to Old River. In addition to expected storm drains and culverts, about 9 miles of landscaped, open drainage channels with sidewalks and bicycle trails are planned for the City (Cella Barr Associates, 1994). The open drainage channel that curves with the suburban streets in my neighborhood terminates at a detention basin that doubles as a grassy, open area where soccer can be played and other outdoor amusements enjoyed unless it has recently rained. Approximately 1000 acre-feet in detention basin capacity is planned with the main purposes of reducing runoff rates and downstream impacts (Cella Barr Associates, 1994). Drainage water quality also can be affected, as the flow velocity slows, suspended solids settle. Tracy is not yet required (since the population is less than 100,000) to obtain a National Pollutant Discharge Elimination System (NPDES) permit for urban runoff. Other communities' use of detention basins has been a "most effective means of satisfying requirements of the NPDES Program" (Cella Barr Associates, 1994). Currently, drainage flows in Tracy are not exactly monitored. Design calculations based on area, runoff coefficients, and land use are used in planning, and flows from the detention basins are metered to some extent by pump capacities, but monthly or annual drainage quantities are not measured and recorded (Bayley, 2000).

Monthly water production in Tracy follows the expected pattern of greater usage in the summer, peaking in the high outdoor water use months of July and August. Wastewater flows can be high in either winter or summer, depending on weather and water usage. When I first considered approximating the consumptive use of urban water, comparing production and wastewater flows seemed the estimation method for indoor water use. Then I discovered the extent to which wastewater systems can experience infiltration and inflow[26]. High winter wastewater flows indicate wet weather, a high water table, and system accretions. The design of wastewater conveyance capacity includes estimates of peak infiltration and inflow (CH2MHill et al., 1996). Inflow is a function of up-slope runoff, infiltration rates depend on conveyance pipe depth relative to the water table. In Tracy, sewer system pipes south of mid-city are generally above groundwater while those to the north are below. Peak infiltration and inflow rates can be above 2.5 million gallons per day (CH2MHill et al., 1996). CH2MHill (1998) estimated wastewater system infiltration and inflow in Tracy to be about 50 million gallons (153 acre-feet) per year.

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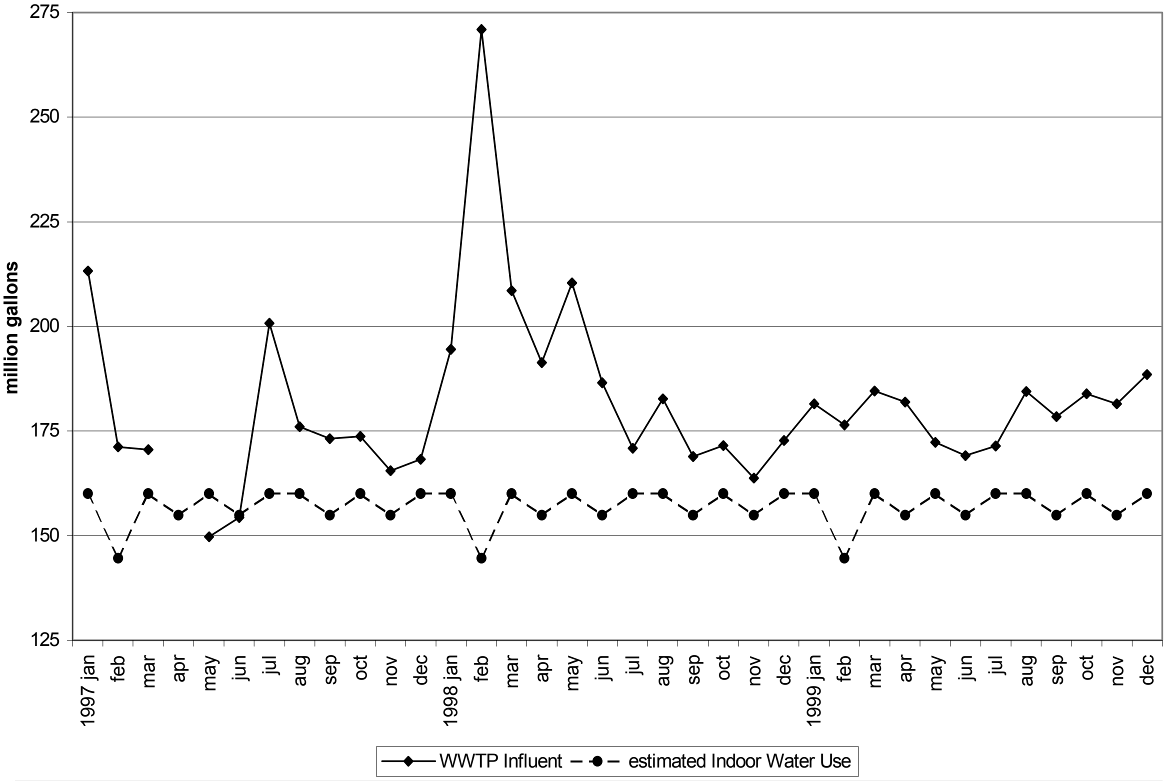
[26] Infiltration: groundwater entering a sewer system. Inflow: surface water entering a sewer system. It can be difficult to distinguish between infiltration and inflow as the source for system accretion.

Chart 6. Tracy WWTP Influent and estimated Indoor Water Use



(million gallons) 1999	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
estimated Indoor Water Use	160	145	160	155	160	155	160	160	155	160	155	160
WWTP Influent	181	176	185	182	172	169	171	184	178	184	181	189
System Accretion	13%	22%	15%	17%	8%	9%	7%	15%	15%	15%	17%	18%

Source: City of Tracy, Department of Public Works
For the estimated Indoor water production, see the Appendix
Note: The high summer effluent of 1997 shows the system impact of the Heinz plant before it closed in early 1998. The very high winter effluent reflects the winter of 1997-1998 storms and flooding.
WWTP = wastewater treatment plant.

When wastewater flow is plotted with an estimate of indoor water use, a picture of system accretion emerges. Wastewater flow almost always exceeds estimated water production for indoor use. The difference between estimated indoor water use and wastewater treatment plant influent is 269 million gallons for 1999, an average of 14% more wastewater treatment plant influent than indoor water use.

Infiltration as one explanation for the apparently excessive effluent flow is related to a wastewater quality problem. The lower zone groundwater pumped up for municipal use has had an annual average total dissolved solids concentration from 610 to 739 mg/L since 1993, the treated surface water has varied from 130 to 410 mg/L over the same time period (Figures 4 & 5). Yet, the wastewater concentration can be in excess of 1200 mg/L for total dissolved solids (CH2MHill et al., 1994). A study of mineralization in Tracy wastewater (CH2MHill, 1992) reported significant portions of the City's wastewater system is constructed in areas with soils that are often saturated; the water table in the Tracy area is considered high, between 1 and 20 feet. Upper zone water can exceed freshwater limits with concentrations of total dissolved solids around 2000mg/L and higher (CH2MHill, 1992; City of Tracy, 1995). In a 1995 letter to the Regional Water Quality Control Board, the City of Tracy submitted a status report on their effluent mineralization investigation. Total dissolved solids increase in the water, from source to effluent, was estimated at 500 mg/L., approximately half of this increase was attributed to the use of home water softening units. The combination of salty upper zone infiltration and flushed softening brine in the wastewater stream may contribute most of the total dissolved solids increase, of the two, only infiltration contributes to system accretion.

Wastewater reclamation and the capture of runoff are urban options for increasing water supply without contracting for new sources. Tracy Hills plans to reclaim wastewater produced in the development through tertiary treatment, for application to nonpotable demands. The City of Tracy has a policy to "Use reclaimed water to reduce non-potable water demands wherever practical and feasible" (City of Tracy et al., 1993). Use of reclaimed water usually requires a storage facility to regulate the difference between availability and need. Tracy Hills has suggested using a quarry as a shallow aquifer storage and recovery system (Randall Planning & Design et al., 1997). The specified quarry is part of the Corral Hollow Creek alluvial fan which extends into the Tracy sphere of influence. Over 2500 acres of the fan are classified by the State Division of Mines and Geology as containing significant mineral deposits (sand and gravel, aggregate) (City of Tracy et al., 1993). The Department of Public Works in Tracy has concerns about the proposed use of the quarry because of the unknown potential impacts to the aquifer and the municipal groundwater supply (Nolte and Associates, 1997). In the Tracy area, Corral Hollow Creek with its alluvial fan and floodplain is considered to be the most substantial groundwater recharge area (City of Tracy et al., 1993). Perennial streams of the Diablo Range, such as Corral Hollow Creek, are estimated to lose 60% to 80% of their flow to infiltration into the groundwater basin (Hotchkiss and Balding, 1971), perhaps to several aquifer zones as the streambed descends into the valley. Recharge of the aquifer's upper zone is believed to be primarily from the percolation of applied water used in agricultural irrigation and seepage from canals (Kennedy/Jenks/Chilton, 1990), percolation from urban irrigation may also contribute. Recharge of the lower zone may be from subsurface inflow, and leakage from the upper zone through the clay confining layer, or through cross-zone wells (Kennedy/Jenks/Chilton, 1990). Hotchkiss and Balding (1971) suggest artificial lower zone recharge on foothill outcrops of lower zone deposits and through wells. The City of Tracy has not yet conducted any groundwater recharge operations (Kennedy/Jenks Consultants, 1994a), wastewater reclamation, or runoff capture for urban use. Unless discharge of runoff and treated wastewater to Old River and the subsequent ‘downstream’ diversion from the Delta Mendota Canal can be counted.

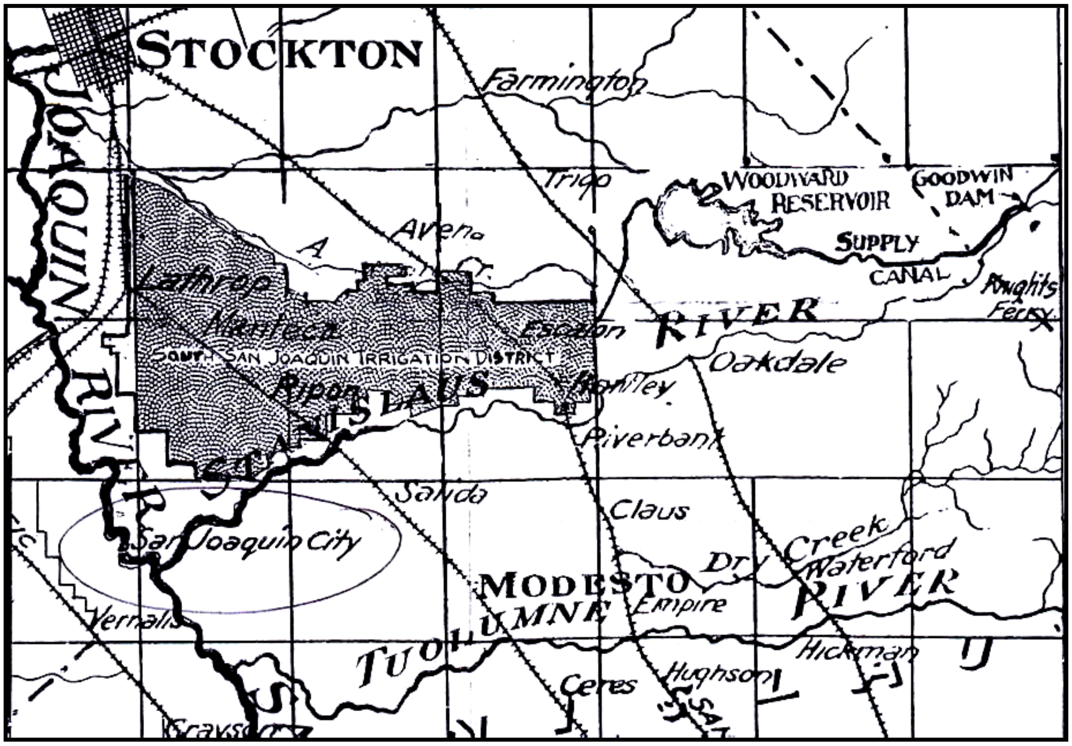
The expected tripling of population in Tracy over the next 20 or 30 years will require substantial infrastructure additions and changes to maintain current levels of water reliability and sanitation. Listed environmental impacts from increased demands on water, wastewater, and drainage systems are all evaluated as less than significant once mitigated (City of Tracy et al., 1993). Increased degradation of Old River due to the discharge of more treated wastewater is considered avoidable through tertiary treatment of new wastewater treatment plant capacity, and the use of reclaimed water on city parks, golf courses, and landscaping. Until urban runoff standards are applicable to Tracy, degradation of Old River due to drainage discharge is listed as only potentially significant. While water supply is identified as the limiting factor for growth in the City of Tracy (City of Tracy et al., 1993), urban water usage is defined in the California water code (section 106) as the primary beneficial use of the resource (CA Legislative website). The annual availability of an additional 23,000 acre-feet of water or more is not quite addressed in the environmental analysis. Mitigation is a practical list of measures: conservation, water system improvements, and care to approve only those building permits where water supply exists (City of Tracy et al.,, 1993). The procurement of an adequate water supply is assumed.

No town beckoned the 1862 California State Geological Survey crew in the Tracy area, they camped at Zimmerman's Mountain House at the foot of the Livermore Pass and along Corral Hollow Creek. Seven years after William H. Brewer's spring visit, permanent settlement began in the Tracy area (City of Tracy et al., 1993) and growth of an urban area began. Growth was consistently stimulated by availability of quality land, nearby water, and opportunities gained from a unique location. The land no longer has the appearance of terrifying vastness; towns, cities, roadways, canals, irrigated fields, and many people occupy the Valley. The land has been transformed to support human existence beyond the imagination of an educated man in the nineteenth century.

3. WATER FOR URBAN GROWTH ……………conflicts, connections, collaboration

South San Joaquin Irrigation District's proposed water transfer to the City of Tracy has been met with great expectation, and with controversy. District water history and water future are being scrutinized and hailed in newspapers, in public meetings, and in court. What are the regional and local impacts of this anticipated water sale?

Map 3. The South San Joaquin Irrigation District (Bond Commission, 1913)

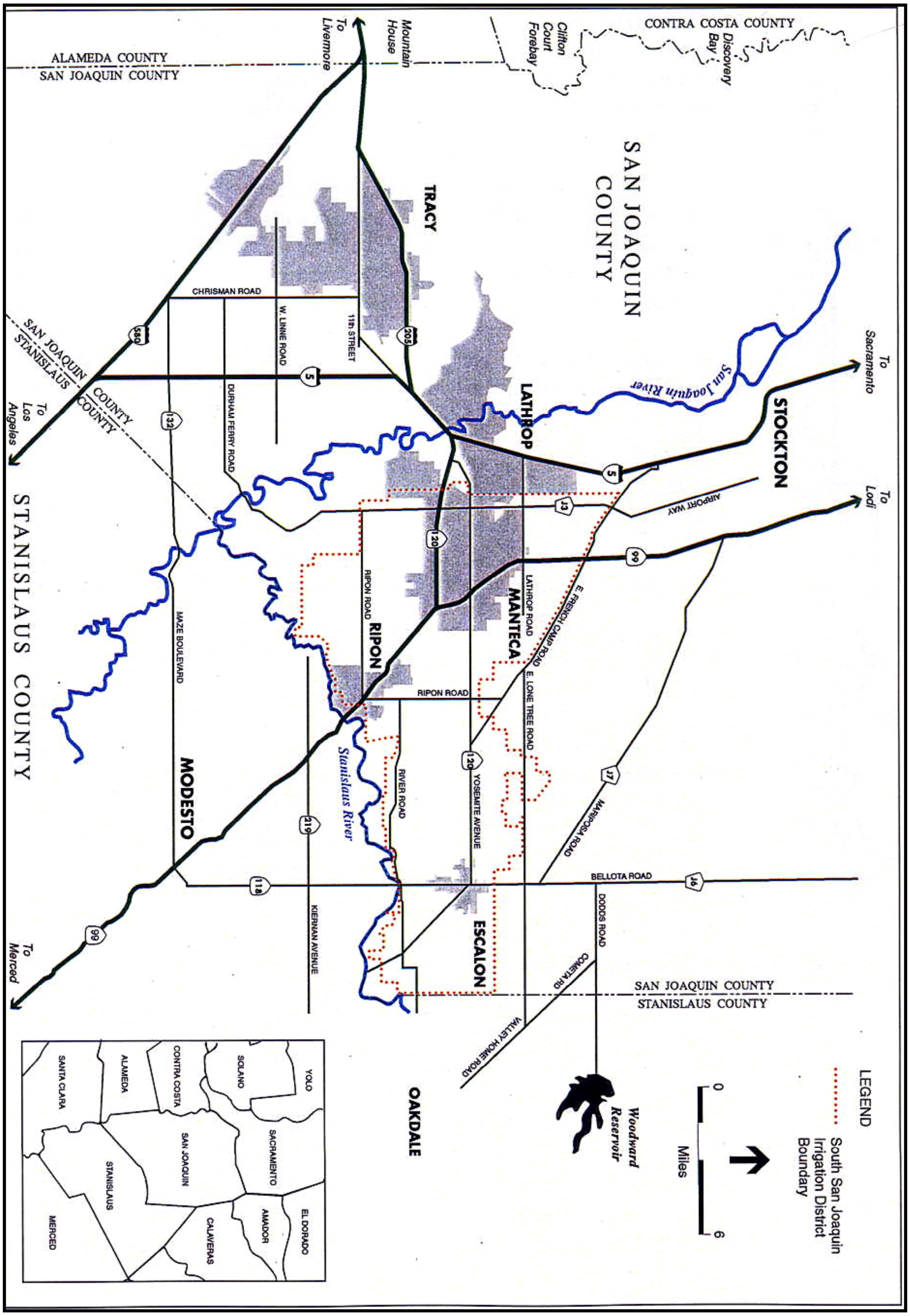


The South San Joaquin Irrigation District organized in May of 1909, coinciding with the last phase of nearby San Joaquin City disbandment. San Joaquin City was located on the west bank of the San Joaquin River, just downstream of the Stanislaus confluence and about a mile west of Sturgeon Bend (Williams, 1973-74). The site was chosen for higher ground, not subject to the flooding common elsewhere on the Valley floor. Along the old

River Road and close to Durham Ferry, San Joaquin City thrived as a center of transportation and commerce for about fifty years. Then, as rail and other roads acquired much of the old River Road traffic, San Joaquin City faded along with the overland cattle drives that used to stop in town. San Joaquin City was part of 19th century California, new transportation routes and irrigation districts were forming a new and different century.

Located on the north side of the Stanislaus River, South San Joaquin Irrigation District (SSJID) lands are not quite consistently adjacent to the rugged river canyon. The Oakdale and Central San Joaquin Irrigation Districts bound SSJID on the east and north. The downstream, western District boundary is the South Delta Water Agency and the town of Lathrop. Across the river from the southwest corner of the District is the site of old San Joaquin City.

Map 4. Contracting Cities for the South County Surface Water Supply Project



Source: ESA, 1999a

Established to provide "a reliable and economical source of irrigation water for the agricultural industries of Escalon, Ripon, and Manteca" (SSJID website, 2000), the South San Joaquin Irrigation District (SSJID) plans to keep pace with current and future San Joaquin County urbanization through the South County Surface Water Supply Project (the Project). The Project proposes to provide the cities of Tracy, Manteca, Escalon, and Lathrop with a supplemental supply of treated, high quality water from the Stanislaus River. Included in the Project is a water treatment plant near Woodward Reservoir and 36.5 miles of pressurized pipeline to eventually deliver about 44,000 acre-feet of drinking water each year to the contracting cities. Not intended to completely supply the contracting cities, the Project is designed to progress in two phases according to projected urban growth. Unlike the others, the City of Tracy would receive its entire contract amount, 10,000 acre-feet annually, in the first phase.

Table 13. South County Surface Water Supply Project Contracting Cities

	Manteca	Escalon	Lathrop	Tracy
Planning area	16,432 acres	1,953 acres	15,436 acres	77,000 acres
City area	9,714 acres		2,300 acres	7680 acres
Current Demand	12taf/yr	1.6 taf/yr	2.0 taf/yr	13 taf/yr
Demand in 2025	35 taf/yr	3.2 taf/yr	16 taf/yr	46 taf/yr (in 2017)
Problems	Estimated safe yield is 1 af/acre, pumping at 2.4 af/acre. Quality	Nitrates, arsenic, DBCP, EDM	Manganese, iron, saltwater intrusion. Groundwater overdraft.	Demand expected to exceed supply. Quality.
Project Phase 1	12,700 af/yr	2,015 af/yr	8,007 af/yr	10,000 af/yr
Project Phase 2	18,500 af/yr	2,799 af/yr	11,791 af/yr	10,000 af/yr

Notes: af/yr = acre-feet of water per year
Sources: (ESA, 1999a), and (ESA, 1999b), and SSJID board meeting on 5/30/00

The South County Surface Water Supply Project (the Project) is a solo venture of SSJID, but many SSJID projects have been planned and completed jointly with Oakdale Irrigation District (OID). OID and SSJID cooperation on projects began soon after they organized under the 1897 Bridgeford Act (Jackson and Mikesell, 1979). Initially the Districts purchased water rights, built dams for water regulation, storage and power, and maintained independence from state and federal programs. Jackson and Mikesell identify the Christmas flood of 1964 as the decisive event which changed the level of independence in the Stanislaus River Basin and encouraged acceptance of a federal presence. The flood caused local confidence in local solutions to falter, but SSJID and OID continued to believe in the superiority of locally planned, constructed, and controlled facilities for water storage, conveyance, and flood control. The two Districts unsuccessfully promoted their own plan for further Stanislaus River development. [27] A 1972 Agreement and Stipulation between the U.S. Bureau of Reclamation (USBR), SSJID, and OID formalized local agency acquiescence to the New Melones project, and USBR recognition of District water rights.

Table 14. Joint SSJID / OID Constructed Reservoirs (except Woodward)

Reservoir	Construction date	Gross capacity (taf)	Net capacity (taf)	Miles from Goodwin Dam	Notes
Old Melones	1925-26	122.5	101.8	9	Replaced with New Melones in 1979 (2.4 maf)
Tulloch	1955-58	68.4	56.4	1.5	USBR uses as an afterbay for New Melones
Donnells	1955-58	64.5	62.4	60	Middle fork of the Stanislaus
Beardsley	1955-58	97.5	77.5	48	Middle fork of the Stanislaus
Woodward	1916	36	36	15	Offstream (SSJID only)

Notes: taf = thousand acre-feet of water, maf = million acre-feet
Source: (ESA, 1999a)

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[27] The Stanislaus River Basin Group (SSJID, OID, Calaveras County Water District, Tuolumne County Water District no.2) planned to develop the Basin. Facilities included 294 taf storage on North Fork Stanislaus, an enlarged Melones Reservoir (1.1 maf capacity), 74 taf new storage in Calaveras and Tuolumne Counties (The Group, 1961).

Goodwin Diversion Dam was built jointly by SSJID and OID. Completion of the dam in 1912 and sufficient progress on the delivery system in 1913 allowed SSJID to begin irrigation in the spring of 1914 (SSJID website, 2000). [28] The early need for District water storage was satisfied with the 1916 construction of Woodward Reservoir, SSJID's offstream facility. Irrigated acreage in the District was 22,000 acres in 1915, by 1927 nearly 53,000 acres received water from the Stanislaus River (Nye, 1986; Jackson & Mikesell, 1979). Between 1988 and 1997 irrigated acreage ranged from 60,000 to 64,000 acres, an average of 61,500 acres per year; SSJID only supplies water for agriculture (ESA, 1999a). Prior to construction of irrigation facilities, wheat was cultivated on lands that became the South San Joaquin Irrigation District (Bond Commission, 1913).

The delivery of irrigation water to District farmland was accompanied by local analysis of water requirements and flow patterns. In 1913, the engineering firm of Duryea, Haehl & Gilman was hired by the District; the engineers estimated farm delivery requirements to be three acre-feet of water per acre over an assumed maximum of 56,840 irrigated acres (170,520 acre-feet of water). These estimates have been exceeded, around 3.8 acre-feet of water per acre was applied for the 1988 irrigation season (SSJID, 1989#4). By 1999, applied water had dropped about 10%, to around 3.4 acre-feet per acre (Table 15). The engineering firm also estimated conveyance losses between the river and the farm would be 36% of the water diverted (Bond Commission, 1913). By 1941 conveyance loss estimates were adjusted to 25% of diversions (Gianelli, 1941). Return flows were estimated in 1930 to run 25% to the Stanislaus River and 75% to the San Joaquin (Blote,

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[28] The delivery system today consists of 320 miles of underground pipeline and 120 miles of open ditches (SSJID website, 2000)

1930). Stanislaus River flow at Ripon (35 miles downstream of Goodwin Dam) is about 30% higher than below Goodwin Dam, due to accretion from tributaries (20 are ungaged) and groundwater (ESA, 1999a). These tributaries collect agricultural return flows and spills of water, averaging about 112,000 acre-feet annually between 1957 and 1991 (Montgomery Watson, 1993), originating from both the Stanislaus and Tuolumne Rivers. Two gauged agricultural return flows from SSJID increased the flow of the lower Stanislaus River by 3124 acre-feet in 1996 and 3906 acre-feet of water in 1997 (EA Engineering, 1999).

Table 15. Current Estimated South San Joaquin Irrigation District Water Usage

Crops (% of acreage)	Acreage	Farm delivery requirements (af/ac)	Applied water (af)	Irrigation efficiency	Return flows and percolation (af)
almonds (52%)	31,980	3.65	116,727	0.69	36,185
walnuts (3%)	1,845	3.65	6,734	0.69	2,088
peaches (3%)	1,845	3.65	6,734	0.69	2,088
grapes (10%)	6,150	2.40	14,760	0.71	4,280
grains (8%)	4,920	1.00	4,920	0.65	1,722
clover (3%)	1,845	4.35	8,028	0.62	3,050
pasture (5%)	3,075	5.00	15,375	0.70	4,613
corn (5%)	3,075	2.75	8,456	0.61	3,298
alfalfa (4%)	2,460	4.35	10,701	0.62	4,066
other (7%)	4,305	3.45	14,852	0.64	5,347
Total/Average	61,500	3.37	207,300	0.68	66,700

Notes: Totals are rounded. af/ac = acre-feet of water per acre

Farm delivery requirements: clover is assumed to have the same farm delivery requirement as alfalfa, "other" is assumed to have the average farm delivery requirement of field crops, rice, sugar beets and tomatoes. (20,3-24)

Return flows and percolation = applied water - applied water * efficiency. (Assumes no irretrievable losses other than evapotranspiration.)

Total acreage is the average crop acreage between 1988 - 1997. (see text)

Irrigation efficiency is evapotranspiration of applied water (ETAW) / applied water (AW) both from CVPIA PEIS, CVPM M/M, Tables II-5 and II-6 for CVPM region 11.

Sources: SSJID, 1989, and ESA, 1999a, and CVPIA PEIS, 1997

The use of return flows from upland District areas on lands at lower levels occurs (Bond Commission, 1913; SSJID, 1989), but is not quantified. From 1979 through 1988, runoff from rainfall plus irrigation surface water return flows averaged 57,000 acre-feet per year, annual irretrievable losses (other than crop evapotranspiration) were around 27,000 acre-feet (Montgomery Watson, 1993). Annual seepage to the aquifer and percolation of applied water was around 135,000 acre-feet. Implementation of the Project is expected to reduce the amount of percolation from applied water, increase slightly the seepage, and decrease the groundwater pumped in the contracting cities (ESA, 1999a).

Annual diversion of water by SSJID has risen steadily until recently. Since the late 1980s, despite a generally constant irrigated acreage, the diversion of Stanislaus River water by the District decreased. Upgrading and automation of the water distribution system, canal lining, construction and use of a regulating reservoir, and implementation of best management practices by District growers are given credit for the increased efficiency (ESA, 1999a). SSJID uses the planning number of 241,000 acre-feet per year to cover current District water needs; this represents the highest annual water use from water years 1988 through 1997. Planning numbers for the future are decreasing, from 232,000 acre-feet per year in 2010 to 220,000 acre-feet annually by 2025. Future farmland conversion of 37,000 acres through urban planning area completions by contracting cities is expected to be the major change in future water use (ESA, 1999a).

Table 16. South San Joaquin Irrigation District Water Demand

Time period	Average annual diversion from the Stanislaus River (af)	Reference
1915 – 1920	137,000 (releases from Woodward Reservoir)	(Bond Commission, 1913)
1940 – 1958	239,591	(SSJID, 1989)
1960 – 1970	258,544	(SSJID, 1989)
1971 – 1981	260,143	(SSJID, 1989)
1982 – 1987	280,851 / 270,000	(SSJID, 1989) / (ESA, 1999a)
1988 – 1997	220,000	(ESA, 1999a)

Water conserved by South San Joaquin Irrigation District (SSJID) is stored in New Melones Reservoir by the U.S. Bureau of Reclamation (USBR) until required by the District or until exceeding storage rights (ESA, 2000). The most recent Agreement and Stipulation with USBR, signed by South San Joaquin and Oakdale Irrigation Districts (SSJID and OID) in August of 1988, allows the two Districts to conditionally store up to 200,000 acre-feet of water in New Melones (ESA, 1999a; SSJID, 1989).[29] The water stored by the Districts is defined as conserved water in this Agreement, the difference between their entitlement and water delivered at Goodwin Dam (SSJID, 1989#6). Annual District entitlement is dependent upon the April forecast of New Melones inflow, up to a maximum of 600,000 acre-feet per year, 300,000 acre-feet per District. The formula used by the USBR to compute the District's entitlement in years of New Melones inflow less than 600,000 acre-feet is: the total New Melones inflow for the water year (Oct 1 to Sept 30) plus 600,000 acre-feet minus the inflow all divided by three. This entitlement is divided equally by the two Districts. Using USBR's model of the Stanislaus (STANMOD) to simulate the hydrology for the years 1922-1992, SSJID reports the average inflow to New Melones is 1,060,000 acre-feet per year. In 80% of the years modeled, 300,000 acre-feet was available to SSJID, the average amount was 291,000 acre-feet of water (ESA, 1999a). In previous years, some water conserved by SSJID has been sold. These sales have been short-term, varying yearly. In 1997 and 1998 the sales were used for fishery releases in April and May (ESA, 1999a).

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[29] Main conditions of SSJID and OID water storage and use of conserved water in New Melones Reservoir: 1) in years when Stanislaus River Central Valley Project users are assessed shortages, the Districts may not use conserved water if their diversions are greater than 450,000 acre-feet, except when that shortage percentage applied to their 600,000 acre-feet annual entitlement provides a larger amount, 2) total Districts' diversions are less than or equal to 600,000 acre-feet per year, 3) SSJID and OID conserved water is first to spill for flood control (SSJID, 1989#6).

Table 17. Sales of Conserved South San Joaquin Irrigation District Water

Sale year	Water conserved * (thousand acre-feet)	Sale amount (thousand acre-feet)	Buyer
1992	60	30	Drought water bank
1994	100	37.4	U.S. Bureau of Reclamation
1997	70	40	U.S. Bureau of Reclamation
1998	100	25	U.S. Bureau of Reclamation

*The amount actually stored and available to SSJID depends on whether all of the 1988 Agreement and Stipulation storage conditions were met. See footnote xx
Source: (ESA, 1999a, Figure 3-8)

While efficiency improvements do conserve water, the improvements may not result in new water available to the watershed unless consumptive use (evapotranspiration and other irretrievable losses) has been reduced. [30] Conserved water is surplus to the needs of the water rights holder, however, the water supply of those downstream can be partially or completely composed of upstream return flows and accessible percolation to groundwater. Groundwater movement in SSJID is generally from the Stanislaus River to the San Joaquin River and the pumping depression under the city of Stockton (ESA, 1999a). Water not used consumptively in the District can recharge the regional aquifer and increase the dilution potential of the San Joaquin River as it enters the Delta. Connections between water uses tend to make water rights appurtenant to a place over time (National Research Council, 1992; Bain et al., 1966). The repercussions of separating water from the land or river of historical beneficial use can complicate a water transfer, even when water rights are appropriative, pre-1914, and quantified.

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[30] Consumptive use is defined in the California Water Code, Section 484 as the amount of water which has been consumed through use by evapotranspiration, has percolated underground, or has been otherwise removed from use in a downstream water supply as a result of direct diversion. DWR definitions: new water = water not previously available in the system, real water = water for transfer that is not derived at the expense of any other lawful water user. USBR definitions: all transfers will be limited to CVP water that would have been consumptively used (ET) or irretrievably lost (deep percolation) to beneficial use. (Bookman-Edmonston, 1996)

Both South San Joaquin (SSJID) and Oakdale Irrigation Districts (OID) formed about 50 years after agricultural water development began in the Stanislaus River watershed (ESA, 1999a). The old Melones dam was named after the mining and agricultural town at the upstream edge of old Melones reservoir (Costello, 1983). Produce from local ranches, orchards and row crops fed the community. In August of 1902, the U.S. Geological Survey measured high mountain diversions of the Stanislaus River and found four with a total withdrawal of 149 cubic feet per second (cfs). A simultaneous withdrawal of 154 cfs was occurring at Tulloch Ditch; the river flow below Tulloch Ditch at Knight's Ferry (Map 3) was 166 cfs. This 166 cfs was considered available for appropriation, subject to any downstream appropriative or riparian rights (Bond Commission, 1913). Prior to District organization, the only apropriations made and perfected in the vicinity of Knight's Ferry were those owned by the Consolidated Stanislaus Water and Power Company, locally known as the "Tulloch Ditch System". The original location of these rights was made in 1855, and the whole system was purchased jointly by the South San Joaquin and Oakdale Irrigation Districts in 1910 (Bond Commission, 1913; Jackson and Mikesell, 1979). In researching SSJID water rights of 1913, the California Irrigation District Bond Commission investigated appropriations made on behalf of SSJID and OID in 1908. Although claims for Stanislaus River water far exceeded the flow, water appropriated by the Districts was otherwise unused and there had been no adverse claims for five years (Bond Commission, 1913).[31] The Commission regarded the lack of controversy as establishment of OID's and SSJID's water right to 44,400 miner's inches

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[31] All or part of an appropriative right may be lost if not put to beneficial use – a hearing is required prior to forfeiture (Littleworth and Garner, 1995). Loss of appropriative right: pre1914=nonuse over 5 years, by prescription, condemnation, default (Archibald, 1977).

(1110 cfs) under the 1908 appropriation. Additionally, the jointly purchased Tulloch system included approximately 6,000 miner's inches (150 cfs) of water.[32] In 1929, the pre-1914 joint water rights of SSJID and OID to divert Stanislaus river water for the annual irrigation season (March 1 – October 31) were adjudicated and confirmed as a flow of 1816.6 cfs, to be divided equally by the two Districts (ESA, 2000).

The South County Surface Water Supply Project (the Project) will be supplied out of pre-1914 water rights (ESA, 2000). SSJID plans to maintain maximum storage in Woodward during the irrigation season and use the reservoir for project deliveries in other months. Since pre-1914 water rights predate the Water Commission Act, a change in the place or purpose of water use does not require review by the State Water Resources Control Board (SWRCB website, 2000). California Water Code section 1706 qualifies this exemption with, "if others are not injured by such change". South San Joaquin Irrigation District (SSJID) defines the Project as a water transfer of insignificant impact on others, a simple change in the place and purpose of beneficial water use. Since the Water Code is not specific about changes in use or location of pre-1914 rights, the Project raises questions. Must the place and purpose of use remain in the District? Does the use of Woodward Reservoir storage (post-1914 storage rights (ESA, 2000)) by the Project challenge the exemption? What constitutes significant injury to others?

SSJID surface water entitlement not diverted by the District usually exits the Stanislaus Basin by the river. The Project would change this historic movement of water by

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[32] (Bond Commission, 1913) the Tulloch Ditch carried about 40taf/yr.

commencing pipeline conveyance to four contracting cities. Interpretation of this proposed new pattern in water flow is controversial. The South San Joaquin Irrigation District (SSJID) presents the Project as a more efficient use of water that will benefit the county. Project modeling results show reduced groundwater depletion of the critically overdrafted Eastern San Joaquin County Groundwater Basin.[33] The modeling assumption is that contracting cities will use the Project surface water to meet needs before pumping local groundwater, at least until 2025. All four cities currently pump groundwater for at least part of their supply. Groundwater quality deterioration in Lathrop and Manteca, where saltwater intrusion is also a problem, has prompted their search for new water supplies. The Project would improve the quality of municipal water for all of the contracting cities.

The U.S. Bureau of Reclamation (USBR) is concerned about losing the instream and downstream value of the Project's water. Only four years after the New Melones Reservoir filled, operations of this Central Valley Project (CVP) element were severely tested by the 1987 – 1992 drought. Meeting demands on the reservoir was not always possible then (ESA, 1999a; ESA, 2000), and continues to be a problem now (SWRCB, 1999a). Under State Water Resources Control Board (SWRCB) Decision-1422,[34] USBR is responsible for meeting Vernalis (lower San Joaquin River) salinity objectives, dissolved oxygen concentrations in the Stanislaus River, and up to 98,000 acre-feet of water per year for the "preservation and enhancement of fish and wildlife", with New

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[33] Eastern San Joaquin County Groundwater Basin boundaries: North is the San Joaquin County line, South is the Stanislaus River, West is the San Joaquin River, East is the foothill alluvium (DWR, 1989) SSJID is completely within the East San Joaquin Groundwater Basin (ESA, 1999a).

Melones releases (SWRCB, 1973). A 1987 agreement between USBR and the California Department of Fish and Game updated fishery releases to range from 98,300 acre-feet to 302,100 acre-feet annually depending on New Melones carryover storage (SWRCB, 1999). Both the San Joaquin and Stanislaus rivers are listed as having impaired[35] lower reaches (CVRWQCB, 1996; ESA, 2000; EPA website, 2000).

Decision-1422 is state directed mitigation for Central Valley Project (CVP) impacts on the San Joaquin River. The federally owned and managed CVP conveys San Joaquin River water captured by the Friant Dam (completed in 1947) to the Tulare Basin. This conveyance reduces the average annual flow of the San Joaquin River at Vernalis by 500,000 to 1,000,000 acre-feet, or as much as 29% of current average flow (SWRCB, 1999). Exchange Contractors, holding Miller & Lux riparian and appropriative water rights dating back to the 1880s, traded their use of San Joaquin River water for a substitute supply from the Delta Mendota Canal (EA Engineering, 1999). This trade allowed the Friant Dam operation to proceed, and the CVP to transform the San Joaquin River. Water availability from the Central Valley Project (CVP) and State Water Project (SWP) also allowed the conversion of seasonally dry Valley land into irrigated farmland. In 1987 interviews (Hukkinen, 1990), the local agricultural community described drainage water from the San Joaquin River Exchange Contractor's lands as of good enough quality to be reused prior to the application of CVP and SWP water to upslope areas. High priority water quality problems of the lower San Joaquin River, as listed by

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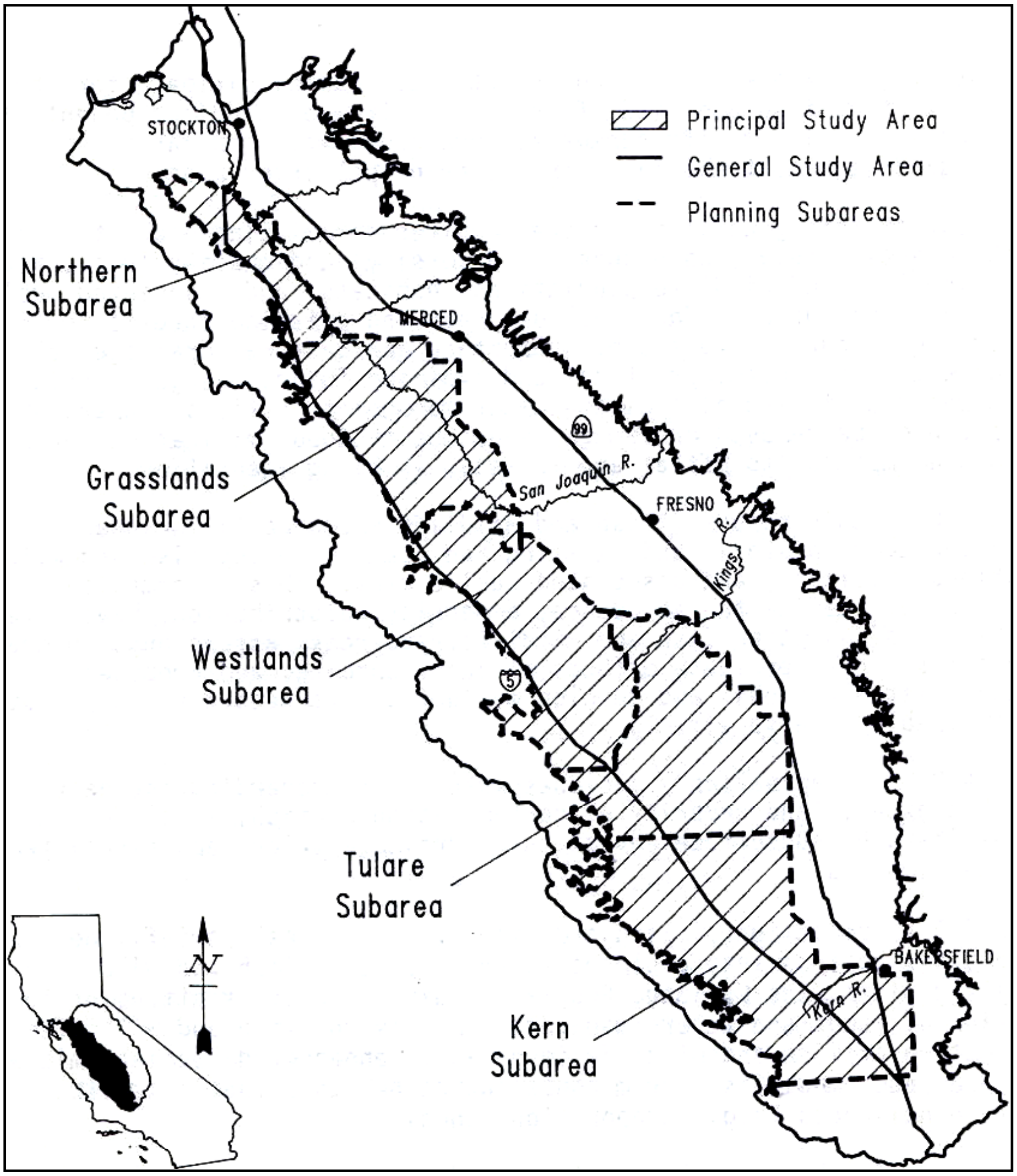
[34] Decision–1422, issued by the California State Water Resources Control Board in 1973, defines the primary operational criteria for New Melones Reservoir with a list of 25 conditions (SWRCB, 1973).

the California State Water Resources Control Board in 1998 (Clean Water Act, Section 303(d) list), included Boron, Selenium, and a measure of total dissolved solids, Electrical Conductivity (EPA Website, 2000). For all of the high priority water quality listings on the San Joaquin River, the practice of agriculture is recorded as the source.

Map 5. San Joaquin Valley Drainage Program Problem SubAreas (SJVDP, 1990a)



Source: SJVDIP, 1990a

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[35] "Impaired" refers to section of river that does not meet water quality objectives despite past efforts. Best Management Practices have been insufficient to meet Diazinon standards on the lower Stanislaus River (SWRCB, 1998).

The agricultural drainage areas of concern are located in the central and southern thirds of the San Joaquin Valley (Map 5). Only Grasslands, location of the Exchange Contractor districts, and the Northern subarea are part of the San Joaquin River drainage, surface water in the other subareas normally drains to the Tulare Basin. Low quality drainwater from the upslope areas in western San Joaquin Valley was not an unexpected consequence of the agreement between the Exchange Contractors and the USBR. The San Luis Drain, intended to solve existing and new high water table problems and to flush salts from the system was offered as part of the water trade. As far back as 1957, the California Water Plan (DWR, 1957) specified construction of a drainage conduit from Buena Vista Lake to the Delta as part of the State Water Project facilities. Locally, the San Luis Drain was included on municipal planning maps of the late 1960s and 1970s (Grunwald, Crawford and Associates, 1969). Over 80 miles of the Drain were completed by the USBR, from Laguna Avenue in Fresno County (eastern boundary of Westlands Water District ((Narasimhan and Quinn, 1996)) to Kesterson Reservoir[36] (SJVDIP, 1998). Since the Drain has not, and may not, become an element of the water system in the San Joaquin Valley, California agriculture has joined the ranks of other industry by researching "in-house" solutions for the environmental problems of production.

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[36] Since the relationship between selenium concentration and the survival of birds was demonstrated at Kesterson Reservoir, proposals and demands to complete the San Luis Drain have been untenable.

Table 18. Status of Strategies for Improving San Joaquin Valley Agricultural Drainage

Strategy	SJVDP Recommendations	Status	Unresolved issues
Source control	329,000 acres by 2000	Objectives achieved or exceeded over large areas. Significant reductions in deep percolation and volume.	Shallow groundwater areas levels are constant or rising. Increased salt and Se concentrations.
Drainage reuse	23,000 acres of halophytes by 2000	Testing continues, extended to include aquaculture.	Sustainability, adverse impacts on wildlife, salt disposal.
Evaporation systems	Pond modification to discourage wildlife. 2600 acres by 2000 in with reuse.	Modifications ahead of schedule. Mitigating habitats established. Decrease in pond acreage.	Sustainability, salt disposal, testing continues on drainage reuse.
Land retirement	21,100 acres by 2000 75,000 acres by 2040	CVPIA land retirement program: 9010 acres bought or in escrow.	Opposition. Disposition of water rights. Management plans – possible environmental problems.
Groundwater management	On 40,000 acres by 2000	WWD found it infeasible; no one else uses it.	Possible aquifer degradation, cost, finding appropriate zones.
Discharge to San Joaquin River	San Luis Drain extension to past Merced River.	Grasslands Bypass Channel project	Project is for 5 years. San Luis Drain extension not developed. Meeting load limits
Institutional	Improved delivery, water transfer, block rate tiered pricing	Broadview Water District has block rate tiered pricing and reduced water delivery / drainage	Transfers controversial. Limited implementation.
Treatment	Systems not sufficiently advanced to recommend.	Testing: reverse osmosis, solar distillation, and biological treatment.	Cost, salt disposal, salt market.
Monitoring	Long-term, systematic	Extensive plan	Funding

Notes: SJVDP is the San Joaquin Valley Drainage Program, initiated in 1984 to investigate problems associated with agricultural drainage in the San Joaquin Valley and recommend solutions. Soon after the recommendations of the SJVDP were finalized in 1990, the San Joaquin Valley Drainage Implementation Program was organized to implement the plans.
WWD is the Westlands Water District
CVPIA is the Central Valley Project Improvement Act of 1992
Sources: SJVDIP, 1998; SJVDIP, 1999a; SJVDIP, 2000; May, Bob,Title 34 Update Vol. 7 No. 1, 8/00

Potential solutions for agricultural drainage problems on the western side of the San Joaquin Valley were researched and evaluated by the San Joaquin Valley Drainage Program (SJVDP), a team of federal and state participants, from 1984 to 1990 (SJVDP, 1990). Rather than supporting a single plan, the SJVDP recommended plan components, or strategies, be applied to appropriate acreage in each region. While all of the strategies are designed to reduce poor quality drainage volume, source control, groundwater management, drainage reuse, and land retirement are particularly focused on producing less drainage water. Evaporation systems and treatment of drainage water change the destination of salts and selenium from water to land. Removal of salts and selenium from San Joaquin Valley soils and water can be accomplished by collection after drain water evaporation, by discharge to the San Joaquin River, and by their harvest and sale as Valley products.

The strategies to improve the quality of San Joaquin River water are constantly being refined with experience and research, but the extent of their effectiveness is not yet clear. From 1990 to 1998 the annual total dissolved solids (TDS) load recorded at Vernalis was around 13% less than from 1980 to 1989, but separating drought effects from implementation progress during the first few years of the program is difficult. Since more groundwater is pumped when less surface water is available during a drought, less waterlogged soil and less drainage water result. The increase in groundwater pumping from 1988-1993 lowered water table elevations by 2 to 6 feet over much of irrigated western San Joaquin Valley (SJVDIP, 1999). Wetter years and higher flows are usually associated with a higher total dissolved solids (TDS) load as more soil minerals dissolve into the general runoff. Presser et al. (1990) found the transport of selenium during high flow was due to the domination of subsurface sources of runoff. Subsurface flow can initiate mass wasting, forcing soils into streams and rivers. Or, salts remaining after evaporation can suddenly be flushed from the soil during infrequent, heavy rainfall. Average flow weighted TDS loads at Vernalis in the wet years of 1986 and 1995 were almost twice those for the intervening drier years, as were average Selenium and Boron loads (CVRWQCB, 1998).

Table 19. Vernalis Water Quality

A Regulatory History		**Average Total Dissolved Solids (TDS) load**		
Decision or Plan	Description	Time period	Months	Amount (tons)
D-1275 (1967)	If New Melones is operated for water quality control: 500 ppm* TDS max with a maximum release of 70 taf/yr	1960 – 1969	April to August Annual	288,000 846,000
D-1422 (1973)	Mean monthly TDS of 500 ppm or less, does not limit release quantity	1970 to 1979	April to August Annual	316,000 897,000
1991 Bay/Delta Plan	Not adopted. D-1422 remains in effect.	1980 to 1989	April to August Annual	466,000 1,166,000
1995 Bay/Delta Plan WR 95-6	0.7 mmhos/cm April - August (~455 ppm TDS) 1.0 mmhos/cm September - March (~650 ppm TDS)	1990 to 1998	Annual	1,010,000

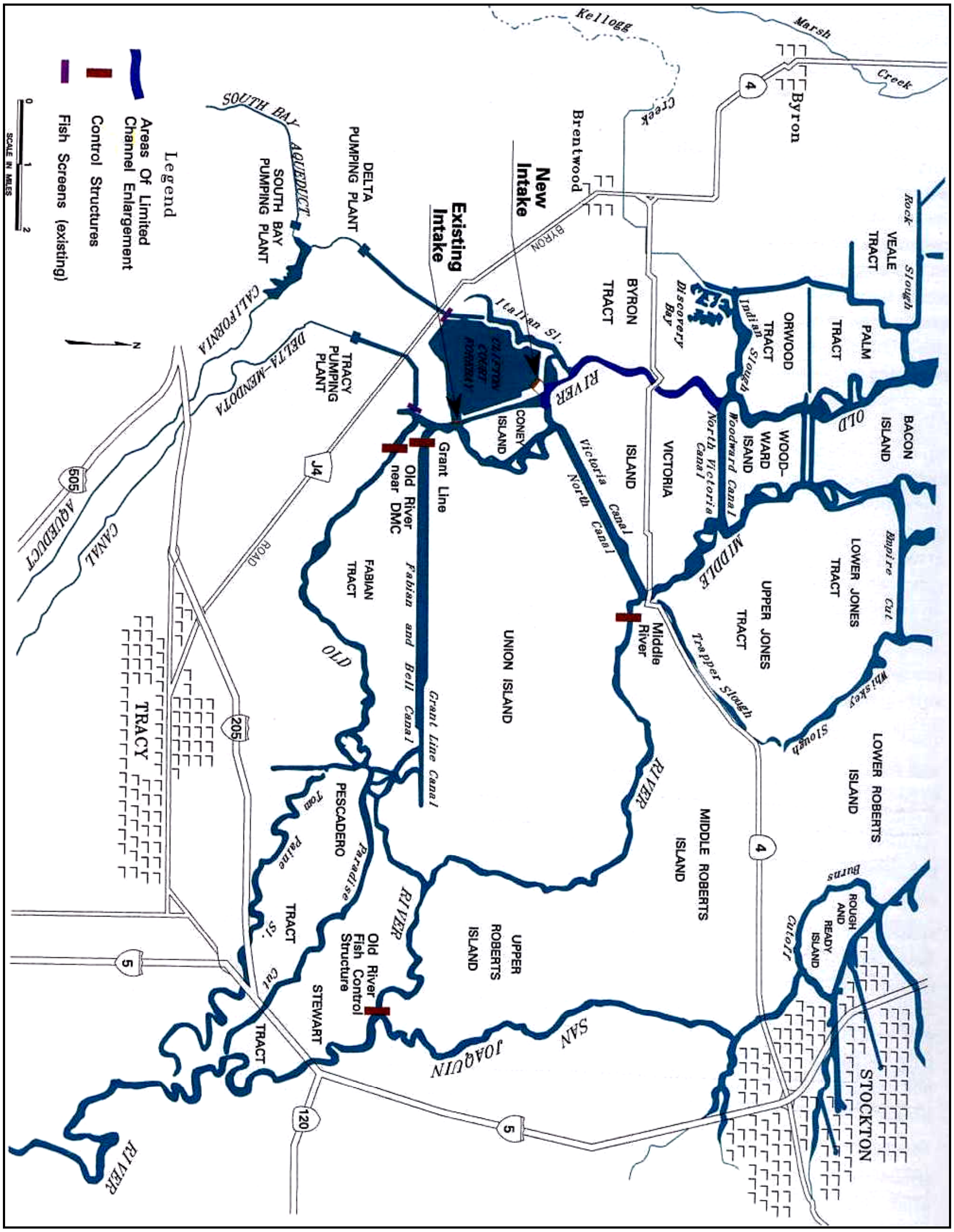
* 500 ppm was chosen because during the drought period of 1930 –34, TDS concentrations at Vernalis rarely exceeded 500 ppm (Orlob, 1991).
Sources: (SWRCB, 1999 (for 1960-1989); CVRWQCB, 2000 (for 1996-1998); CVRWQCB, 1998 (for 1990-1995)

The State Water Resources Control Board (SWRCB) applied the 1995 Bay-Delta Plan water quality objectives for Vernalis to water years 1986 through 1995, and found they were exceeded during 62% of the irrigation season (April – August) and 16% of the rest of the year (SWRCB, 1999). Development of San Joaquin River tributaries and use of higher salinity Delta water for irrigation on the western side of the Valley are the two primary causes of doubling the salt levels near Vernalis since the 1940s (SWRCB, 1996a); boron, selenium, molybdenum, and other trace element concentrations have also increased (SWRCB and CVRWQCB, 1994). Vernalis is a major San Joaquin River water quality and flow monitoring station, located between the Delta and the Stanislaus River confluence. It is at Vernalis that the health of the San Joaquin River and tributaries is checked, program efforts monitored, and regulatory reference made. Vernalis is the chosen transition point between river and delta, if problems have not been resolved upstream of Vernalis they are transported to the downstream delta.

The downstream recipient of flows at Vernalis is the South Delta Water Agency (SDWA). The impaired lowest reach of the San Joaquin River runs through eastern SDWA lands, on the western border of the Agency are the Central Valley Project (CVP) and State Water Project (SWP) export pumps. In this location, any project which could reduce the amount of good quality water entering the southern Delta is considered a threat. The particular water problems of the southern Delta largely depend on water usage and management beyond their borders. Recognition of this fact is demonstrated by the 1884 federal court decision to terminate discharge of mining debris into California rivers, by the series of Delta water quality standards issued by the State Water Resources Control Board, by the Delta Protection Act, by the CALFED Bay-Delta Program, and by the 1973 California Legislative authorization of the South Delta Water Agency (SDWA). The SDWA is responsible for protecting the quality and quantity of water in the South Delta for all beneficial uses (SDWA, 2000), often by entering into contracts with the U.S. and the State of California (DWR and USBR, 1990).

Reduction of water depth in South Delta channels due to operation of the export pumps has been identified by SDWA as an impact of the Central Valley Project (CVP) and State Water Project (SWP) on southern Delta water (SDWA, 2000). This drawdown, accentuated by less annual San Joaquin River flow, makes water depth during low tide often too shallow for operation of agricultural diversions. In 1991, the California Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (USBR) negotiated a settlement agreement with SDWA to implement measures for mitigation of damages that their water export projects could have caused in southern Delta channels. The U.S. Bureau of Reclamation (USBR) agreed to interim releases from New Melones Reservoir to enhance San Joaquin River flows and DWR began testing the use of barriers to improve water quality and quantity in the southern Delta (SWRCB, 1999). Since 1991, the SWP has not taken water into Clifton Court Forebay during low tide.

Map 6. South Delta and Proposed Barriers



Source: DWR, 1996

The USBR (1980) estimated 75% of the San Joaquin River flow goes down Old River towards the export pumps during the summer season. Using mathematical modeling, Orlob (1991) estimated up to 50% of the water exported by the CVP through the Delta Mendota Canal originates in the San Joaquin River, with barriers to cross-Delta flows in place the estimate drops to 20%. A temporary barriers project was initiated in 1991 to improve water conditions in the southern Delta and develop data for the design of permanent barriers. The barrier at the head of Old River has been installed intermittently since 1963 to assist fish migration on the San Joaquin River (SWRCB, 1999). Seasonal barriers were installed in Middle River (since 1987), Old River (since 1991), and Grant Line Canal (since 1996) to capture high tidal flows for improvement of water levels and circulation. The retention of high tidal flows forms a hydraulic barrier against San Joaquin River water, preventing reverse flows in the San Joaquin River and changing the circulation of salts from the Valley through the Delta. Instead of promoting a "salinity cycle", pulling San Joaquin River water directly to the export pumps, much of the Valley drainage water is conveyed to the Central Delta and away from immediate re-export (Hildebrand, 2000). This maneuver is expected to improve water quality in both the San Joaquin River and the southern Delta.

Table 20. Valley Salt Balance Estimates

Annual Inflow of salt with Surface Water (tons)	Destination of Inflow In San Joaquin Valley	Annual Outflow of salt in San Joaquin River (tons)	Estimate Source
800,000 CVP and SWP 2,000,000 CVP and SWP 1,500,000 local runoff, rainfall	North and Central South and Central	350,000 0	(DWR, 1998a)
2,000,000 to 3,000,000 CVP and SWP	North/Central/South		(SJVDIP,2000)
1,400,000 CVP	North and Central	966,000	(Orlob,1991)
	North and Central	740,000	(SWRCB, 1999)
1,000,000 CVP	Central	400,000	(SDWA, 2000)
1,100,000 CVP 500,000 east side rivers 500,000 SWP	North and Central South and Central	620,000 0	(SJVDIP, 1998)

Notes: CVP = Central Valley Project, average TDS range-400 to 500 mg/L (Narasimhan and Quinn, 1996).
SWP = State Water Project, average TDS range is 200 to 300 mg/L (DWR, 1998).

Importation of salt into the San Joaquin Valley is not balanced by similar export. Roughly 40% to 70% of the salt quantity entering the lower San Joaquin Valley by water is estimated to exit, practically none of the salt inflow leaves the Tulare Basin. Other avenues of import include fertilizers, pesticides, and soil amendments which add thousands of tons of salt to Valley land and water each year (DWR, 1998a). Additionally, marine sediments, high in salts and trace elements, are the parent material of soils on the western side of the San Joaquin Valley (SJVDP, 1990). As applied water or rainfall seeps through this soil, salts, selenium, boron, and other marine sediment components dissolve, percolate to groundwater and subsurface flow to the San Joaquin River. The application of irrigation water to west side land has accelerated the movement of salts[37] into the semi-confined aquifer above the Corcoran Clay (SWRCB, 1999), and on to the Valley trough, historically an area of groundwater discharge and characterized by high soil salinity (Fio and Leighton, 1994). Using U.S. Geological Survey and Department of Water Resources water quality data, Orlob (1991) determined the inflow and outflow of salt were balanced in the Valley from 1930 to about 1950. Since then salt has been accumulating in Valley soils and groundwater.

About 1,000,000 acres, 20% of the irrigated San Joaquin Valley, are affected by shallow, saline groundwater (SJVDIP, 1999). The depth to the water table is generally less than 5 to 10 feet in these areas. Salinity problems and shallow water tables have accompanied agriculture in the San Joaquin valley since the practice of reclamation and application of irrigation water. Shallow groundwater was noted as early as 1886 on the eastern side of the Valley (SWRCB, 1999). Two years after South San Joaquin Irrigation District (SSJID) began agricultural deliveries of Stanislaus River water, high water tables threatened the western half of the District, by the 1920s two-thirds of the District was waterlogged (Cope Rand Means Co., 1921). However, the good quality drainage water from SSJID can be added to District water supplies (Gianelli, 1941). Gianelli recommended SSJID line their canals, cease overirrigation, and pump excess water to maintain sub-irrigation where practical and lower water tables otherwise. The higher quality of SSJID return flows permitted straightforward solutions, in contrast to the struggle for drainage improvement on the western side of the San Joaquin Valley.

The South County Surface Water Supply Project (the Project) is only one of the changes in operations planned by SSJID (Table 21). Other agreements and commitments reallocate most, if not all, of the water conserved annually by the District. A transfer agreement with Stockton East Water District (SEWD) diverts water from the Stanislaus River and conveys it from Goodwin Dam to Stockton through a 47-mile network of tunnels, pipelines, and unlined canals (ESA, 1999a). The amount of water diverted to SEWD under this 10 year agreement depends on forecasted New Melones inflow (ESA, 1999b). Located mostly within SSJID, along the Stanislaus River and Route 99, the town of Ripon expects to receive an increasing amount of raw water beginning in 2002, delivered by existing irrigation canals (ESA, 2000). Shortages in water supply would affect the SEWD and Ripon transfers first, as they are most recent agreements. Then, approximately the same percentage reduction would be applied to the Project cities as to SSJID's agricultural customers (ESA, 1999b). With the Project completed over a 71-year

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[37] ((Narasimhan and Quinn, 1996): 1961-1977 irrigation recharge = 40 times the natural recharge.

(1922-1992) simulated hydrologic sequence, SSJID would have experienced surface water supply shortages ranging from 2,000 to 50,000 acre-feet per year during 12 to 13 years (ESA, 1999a).

Table 21. Planned Projects of the South San Joaquin Irrigation District

Water use	2002	2010	2025
SSJID agricultural demand	241,000	232,000	220,000
SEWD transfer	4,000 – 15,000	4,000 – 15,000	0
SJRA (VAMP mechanism)	0 to 11,000	0 to 11,000	0 to 11,000
Ripon	500	1645	5080
Project	21,200	31,000	44,000
Total	266,700 – 288,700	268,645 – 290,645	269,080 – 280,080

Notes: SEWD = Stockton East Water District. VAMP = Vernalis Adaptive Management Plan, an experiment to determine the relative impact of flow in the San Joaquin River and exports in the Delta on chinook salmon in the lower San Joaquin river (SWRCB, 1999). SJRA = San Joaquin River Agreement, a mechanism for conducting the VAMP.
VAMP and SJRA differences (SWRCB, 1999): *Minimum flows*: SJRA =2,000 cfs, VAMP = 3,200 cfs. VAMP flow obligation: SJRA is capped at 110 taf/yr. *Flow timing*: VAMP pulse flows in April and May, SJRA = VAMP flows plus October and other times. *Export limitations*: VAMP = limits CVP and SWP during pulse flows, SJRA = limitation may be lifted.
Source: (ESA, 2000 -Table 5-3, revised)

The San Joaquin River Agreement (SJRA) releases water for fisheries, mainly in April, May and October.[38] SJRA releases are tied to the existing flow at Vernalis, SSJID could be responsible for up to 11,000 acre-feet per year (SWRCB, 1999). Any water released at Goodwin Dam by SSJID for the SJRA would flow down the Stanislaus River.[39] The

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[38] Willing sellers of water for the SJRA are: Modesto Irrigation District, Turlock Irrigation District SSJID, OID, Merced Irrigation District, San Joaquin River Exchange Contractors. The SJRA was developed by state (DWR) and federal (Department of the Interior) resources agencies, Delta water export interests (CVP and SWP), environmental community representatives (DFG) and San Joaquin River Stakeholders (SJRGA). The SJRA is the acquisition of water by Department of Interior from SJRGA to provide a pulse flow at Vernalis in April, May, and October, plus specified additional water (EA Engineering, 1999). The flows are part of an experiment which attempts to achieve the CVPIA objective of doubling the anadromous fish population. The baseline for population doubling is the average level during 1967 – 1991. The agreement is for 12 years but is expected to continue in a similar form as results are analyzed. SJRGA members are: Modesto Irrigation District, Turlock Irrigation District SSJID, OID, Merced Irrigation District, San Joaquin River Exchange Contractors, and Friant Water Users Authority.

[39] If flow below Goodwin Dam is equal to or greater than the instream limit of 1500 cfs, the required amount would be released by Modesto Irrigation District down the Tuolumne River for SSJID, and an equivalent amount would then be conveyed to Modesto Irrigation District in replacement (EA Engineering, 1999). The instream limit is maintained whenever possible to prevent seepage and flooding problems (ESA, 1999a). Other arrangements are also possible. In 1999, SSJID commitments to the SJRA were met by Merced Irrigation District (EA Engineering, 1999a).

SJRA is a local partnership with federal and state resource agencies to research and test implementation strategies of the Central Valley Project Improvement Act, Section 3406(b)(1,2, and 3).[40] An added benefit to the fishery releases is an improvement in water quality at Vernalis. A 71-year (1922-1992) hydrologic simulation of the SJRA showed a 16% decrease in months exceeding 1995 Water Quality Control Plan objectives at Vernalis (EA Engineering, 1999).

The legal commitments plus the natural and engineered hydrologic connections between the Delta, the San Joaquin River, the western side of the San Joaquin Valley, and SSJID through its use of Stanislaus River water, make proposed changes in water allocation a challenge to accomplish. The South County Surface Water Supply Project (the Project) began as a transaction between buyers and a seller, then expanded into a community of related concerns. This complication of an apparently simple water transfer would not surprise Joseph L. Sax (1994) who describes water markets as unlike more traditional markets, "…a more appropriate model would be a diplomatic negotiation with a number of parties, each with important and legitimate interests that need to be accommodated, but without clearly defined rights." The need for negotiation becomes even more important as the legitimate interests bring not only their concerns about a project but also partial solutions. It may be possible to improve water quality at Vernalis through the San Joaquin Valley Drainage Program strategies, the barriers in the southern Delta, and the

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[40] CVPIA, Section 3406(b)(1): requires a program that sustainably maintains anadromous fish populations in Central Valley rivers at levels at least twice the average during 1967-1991. (b)(2): 800,000 acre-feet annually of the Central Valley Project yield are to be dedicated to and managed for environmental restoration. (b)(3): provides for the acquisition of water from willing sellers such as the San Joaquin River Group Authority.(EA Engineering, 1999)

San Joaquin River Agreement. Perhaps the cumulative improvement will be enough that significant dilution flows from New Melones Reservoir are not as crucial.

Considering the Project as a negotiation rather than a commodity sale describes a third major transition for SSJID. From the time SSJID and OID organized in 1909 until the New Melones Dam was constructed, the two Districts had rights to and diverted most of the Stanislaus River flow during the irrigation months of March through October (SWRCB, 1973). Since U.S. Bureau of Reclamation management of New Melones Reservoir the Districts receive a more reliable supply of irrigation water, but no longer control the river. Now, the Project has drawn diverse interests into SSJID operations and is illuminating how District actions can be regional in scope. Concerned responses to the Project test the exclusiveness of SSJID water rights.

Robert A. Young (1996) and other economists refer to water as a “high-exclusion cost” resource. The public and private aspects of such a mobile resource are difficult to separate. As water flows, seeps, and evaporates through the hydrologic cycle, various beneficial uses are realized. The water entitlement of SSJID is an example of beneficial use variety. Within the District, agricultural irrigation needs are met. Return flows from District use of water can supply groundwater needs, downstream riparian and appropriative rights, and improvement of poor quality San Joaquin River flows. Unused (by the District) or sold SSJID water has provided fishery flows, supply for Central Valley Project contracts, water quality enhancement, and instream benefits. Project proposals for municipal supply to four cities (the Project), to Ripon, and to Stockton East

Water District describe a new beneficial use for SSJID water. This new use may affect return flows from the District, would change the amount of conserved water stored in New Melones, and reallocate SSJID surplus water. What is the extent of SSJID responsibility for maintenance of current, rather than planned, beneficial uses of their water entitlement?

The current water transfer rules applicable to pre-1914 water rights are general. The "no injury" clause protects the water rights of other legal water users. To precisely determine potential and actual injury, an accounting of everyone's water sources, amount of consumptive use, return flow quantities and destinations, and other losses is necessary. Should more specific water transfer rules be derived from the concerns about and protests to the South County Surface Water Supply Project (the Project)? The CALFED Bay-Delta Program[41] (2000) proposes eight water transfer criteria that seek to minimize injury, improve efficiency, and keep the process public. Development of standardized transfer rules is promoted for transfers involving the use of state or federal facilities and for transfers based on groundwater replacement. At the same time, each transfer is considered unique, "Transfers are complicated and best evaluated on a case-by-case basis."(CALFED, 2000) More specific water transfer rules would tend to centralize oversight of water marketing. The traditional response of the agricultural community to the possibility of rules that override local control is evident in the San Joaquin River Group Authority response (development of SJRA) to the Central Valley Project Improvement Act and Vernalis Adaptive Management Plan, by the South Delta Water

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[41] CALFED is a cooperative effort of 15 state and federal agencies to address issues that surround the Sacramento-San Joaquin Delta.

Agency demand for barriers to cross-Delta flows, and even by the Stanislaus River Basin Group (footnote #1) development plan in response to New Melones. There has been a marked preference for local control. In a systems analysis of three irrigation communities in Spain and three more in the western United States, Maass and Anderson (1978) concluded, "local control has been the dominant characteristic of irrigation in these regions, regardless of the nationality or religion of the farmers, the epoch, whether formal control is vested in an irrigation community or in higher levels of government, the forms of government at the higher levels, and perhaps even the legal nature of the water rights." The study described agrarian communities bound by common purpose, accustomed to a measure of cooperative effort, passionate about their water and self-governance. What happens to ties to and beliefs about water when communities previously focused on agriculture become increasingly urban, as are the communities contracting for surplus SSJID water?

SSJID is breaking rank with some agricultural institutions by proposing long term transfers of water to local cities. Agricultural tradition is to hold and protect water against other uses (Maass and Anderson, 1978); "Agricultural water districts have been the most vocal opponents of reallocation" (Haddad, 1996). Providing a safe, reliable water supply to southern San Joaquin County cities, and maximizing local reliance are the first two primary objectives of the South County Surface Water Supply Project (ESA, 1999a). As urbanization continues to absorb farmland, the relationship between city and country changes. Although the city continues to be a market for farm production, a rural versus urban competition for land and water can also develop. Plans for substantial farmland conversion can reduce rural community cohesion and increase confrontations between farmers and city residents, leading to the sale of farm water and land.

From 1976 to 1988, about 10,500 acres of farmland was converted to urban use in San Joaquin County (Jones & Stokes, 1991), this trend continued from 1992 to 1998 when an additional 5300 acres were urbanized (DOC, 1996-2000). Of the total land area in the county, 7% was urban in 1992 and 70% was important farmland. By 1998 a change of about 1% had occurred, the urban percentage increased and the important farmland had decreased. Eighty percent of the increase in urban land was due to the conversion of important farmland. If the current rate of farmland conversion persists, the conversion of 37,000 acres (ESA, 1999a) by urban management plan buildout of the four Project cities will be completed in about 40 years.

Table 22. San Joaquin County Trends in Land Use

(ACRES of LAND)	1992	1994	1996	1998
Important Farmland	635,655	635,097	633,535	632,360
Urban and Built-Up Land	66,297	67,590	69,739	71,596
Land Conversion				
Important farmland to Urban		917	1,944	1,494
Other land to Urban		376	205	363
Percent new Urban from Important Farmland		*71%*	*90%*	*80%*
Total area inventoried	912,328	912,599	912,600	912,600
Percent important farmland	*70%*	*70%*	*69%*	*69%*
Percent urban and built-up land	*7%*	*7%*	*8%*	*8%*

Notes: "Urban" and "Urban and Built-up Land" are equivalent. "Important" farmland is composed of prime farmland, farmland of statewide importance, unique farmland, and farmland of local importance. Not included is grazing land. The basis for "important" farmlands is a land classification system that combines technical soil ratings and current land use.

Source: California Department of Conservation (DOC), Farmland Conversion Reports for 1992 - 1994, 1994 - 1996, 1996 - 1998.

The dominant use of land in San Joaquin County is agriculture (Table 22), but the trend is urbanization, primarily of important farmland. South San Joaquin Irrigation District accepts this trend, and through the South County Surface Water Supply Project promises to deliver high quality supplemental surface water to four locally expanding cities. These cities seek more water to satisfy the expected demands of planned urban growth. Since water is a daily necessity, a public good, and reusable, the impacts of a water sale to downstream holders of water rights, to the indirectly affected, to groundwater levels, to downstream water quality, and to wildlife are formally (Environmental Impact Report or Statement) and informally (stakeholder review) analyzed. The purchase of water is unlike other municipal contracts. Buying urban water requires more than specific agreement on price and conveyance, it also demands general agreement on the most suitable beneficial uses of the transaction water. Arriving at agreement is the current challenge, whether by new and secure rules or by unique ingenuity.

The formation of Irrigation Districts in the early 20th century organized farmers in their acquisition of water and water rights. The 21st century brings Irrigation Districts to a new level of management and involvement. District interests, as well as influence, have transcended District borders.

The municipal water supply for the City of Tracy is probably sufficient for this year and maybe next year, but the situation is expected to change soon, as it may for other growing northern San Joaquin Valley cities where water has been ample for many years. Although the search for a supplemental water supply is focused on resource acquisition, the nature of water involves environmental, legal, economic, and engineering questions. The progress of the South County Surface Water Supply Project (South San Joaquin Irrigation District) demonstrates that economic and engineering feasibility questions can be straightforward while hydrologic, legal, and environmental concerns require more time for resolution. The availability of additional water for urbanization in California largely depends on three interconnected, politically and institutionally defined conditions: the urban relationship with both agriculture and the natural environment, our understanding of the supporting hydrologic system, and the part a potential acquisition plays in the local, regional, and statewide water system.

Urban water supply over-planning is traditional in California (Walker and Williams, 1982); we expect city planners to procure a more than adequate supply of such a vital resource. If air was transient and storable, a surplus supply would also be desired. The Central Valley Project contract with the City of Tracy has supplemented the local municipal groundwater supply with more than enough water for over twenty years. It was hoped a similar planning strategy could be effected with the South San Joaquin Irrigation District's South County Surface Water Supply Project, and maybe it will. Over-planning a water supply in an allocated water system is more challenging than when water projects were seeking customers; it may be more difficult for cities to acquire new water supplies as far in advance of need as was accomplished in the 20th century. Meanwhile, Tracy has ordered an aquifer yield study and is negotiating potential water purchases from neighboring irrigation districts (City of Tracy, 2000). As city water inventories become leaner, effective water supply management tends to become more creative and dynamic.

A new urban water supply is assessed for both the available quantity and the characteristic quality of the resource. With pre-1914 water rights, the South San Joaquin Irrigation District can offer a high level of reliability with the South County Surface Water Supply Project. The California Department of Health Services (ESA, 2000) recommends the Project since it would improve the marginal or threatened water quality of each contracting city. Water possessing these desirable attributes is not easily purchased for use elsewhere in an allocated system. Downstream impacts are to be expected unless all of the water in a proposed transfer (outside the area of historic use) was consumptively used (evapotranspiration) or irretrievably lost (deep percolation, flowed to a salt sink, surface evaporation). Avoidance of many downstream impacts could be achieved if the Project water was conveyed by the Stanislaus and San Joaquin Rivers to Escalon, Manteca, Lathrop, and Tracy instead of by pipeline, but water quality would decrease significantly. Since none of the contracting cities currently divert water from either the lower Stanislaus or San Joaquin Rivers, the decrease in quality with river conveyance plus the needed distribution and treatment infrastructure could reduce the attractiveness of the Project.

Better water tracking, a more accurate knowledge of what is available for a particular use and what each use requires is sometimes demanded when subdividing such an increasingly scarce resource. A more complete description of the present water system and probable water future in the South San Joaquin Irrigation District, the contracting cities, and on the Stanislaus River and downstream, was considered necessary for fair evaluation of the Project. Of the 57 comments recorded in the Final Environmental Impact Report of the South County Surface Water Supply Project (ESA, 2000), almost 30% ask for better, clearer, or more comprehensive water accounting. Better knowledge of water sources, losses (both to beneficial use and otherwise), reuse potential (return flows, percolation, downstream use), and eventual system outflows should improve estimates of available supply as well as water transfer impacts. While better numbers do improve system assessment and prediction of probable consequences to proposed actions, they don't guarantee project success. The best and most accurate quantitative assessment may not be accepted initially, or ever. Decisions have always been a curious mixture of values and factual interpretation. As a commodity, water has unique transaction costs which may someday be standardized; today, they are usually either negotiated or decided in court.

Cities can avoid or delay the purchase of supplemental water through reduction of consumptively used water, and reuse of water which is not expected downstream as supply. Since almost all urban consumptive use of water is outdoors, urban design and landscaping choices are important. A better understanding of water consumed in the City of Tracy should result from a program being developed to perform water audits on large landscaped areas (City of Tracy, 2000). Meanwhile, the tradition of at least front-yard lawns in Tracy continues in newly constructed areas despite the water required by green grass. A transition to low water consumption landscaping changes urban water management by leaving less potential for cutbacks during drought, and by increasing supply in average to wet years through reduction of water applied to urban irrigation. If either surface or underground storage is available, conserved urban irrigation water could be stored for emergency or drought use. Additionally, urban landscaping can be irrigated with water reclaimed from wastewater. Currently, most reclaimed water in California is used for landscape or agricultural irrigation, but groundwater recharge is planned in several cities, especially in Southern California (DWR, 1998). Reclamation and reuse of water in many cities requires additional wastewater treatment and new facilities to pump and convey the water to places of use. Reuse in the City of Tracy consists of irrigation around the Wastewater Treatment Plant (City of Tracy, 2000). The amount of water a city can reuse is limited by the level of wastewater treatment, the economics of additional infrastructure, and by public perception of reclaimed water. Public perception can also determine landscaping; not everyone wants to sell the lawnmower.

As long as urban growth is welcomed, expected, or just considered necessary to house the next generation, cities will consume more water and probably require more land. Expanding cities also require more, or better, transportation options. Driving the 25 miles from Tracy to Modesto on "Blood Alley" (Route 132 - a large roadside sign announces 75 deaths in recent years) around 5 PM on any ordinary weekday, the eastbound lane is one long column of commuters. The obvious observation is that the road should have additional lanes, but how many lanes are sufficient? The commute from Tracy to the Oakland Coliseum was around 50 minutes in 1989, in 2000 the same distance requires almost twice the time (more on the Friday afternoon trip home) during commute hours. Each improved intersection and interchange, along with additional lanes, has reduced congestion on the roadways surrounding Tracy, temporarily. The ever-increasing local and regional demand for rapid transportation outpaces road improvements. A rapidly growing population quickly challenges the effectiveness of planning ideas and infrastructure solutions. Simultaneous increases in city size seem to compound the challenge.

As with many locations conformed to human needs, the process of land development generally reduced the presence and influence of wildlife in the northern San Joaquin Valley. Farming usually demanded quick adaptation or departure of the native flora and fauna. Urbanization of farmland demands another level of survival skills from the local wildlife. Burrowing owls used to live about two blocks from my house in Tracy, along an unfinished street. After more homes and a middle school were constructed, the street was completed and the ditches redesigned as part of the city drainage system. Displaced, the owls moved to an edge of the school property. Roaming pets and curious people routinely checked on the owls, sometimes by standing directly over an occupied burrow to peer inside. This year, the burrows were cut out of the sloped schoolyard as the land is being rearranged for parking lot improvement. Yet, we seem to miss the wildness forced from our surroundings. Numerous weekend trips to preserved, minimally developed lands indicate at least an appreciation for places under less human influence. It may also indicate wildness is most desired in controllable doses.

Water has softened the harshness of the northern San Joaquin Valley landscape. Travelers are no longer dismayed by a bleak, summertime plain parched to dust. Water has contributed significantly to human productivity in the Valley, one quick glance east from Interstate 5 south of Tracy is enough to convince. Water has been a dominant force in shaping the Valley and in selecting for the surviving species. Water diversions and imported water changed the carrying capacity of the land. Can water from the Stanislaus River be delivered to the contracting cities without causing substantial ecological damage? Sixteen percent of those commenting on the South County Surface Water Supply Project (ESA, 2000) questioned the impact on wildlife habitat, sensitive species, and fisheries both in the Stanislaus River riparian area and downstream. The Environmental Impact Statement, the recorded comments on the Statement, the subsequent legal actions and eventual decision demonstrate how the vulnerability of ecosystem thresholds can be determined. This process applies a social test of system sustainability if that system is changed to accommodate a proposed modification. Within that process, the application and interpretation of the relevant science is also debated. The American Society of Civil Engineers (1998) defines system sustainability as meeting societal objectives while maintaining the ecological, environmental, and hydrological integrity of the system; the definition assumes either a currently sustainable situation or the immediate possibility of attaining sustainability. With the Central Valley Project Improvement Act, the US Bureau of Reclamation defined the Valley situation as unsustainable unless changed as prescribed. The effect of the South County Surface Water Supply Project on a system already challenged by water quality and wildlife concerns is the primary unresolved issue. Depletion of wildlife (CVPIA), the mining of groundwater (Eastern San Joaquin County Groundwater Basin), and degradation of water quality (impaired lower Stanislaus and San Joaquin Rivers) beyond recovery over the time period of continued agricultural and urban activities exceeds living on natural interest. Natural capital is being spent; according to Ehrlich and Ehrlich (1996), such spending is the definition of exceeding carrying capacity.

Current Tracy population is close to the limit of current municipal water supplies. As Tracy area developers haggle and file suit over the remaining available water, it does seem a limit to urban growth is being negotiated. Urban growth limits have previously been identified and confronted in Tracy and the northern San Joaquin Valley. William H. Brewer (Farquhar, 1949) saw the extreme environmental conditions in the 1860s, the lack of water quality and quantity in addition to the difficult travel, as evidence of limited development potential for the Valley. The uncompromising aridity during the hottest months of the year was perhaps the most difficult situation to imagine resolution. In the 19th century, few people chose to live in the Valley, urban impacts on the natural environment were limited. The transients and early townspeople were basically *ecosystem people*[42]. Construction of transportation lines, the intersection of railroad tracks and eventual access to goods beyond the immediately available, induced settlement. Twentieth century infrastructure, water pumping and conveyance along with transportation improvements, redefined the City of Tracy into a location of abundant water and easy connections to the region and the state. As a result, the natural environment was transformed from perennial grassland and riparian forest to predominantly farmland, and much of it irrigated. Trade and transportation reduced the isolation and the reliance on local resources; the transition from *ecosystem* to *biosphere people* was accomplished. The city of Tracy became a more comfortable place for people to live. Irrigated farming supported the growth of regional cities and urban areas far more distant. Unlike the starkness of previous limits, current available water appears a temporary hold (if that) on city expansion. Will the relationship with the natural environment change again as more water is secured for urban use in the northern San Joaquin Valley?

A presumption throughout California's development has been that water would be found for urban growth (Walker and Williams, 1982). Despite the recent lack of new water development this presumption continues in expected water transfers from agriculture (DWR, 1998). Further support is found in the California Water Code (section 106) which defines domestic water use as the highest beneficial purpose of the resource. As *ecosystem* people the reasonableness of urban supremacy is highly questionable, but as *biosphere* people, maybe not. Urbanization continues to reconfigure the California landscape with each new wave of immigrants and emancipated offspring. Each newly urbanized portion of land demands water, water probably used elsewhere; the availability of water determines the life possible in both places.

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[42] For discussion of *ecosystem* and *biosphere* people, see Chapter 1, page 6.

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Appendix Urban Consumptive Use of Water

At first glance, the consumptive use of urban water production seems a water balance result. Water production flows into the municipal system while drainage, wastewater, and percolation to groundwater are outflows. The difference between inflow and outflows is the system loss plus the amount of water used consumptively. However, percolation is not usually measured, and the City of Tracy does not meter drainage. Furthermore, due to the locally high water table wastewater flows in Tracy are usually higher than estimates of indoor water use. Monthly water production amounts for the City of Tracy are known, from these indoor and outdoor consumptive use can be estimated.

Urban consumptive use of water is defined here as the water beneficially used and lost to the system through evaporation (indoor use) or evapotranspiration (outdoor use).

1. Estimates of indoor and outdoor water use from water production amounts

Urban water delivery systems can lose 6 to 30% in unaccounted water, the difference between water production and water delivery (DWR, 1994). Authorized uses which contribute to unaccounted water amounts include emergency uses for fires, and routine uses for flushing water mains or sewer systems. Unauthorized uses include theft, meter errors, and leaks (DWR, 1994).

Table A-1 Estimated Indoor and Outdoor Water Use

(million gallons) *mgd = million gallons per day*

1997	Water Production	Unaccounted Water 7.9%	Metered Water	Metered mgd (lowest)	Indoor Water Use	Indoor Water Use Metered Water	Outdoor Water Use
jan	196	15.48	180.52	5.82	160.09	89%	20.43
feb	188	14.85	173.15	6.18	144.60	84%	28.55
mar	308	24.33	283.67	9.15	160.09	56%	123.58
apr	383	30.26	352.74	11.76	154.93	44%	197.82
may	435	34.37	400.64	12.92	160.09	40%	240.55
jun	444	35.08	408.92	13.63	154.93	38%	254.00
jul	532	42.03	489.97	15.81	160.09	33%	329.88
aug	507	40.05	466.95	15.06	160.09	34%	306.86
sep	456	36.02	419.98	14.00	154.93	37%	265.05
oct	369	29.15	339.85	10.96	160.09	47%	179.76
nov	253	19.99	233.01	7.77	154.93	66%	78.09
dec	192	15.17	176.83	5.70	160.09	91%	16.74
	4263	337	3926		1885	48%	2041
1998							
jan	191	15.09	175.91	5.67	160.09	91%	15.82
feb	157	12.40	144.60	5.16	144.60	100%	0.00
mar	185	14.62	170.39	5.50	160.09	94%	10.30
apr	223	17.62	205.38	6.85	154.93	75%	50.46
may	259	20.46	238.54	7.69	160.09	67%	78.45
jun	367	28.99	338.01	11.27	154.93	46%	183.08
jul	471	37.21	433.79	13.99	160.09	37%	273.70
aug	488	38.55	449.45	14.50	160.09	36%	289.36
sep	411	32.47	378.53	12.62	154.93	41%	223.61
oct	323	25.52	297.48	9.60	160.09	54%	137.39
nov	219	17.30	201.70	6.72	154.93	77%	46.77
dec	221	17.46	203.54	6.57	160.09	79%	43.45
	3515	278	3237		1885	58%	1352
1999							
jan	205	16.20	188.81	6.09	160.09	85%	28.72
feb	177	13.98	163.02	5.82	144.60	89%	18.42
mar	208	16.43	191.57	6.18	160.09	84%	31.48
apr	273	21.57	251.43	8.38	154.93	62%	96.51
may	420	33.18	386.82	12.48	160.09	41%	226.73
jun	481	38.00	443.00	14.77	154.93	35%	288.08
jul	533	42.11	490.89	15.84	160.09	33%	330.80
aug	505	39.90	465.11	15.00	160.09	34%	305.02
sep	442	34.92	407.08	13.57	154.93	38%	252.16
oct	393	31.05	361.95	11.68	160.09	44%	201.86
nov	275	21.73	253.28	8.44	154.93	61%	98.35
dec	244	19.28	224.72	7.25	160.09	71%	64.63
	4156	328	3828		1885	49%	1943

Sources: Water Production Data and 7.9% unaccounted water is from the City of Tracy Department of Public Works.

Indoor consumptive use of water by evaporation was estimated by the Department of Water Resources (DWR, 1983) to be around 2%. Using this estimation, about 38 million gallons of water is used consumptively indoors each year in Tracy. This is about 1% of the estimated metered water.

Table A-2 Indoor Consumptive Use of Water

	Indoor Water Use (million gallons)	2% Indoor Consumptive Use (million gallons)
jan	160.09	3.20
feb	144.60	2.89
mar	160.09	3.20
apr	154.93	3.10
may	160.09	3.20
jun	154.93	3.10
jul	160.09	3.20
aug	160.09	3.20
sep	154.93	3.10
oct	160.09	3.20
nov	154.93	3.10
dec	160.09	3.20
Total	1885	38

The Estimated Indoor Water Use is from Table A-1, and the 2% Consumptive Use estimate is from DWR, 1983, Bulletin 166-3.

3. Estimated Outdoor Consumptive Use of Water.

The Consumptive Use Model (Kadir, 1991) used to calculate the estimated outdoor consumptive use of water uses a moisture balance to determine effective precipitation and irrigation needs. Soil is assumed to be homogeneous in moisture retention and release qualities. Good farm management practices are expected in the general care of the irrigated land and application of water. Irrigation is assumed to occur whenever soil moisture drops below a minimu level. Maximum available soil moisture is 1.5 inches per foot of rooting depth, irrigated pasture has an estimated rooting depth of 2 inches. Precipitation is used before irrigation to satisfy estimated evapotranspiration and minimum soil moisture needs. The amount of monthly urban irrigation necessary to maintain estimated soil moisture requireme moisture requirements for irrigated pasture, the urban landscaping surrogate, varies with effective precipitation.

Table A-3 Outdoor Consumptive Use Model

1997				Starting soil moisture (in.) =		1		Irrigated acres (Table A-6) 1400	
		(all in inches, except where noted)							
	Precipitation	Evapotranspiration Requirement	Consumptive Use of Precipitation	Maximum Soil Moisture	Minimum Soil Moisture	Change In Soil Moisture	Soil Moisture Accumulation	Consumptive Use of Applied Water	Consumptive Use of AW (mg/ac)	estimated Outdoor CU (mg)
JAN	4.02	0.9	0.90	3.00	1.00	2.00	3.00	0.00	0.00	0.00
FEB	0.28	1.6	0.28	3.00	1.00	-1.32	1.68	0.00	0.00	0.00
MAR	0.17	2.7	0.17	3.00	2.00	0.32	2.00	2.85	0.08	108.36
APR	0.06	4.1	0.06	3.00	3.00	1.00	3.00	5.04	0.14	191.63
MAY	0.65	5.5	0.65	3.00	3.00	0.00	3.00	4.85	0.13	184.41
JUN	0.00	6.4	0.00	3.00	2.50	-0.50	2.50	5.90	0.16	224.33
JUL	0.00	7.6	0.00	3.00	2.00	-0.50	2.00	7.10	0.19	269.96
AUG	0.03	6.6	0.03	3.00	2.00	0.00	2.00	6.57	0.18	249.80
SEP	0.00	4.8	0.00	3.00	2.00	0.00	2.00	4.80	0.13	182.51
OCT	0.08	2.8	0.08	3.00	1.50	-0.50	1.50	2.22	0.06	84.41
NOV	2.97	1.4	1.40	3.00	1.00	1.50	3.00	0.00	0.00	0.00
DEC	1.18	0.7	0.70	3.00	1.00	0.00	3.00	0.00	0.00	0.00
	9.44	45.10	4.27					39.33	1.07	1495

Table A-3 is continued on the next page.

Table A-3 Outdoor Consumptive Use Model (continued)

1998 Month	Precipitation	Evapotranspiration Requirement	Consumptive Use of Precipitation	Maximum Soil Moisture	Minimum Soil Moisture	Change In Soil Moisture	Soil Moisture Accumulation	Consumptive Use of Applied Water	Consumptive Use of AW (mg/ac)	estimated Outdoor CU (mg)
JAN	3.34	0.9	0.90	3.00	1.00	0.00	3.00	0.00	0.00	0.00
FEB	6.98	1.6	1.60	3.00	1.00	0.00	3.00	0.00	0.00	0.00
MAR	1.32	2.7	1.32	3.00	2.00	-1.00	2.00	0.38	0.01	14.45
APR	1.27	4.1	1.27	3.00	3.00	1.00	3.00	3.83	0.10	145.62
MAY	2.67	5.5	2.67	3.00	3.00	0.00	3.00	2.83	0.08	107.60
JUN	0.19	6.4	0.19	3.00	2.50	-0.50	2.50	5.71	0.16	217.11
JUL	0.00	7.6	0.00	3.00	2.00	-0.50	2.00	7.10	0.19	269.96
AUG	0.00	6.6	0.00	3.00	2.00	0.00	2.00	6.60	0.18	250.95
SEP	0.10	4.8	0.10	3.00	2.00	0.00	2.00	4.70	0.13	178.70
OCT	0.80	2.8	0.80	3.00	1.50	-0.50	1.50	1.50	0.04	57.03
NOV	1.12	1.4	1.12	3.00	1.00	-0.28	1.22	0.00	0.00	0.00
DEC	0.50	0.7	0.50	3.00	1.00	-0.20	1.02	0.00	0.00	0.00
	18.29	45.10	10.47					32.65	0.89	1241

1999 Month	Precipitation	Evapotranspiration Requirement	Consumptive Use of Precipitation	Maximum Soil Moisture	Minimum Soil Moisture	Change In Soil Moisture	Soil Moisture Accumulation	Consumptive Use of Applied Water	Consumptive Use of AW (mg/ac)	estimated Outdoor CU (mg)
JAN	2.66	0.9	0.90	3.00	1.00	1.76	2.78	0.00	0.00	0.00
FEB	1.61	1.6	1.60	3.00	1.00	0.01	2.79	0.00	0.00	0.00
MAR	1.45	2.7	1.45	3.00	2.00	-0.79	2.00	0.46	0.01	17.49
APR	1.23	4.1	1.23	3.00	3.00	1.00	3.00	3.87	0.11	147.15
MAY	0.68	5.5	0.68	3.00	3.00	0.00	3.00	4.82	0.13	183.27
JUN	0.07	6.4	0.07	3.00	2.50	-0.50	2.50	5.83	0.16	221.67
JUL	0.00	7.6	0.00	3.00	2.00	-0.50	2.00	7.10	0.19	269.96
AUG	0.00	6.6	0.00	3.00	2.00	0.00	2.00	6.60	0.18	250.95
SEP	0.13	4.8	0.13	3.00	2.00	0.00	2.00	4.67	0.13	177.56
OCT	0.19	2.8	0.19	3.00	1.50	-0.50	1.50	2.11	0.06	80.23
NOV	0.40	1.4	0.40	3.00	1.00	-0.50	1.00	0.50	0.01	19.01
DEC	0.07	0.7	0.07	3.00	1.00	0.00	1.00	0.63	0.02	23.95
	8.49	45.10	6.72					36.59	0.99	1391

Notes: mg/ac = million gallons per acre, CU = consumptive use

Sources: Evapotranspiration - CVPIA PEIS cdRom Disk 2 CVGSM/Naa/Input/Cnjet.dat, region 9, urban plus soil evaporation for January, February, and December. Maximum and Minimum Soil Moisture is from Kadir, 1991.
Precipitation - Tracy Carbona (TCR) station, http://cdec.water.ca.gov

In Table A-3, Precipitation, Evapotranspiration Requirement, Maximum and Minimum Soil Moisture are data columns, the other columns are calculated as follows:

Consumptive Use of Precipitation = uses as much of the precipitation as possible for the Evapotranspiration Requirement.

Change in Soil Moisture = maintains the soil moisture between the minimum and maximum values by using precipitation not used for evapotranspiration, accumulated soil moisture from the previous month, and/or demanding irrigation water be applied. Irrigation water is assumed available.

Soil Moisture Accumulation = adds the previous month's accumulated soil moisture to the current change in soil moisture.

Consumptive Use of Applied Water = calculates the amount of applied water (irrigation) used consumptively during the month. This is the sum of the evapotranspiration requirement plus soil moisture required minus precipitation.

Conversion of inches of water to million gallons:

1 million gallons = 3.0684 acre-feet, 1 acre-foot = 12 acre-inches.

Estimated Outdoor Consumptive Use (CU) = The estimated urban acres irrigated (Table A-6), is multiplied by the consumptive use of applied water (AW).

The Table A-3 model conserves water, irrigation is used only to attain the minimum soil moisture level. Attainment of soil moisture levels above minimum is the result of monthly precipitation above the evapotranspiration requirement.

Estimation of irrigated land in the City of Tracy:

Aerial photographs of the City (quadrants 3525 and 3425) were downloaded from the California Department of Water Resources Land Use Data website: *http://dplasp.water.ca.gov/landwateruse/landuse/counties/pdf/96sj.htm.* From these 1996 aerial photographs and field visits, the Department of Water Resources recorded land uses for each parcel of land. Maps of land uses which corresponded to the downloaded quadrants were also retrieved from the same website. Only land uses designated "U" for urban and "UR" for urban residential were considered, a total of about 5,300 acres for the City of Tracy. The aerial photographs were visually examined to determine the specific land use within the broad designations of "U" and "UR". Results of this examination show a majority of the city is composed of single family residential areas.

Table A-4 Tracy Land Use in 1996

Land Use	Acres
ranchettes ($\geq$1/2 acre)	850
single family residential	2980
apartments, trailers	80
commercial	330
industrial	20
parks	160
public facilities	290
vacant	580
	5290

Each land use is zoned for a specified lot coverage. In Tracy, the zoning code limits the amount of coverage allowed by buildings (Table A-5). To estimate the amount of average impervious land and the urban irrigated for each land use, the Tracy zoning code was compared to general Soil Conservation Service (now Resources Conservation Service) figures and an actual measured lot in the City of Tracy.

Applying 1996 acreage estimates to 1997,1998, and 1999 land use patterns is a simplification, especially in a rapidly expanding city. Between January of 1996 and January of 1999, over 5,000 new residents arrived in Tracy and many purchased new single family residences.

The impervious surface of roadways is underestimated, only the planning percentage (13%) (UMP, 1993) used for streets in residential areas is used. This percentage is subtracted from the land use acreage in Table A-4 and recorded in the second column of Table A-6.

Table A-5 Estimation of Urban Artificial Cover

Land Use	Zoning Code Max coverage by buildings	Shamsi and Fletcher % Impervious	Gribbin % Impervious	Typical Tracy Home
ranchettes (≥1/2 acre)	30%	16%	12% - 25%	
single family residential	45%	51%	25% - 65%	65%
apartments, trailers	45%		65%	
commercial	90%	85%	85%	
industrial		72%	72%	
parks		0%		
public facilities	50% (medical zone)	28% (schools)		
vacant				

Notes: Tracy Zoning Code does not include paving surfaces such as driveways, streets, and sidewalks.

Shamsi and Fletcher, 1995 and Gribbin, 1997 both use Soil Conservation Service (now Natural Resources Conservation Service) numbers published in 1986 for urban hydrology, applying them to two different watersheds.

The typical Tracy home measured for covered surfaces was mine, a 1988 average priced home in the City of Tracy. The total lot size was measured and compared to the portions of the lot that were paved (sidewalks, driveway, patio, porch), built upon a foundation (house, shed), covered by semi-pervious materials (pavers or bricks in sand).

From the estimates of impervious surfaces in each land use, a composite was developed to reflect the City of Tracy. The aerial photographs and personal observations were used in addition to the listed formal references. The amount of impervious surface for single family residential land use was heavily weighted by the measurements made of an average homesite in Tracy. Vacant land within the core area of the City does not appear to be irrigated in the aerial photographs and I have not noticed any such irrigation taking place. Ranchettes are difficult to classify because although they have a relatively low impervious surface, it is also probable that they are not completely irrigated. For ranchettes, irrigated land is assumed 10% less than pervious land. However, in the Tracy area most (about 70%) of the ranchettes have their own wells so the total city land can be reduced by about 595 acres to a total of about 4700 acres. Single family residential lots also contain semi-pervious surfaces (notes in Table A-5) that are not irrigated, such as pavers set in sand, rock landscaping, etc. The typical Tracy home had 12% semi-pervious surfaces. For this estimate of irrigated urban land, 35% of the single family residential lot area was considered irrigated.

Table A-6 Estimated Urban Irrigated Land in Tracy (acres)

Land Use	Land	% Impervious	Impervious land	Pervious land	Irrigated land
ranchettes (≥1/2 acre)	222	20%	44	177	155
single family residential	2593	53%	1374	1089	907
apartments, trailers	69.6	70%	48.7	20.9	20.9
commercial	330	90%	297	33	33
industrial	20	70%	14	6	6
parks	160	5%	8	152	152
public facilities	290	50%	145	145	145
vacant	580	0%	0	580	0
Total	4300	44%	1900	2200	1400

Note: the total land area is less than 4700 acres because 13% of the residential land was subtracted for roads.

4. Total Urban Consumptive Use of Water in the City of Tracy.

Combining the estimates of indoor and outdoor consumptive use of water for the City of Tracy, from 37% to 40% of metered water was consumptively used from 1997 through 1999. The Department of Water Resources (1994) found around 53% of net urban water use in the San Joaquin River region is consumed.

The underlined outdoor consumptive use amounts in Table A-7 are greater than estimated available outdoor water. Since the model has a monthly time step, effective precipitation can be under or over estimated. The model may not adapt well to months when rain falls softly and continuously, as occurred in January through May of 1998. Since evapotranspiration requirements are monthly averages, persistently different than average conditions such as extended periods of rainy and overcast weather or unusually cool or hot temperatures, may not be accurately represented. The model also does not account for the non-agrarian background of most Tracy residents, the shade from the homes and other buildings on lawns and other irrigated areas, the effect of mature shade trees on evapotranspiration, and the effect impervious surfaces have on runoff, soil moisture retention, and evapotranspiration.

Estimated drainage is the difference between estimated outdoor water use and outdoor consumptive use. Not all of the drainage is available for reuse, some nonconsumptively used irrigation water in Tracy percolates to groundwater or flows to Old River, some drainage evaporates as it is conveyed - especially when streets, open channels, and detention basins are used. Estimated wastewater flows are the difference between estimated indoor water use and estimated indoor consumptive use. These estimated wastewater flows assume a system that does not accumulate (or lose) flows from (or to) other sources.

Table A-7 Estimated Urban Consumptive Use of Water

	Water Production (mg)	estimated Metered water (mg)	estimated Indoor water (mg)	estimated Indoor CU (mg) 2%	estimated Wastewater (mg)	estimated Outdoor water (mg)	estimated Outdoor CU (mg)	estimated drainage (mg)	% Outdoor CU Outdoor water
jan	196	180.52	160.09	3.20	156.89	20.43	0.00	20.43	0%
feb	188	173.15	144.60	2.89	141.71	28.55	0.00	28.55	0%
mar	308	283.67	160.09	3.20	156.89	123.58	108.36	15.22	88%
apr	383	352.74	154.93	3.10	151.83	197.82	191.63	6.19	97%
may	435	400.64	160.09	3.20	156.89	240.55	184.41	56.14	77%
jun	444	408.92	154.93	3.10	151.83	254.00	224.33	29.67	88%
jul	532	489.97	160.09	3.20	156.89	329.88	269.96	59.93	82%
aug	507	466.95	160.09	3.20	156.89	306.86	249.80	57.05	81%
sep	456	419.98	154.93	3.10	151.83	265.05	182.51	82.55	69%
oct	369	339.85	160.09	3.20	156.89	179.76	84.41	95.35	47%
nov	253	233.01	154.93	3.10	151.83	78.09	0.00	78.09	0%
dec	192	176.83	160.09	3.20	156.89	16.74	0.00	16.74	0%
	4263	3926	1885	38	1847	2041	1495	546	73%
1997	*Total Estimated Urban Consumptive Use:*			*1533*	*million gallon*	*4707*	*acre-feet, and*	39%	*of metered.*
jan	191	175.91	160.09	3.20	156.89	15.82	0.00	15.82	0%
feb	157	144.60	144.60	2.89	141.71	0.00	0.00	0.00	0%
mar	185	170.39	160.09	3.20	156.89	10.30	14.45	0.00	140%
apr	223	205.38	154.93	3.10	151.83	50.46	145.62	0.00	289%
may	259	238.54	160.09	3.20	156.89	78.45	107.60	0.00	137%
jun	367	338.01	154.93	3.10	151.83	183.08	217.11	0.00	119%
jul	471	433.79	160.09	3.20	156.89	273.70	269.96	3.75	99%
aug	488	449.45	160.09	3.20	156.89	289.36	250.95	38.41	87%
sep	411	378.53	154.93	3.10	151.83	223.61	178.70	44.90	80%
oct	323	297.48	160.09	3.20	156.89	137.39	57.03	80.36	42%
nov	219	201.70	154.93	3.10	151.83	46.77	0.00	46.77	0%
dec	221	203.54	160.09	3.20	156.89	43.45	0.00	43.45	0%
	3515	3237	1885	38	1847	1352	1241	273	92%
1998	*Total Estimated Urban Consumptive Use:*			*1279*	*million gallon*	*3927*	*acre-feet, and*	40%	*of metered.*
jan	205	188.81	160.09	3.20	156.89	28.72	0.00	28.72	0%
feb	177	163.02	144.60	2.89	141.71	18.42	0.00	18.42	0%
mar	208	191.57	160.09	3.20	156.89	31.48	17.49	13.99	56%
apr	273	251.43	154.93	3.10	151.83	96.51	147.15	0.00	152%
may	420	386.82	160.09	3.20	156.89	226.73	183.27	43.46	81%
jun	481	443.00	154.93	3.10	151.83	288.08	221.67	66.41	77%
jul	533	490.89	160.09	3.20	156.89	330.80	269.96	60.85	82%
aug	505	465.11	160.09	3.20	156.89	305.02	250.95	54.07	82%
sep	442	407.08	154.93	3.10	151.83	252.16	177.56	74.59	70%
oct	393	361.95	160.09	3.20	156.89	201.86	80.23	121.64	40%
nov	275	253.28	154.93	3.10	151.83	98.35	19.01	79.34	19%
dec	244	224.72	160.09	3.20	156.89	64.63	23.95	40.68	37%
	4156	3828	1885	38	1847	1943	1391	602	72%
1999	*Total Estimated Urban Consumptive Use:*			*1429*	*million gallon*	*4387*	*acre-feet, and*	37%	*of metered.*
Note:	1 million gallons = 3.0684 acre-feet								

5. Comparison of Urban Consumptive Use of water to selected crop consumptive use.

Using the same consumptive use model (as Table A-3), with crop specific adjustments (months in the field, minimum and maximum soil moisture), the consumptive use of water applied to crops grown in the Tracy area can be determined and compared to the urban consumptive use of water. Tables A- 8 through A-13 display the variables used to describe crop water needs.

Soil evaporation was added to the evapotranspiration requirements of sugarbeets and field crops (March) and grain (January) in Table A-9, otherwise an increase in minimum soil moisture occurred without an apparent source of water. This could be considered a month of pre-irrigation, or soil preparation. Soil evaporation was assumed to occur up to depletion of soil moisture accumulation, during months the crop was not in the field.

Table A-8 Crop Mix in the Tracy Area

	Pasture	Alfalfa	SugarBeets	Field	Truck	Tomatoes	Orchard	Grain	Grapes
mix	6%	10%	7%	27%	11%	10%	5%	23%	1%

Source: CVPIA PEIS, CD rom, disk 2, CVGSM Filename: CNJCROP.nea region 9

Table A - 9 Evapotranspiration for crop mix in the Tracy area
(CVPIA PEIS Cdrom disk 2, CVGSM file CNJET.DAT, region 9)

	pasture	alfalfa	sugarbeets	field	truck	tomatoes	orchard	grain	grapes	soil
JAN	*0.9*	*0.9*	*0.9*	*0.9*	*0.9*	*0.9*	0.7	0.9	*0.9*	*0.9*
FEB	*1.6*	*1.6*	*1.6*	*1.6*	*1.6*	*1.6*	1.5	1.5	*1.6*	*1.6*
MAR	2.7	2.7	2.9	2.9	*2.9*	*2.9*	1.7	2.7	*2.9*	*2.9*
APR	4.1	4.1	1.3	1.6	1.3	1.3	2.7	4.6	1.5	*4.1*
MAY	5.5	5.5	3.2	2.6	3.2	3.2	4.9	5	3.6	*5.8*
JUN	6.4	6.4	6	5.5	6.4	6.4	5.9	2.2	4.9	*6.7*
JUL	7.6	7.6	7.9	7.3	8.3	8.3	7	*7*	6.4	*7*
AUG	6.6	6.6	6.6	4.9	5.5	5.5	6.1	*6*	5.3	*6*
SEP	4.8	4.8	4.8	2.2	1.7	1.7	4.4	*4.4*	3.6	*4.4*
OCT	2.8	2.8	2.3	*3.1*	1	1	2.5	*3.1*	1.1	*3.1*
NOV	1.4	*1.5*	1.1	*1.5*	*1.5*	*1.5*	1.1	*1.5*	*1.5*	*1.5*
DEC	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	0.6	*0.7*	*0.7*	*0.7*

Note: Values in *italics* are soil evaporation during months the crop is not in the field or not usually irrigated.

Table A - 10 STARTING SOIL MOISTURE (inches)
(from Table A - 12, December minimum monthly soil moisture)

	pasture	alfalfa	sugarbeets	field	truck	tomatoes	orchard	grain	grapes
inches	1.00	2.00	2.00	1.00	1.00	1.00	2.00	2.00	2.00

Table A - 11 MAXIMUM MONTHLY SOIL MOISTURE (inches)
(from Kadir, 1991)

	pasture	alfalfa	sugarbeets	field	truck	tomatoes	orchard	grain	grapes
OCT	3.00	9.00	7.50	6.00	4.50	7.50	9.00	6.00	7.50
NOV	3.00	9.00	7.50	6.00	4.50	7.50	9.00	6.00	7.50
DEC	3.00	9.00	7.50	6.00	4.50	7.50	9.00	6.00	7.50
JAN	3.00	9.00	7.50	6.00	4.50	7.50	9.00	6.00	7.50
FEB	3.00	9.00	7.50	6.00	4.50	7.50	9.00	6.00	7.50
MAR	3.00	9.00	7.50	6.00	4.50	7.50	9.00	6.00	7.50
APR	3.00	9.00	7.50	6.00	4.50	7.50	9.00	6.00	7.50
MAY	3.00	9.00	7.50	6.00	4.50	7.50	9.00	6.00	7.50
JUN	3.00	9.00	7.50	6.00	4.50	7.50	9.00	6.00	7.50
JUL	3.00	9.00	7.50	6.00	4.50	7.50	9.00	6.00	7.50
AUG	3.00	9.00	7.50	6.00	4.50	7.50	9.00	6.00	7.50
SEP	3.00	9.00	7.50	6.00	4.50	7.50	9.00	6.00	7.50

Table A - 12 MINIMUM MONTHLY SOIL MOISTURE (inches)
(from Kadir, 1991)

	pasture	alfalfa	sugarbeets	field	truck	tomatoes	orchard	grain	grapes
OCT	1.50	4.00	3.00	1.00	1.00	1.00	4.00	1.00	3.00
NOV	1.00	2.00	2.00	1.00	1.00	1.00	2.00	1.00	2.00
DEC	1.00	2.00	2.00	1.00	1.00	1.00	2.00	2.00	2.00
JAN	1.00	2.00	2.00	1.00	1.00	1.00	2.00	3.00	2.00
FEB	1.00	2.00	2.00	1.00	1.00	1.00	2.00	3.00	2.00
MAR	2.00	6.00	4.00	4.00	1.00	1.00	5.00	3.00	2.00
APR	3.00	8.00	4.00	4.00	3.00	3.00	8.00	3.00	5.00
MAY	3.00	9.00	7.50	4.00	4.00	7.50	9.00	1.00	7.50
JUN	2.50	8.00	7.50	5.00	4.50	7.50	8.00	1.00	7.00
JUL	2.00	7.00	6.00	4.50	4.00	6.50	7.00	1.00	6.00
AUG	2.00	6.00	5.00	3.00	4.00	5.50	6.00	1.00	5.00
SEP	2.00	5.00	4.00	2.00	2.00	3.00	5.00	1.00	4.00

Table A - 13 MONTHS CROP IS IRRIGATED
(modified from CVPIA PEIS CDROM disk 2, CVGSM, file: CNJET.DAT, region 9)

	pasture	alfalfa	sugarbeets	field	truck	tomatoes	orchard	grain	grapes
JAN	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00
FEB	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00
MAR	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	0.00
APR	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
MAY	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
JUN	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
JUL	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00
AUG	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00
SEP	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00
OCT	1.00	1.00	1.00	0.00	1.00	1.00	1.00	0.00	1.00
NOV	1.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00
DEC	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00

Modifications: sugarbeets and field crops are irrigated in March, grain is irrigated in January, otherwise the increase in minimum soil moisture occurs without a water source.

Model for pasture, alfalfa, sugarbeets, field, truck, tomatoes, orchard, grain, and grapes.

grapes (all in inches, except the last column is in acre-feet)

1997 Starting soil moisture = 2.00 inches

Month	Precipitation	ET Requirement	CU of Precipitation	Max Soil Moisture	Minimun Soil Moisture	Change In Soil Moisture	Soil Moisture Accumulation	CU of AW	1% of the crop mix
JAN	4.02	0.9	0.90	7.50	2.00	3.12	5.12	0.00	0.00
FEB	0.28	1.6	0.28	7.50	2.00	-1.32	3.80	0.00	0.00
MAR	0.17	2.9	0.17	7.50	2.00	-2.73	1.07	0.00	0.00
APR	0.06	1.5	0.06	7.50	5.00	3.93	5.00	5.37	28.61
MAY	0.65	3.6	0.65	7.50	7.50	2.50	7.50	5.45	29.04
JUN	0.00	4.9	0.00	7.50	7.00	-0.50	7.00	4.40	23.44
JUL	0.00	6.4	0.00	7.50	6.00	-1.00	6.00	5.40	28.77
AUG	0.03	5.3	0.03	7.50	5.00	-1.00	5.00	4.27	22.75
SEP	0.00	3.6	0.00	7.50	4.00	-1.00	4.00	2.60	13.85
OCT	0.08	1.1	0.08	7.50	3.00	-1.00	3.00	0.02	0.11
NOV	2.97	1.5	1.50	7.50	2.00	1.47	4.47	0.00	0.00
DEC	1.18	0.7	0.70	7.50	2.00	0.48	4.95	0.00	0.00
	9.44	34.00	4.37					27.51	146.58

1998

Month	Precipitation	ET Requirement	CU of Precipitation	Max Soil Moisture	Minimun Soil Moisture	Change In Soil Moisture	Soil Moisture Accumulation	CU of AW	1% of the crop mix
JAN	3.34	0.9	0.90	7.50	2.00	2.44	7.39	0.00	0.00
FEB	6.98	1.6	1.60	7.50	2.00	0.11	7.50	0.00	0.00
MAR	1.32	2.9	1.32	7.50	2.00	-1.58	5.92	0.00	0.00
APR	1.27	1.5	1.27	7.50	5.00	-0.23	5.69	0.00	0.00
MAY	2.67	3.6	2.67	7.50	7.50	1.81	7.50	2.74	14.60
JUN	0.19	4.9	0.19	7.50	7.00	-0.50	7.00	4.21	22.43
JUL	0.00	6.4	0.00	7.50	6.00	-1.00	6.00	5.40	28.77
AUG	0.00	5.3	0.00	7.50	5.00	-1.00	5.00	4.30	22.91
SEP	0.10	3.6	0.10	7.50	4.00	-1.00	4.00	2.50	13.32
OCT	0.80	1.1	0.80	7.50	3.00	-0.30	3.70	0.00	0.00
NOV	1.12	1.5	1.12	7.50	2.00	-0.38	3.32	0.00	0.00
DEC	0.50	0.7	0.50	7.50	2.00	-0.20	3.12	0.00	0.00
	18.29	34.00	10.47					19.15	102.03

1999

Month	Precipitation	ET Requirement	CU of Precipitation	Max Soil Moisture	Minimun Soil Moisture	Change In Soil Moisture	Soil Moisture Accumulation	CU of AW	1% of the crop mix
JAN	2.66	0.9	0.90	7.50	2.00	1.76	4.88	0.00	0.00
FEB	1.61	1.6	1.60	7.50	2.00	0.01	4.89	0.00	0.00
MAR	1.45	2.9	1.45	7.50	2.00	-1.45	3.44	0.00	0.00
APR	1.23	1.5	1.23	7.50	5.00	1.56	5.00	1.83	9.75
MAY	0.68	3.6	0.68	7.50	7.50	2.50	7.50	5.42	28.88
JUN	0.07	4.9	0.07	7.50	7.00	-0.50	7.00	4.33	23.07
JUL	0.00	6.4	0.00	7.50	6.00	-1.00	6.00	5.40	28.77
AUG	0.00	5.3	0.00	7.50	5.00	-1.00	5.00	4.30	22.91
SEP	0.13	3.6	0.13	7.50	4.00	-1.00	4.00	2.47	13.16
OCT	0.19	1.1	0.19	7.50	3.00	-0.91	3.09	0.00	0.00
NOV	0.40	1.5	0.40	7.50	2.00	-1.10	1.99	0.00	0.00
DEC	0.07	0.7	0.07	7.50	2.00	-0.63	1.36	0.00	0.00
	8.49	34.00	6.72					23.75	126.54
									acre-feet

Model notes: Evapotranspiration requirements in italics indicate soil evaporation during months the crop is not in the field or not irrigated. No irrigation water is used in the months the crop is not in the field or not normally irrigated. The model accesses Tables A-8 through A-13 for the necessary crop specific information. Model results are recorded in Table A-14 WHEN THE MODEL IS RUN USING THE CODE (macro1).

CU = consumptive use, AW = applied water, ET = evapotranspiration

Table A - 14 CROP CONSUMPTIVE USE OF APPLIED WATER
(acre-feet)

	6%	10%	7%	27%	11%	10%	5%	23%	1%	100%
1997	Pasture	Alfalfa	SugarBeets	FieId	Truck	Tomatoes	Orchard	Grain	Grapes	Total
JAN	0	0	0	0	0	0	0	0	0	0
FEB	0	0	0	0	0	0	0	0	0	0
MAR	65	191	77	416	0	0	48	145	0	942
APR	115	244	33	163	176	163	110	405	29	1438
MAY	111	236	159	207	150	275	103	210	29	1479
JUN	135	218	158	689	292	250	96	196	23	2056
JUL	163	266	169	720	330	285	117	0	29	2078
AUG	150	225	147	357	231	174	99	0	23	1406
SEP	110	153	100	127	0	0	67	0	14	571
OCT	51	69	32	0	0	0	28	0	0	180
NOV	0	0	0	0	0	0	0	0	0	0
DEC	0	0	0	0	0	0	0	0	0	0
	901	1602	875	2679	1179	1147	668	956	147	10152
1998	Pasture	Alfalfa	SugarBeets	FieId	Truck	Tomatoes	Orchard	Grain	Grapes	
JAN	0	0	0	0	0	0	0	0	0	0
FEB	0	0	0	0	0	0	0	0	0	0
MAR	9	0	0	0	0	0	0	0	0	9
APR	88	130	0	0	5	0	16	152	0	390
MAY	65	155	56	0	65	84	63	29	15	531
JUN	131	210	153	652	284	242	92	179	22	1965
JUL	163	266	169	720	330	285	117	0	29	2078
AUG	151	226	147	360	232	176	100	0	23	1415
SEP	108	149	97	117	0	0	65	0	13	549
OCT	34	40	13	0	0	0	14	0	0	102
NOV	0	0	0	0	0	0	0	0	0	0
DEC	0	0	0	0	0	0	0	0	0	0
	748	1176	636	1849	915	786	467	361	102	7039
1999	Pasture	Alfalfa	SugarBeets	FieId	Truck	Tomatoes	Orchard	Grain	Grapes	
JAN	0	0	0	0	0	0	0	111	0	111
FEB	0	0	0	0	0	0	0	0	0	0
MAR	11	83	23	390	0	0	0	102	0	608
APR	89	196	2	39	48	0	73	300	10	757
MAY	110	235	159	203	149	259	102	207	29	1453
JUN	134	215	156	681	289	247	95	190	23	2029
JUL	163	266	169	720	330	285	117	0	29	2078
AUG	151	226	147	360	232	176	100	0	23	1415
SEP	107	148	97	113	0	0	64	0	13	542
OCT	48	65	29	0	0	0	26	0	0	168
NOV	11	0	0	0	0	0	0	0	0	11
DEC	0	0	0	0	0	0	0	0	0	0
	823	1435	781	2507	1047	967	577	909	127	9173

If 4700 acres in the Tracy area were planted with the listed crop mix from 1997 through 1999, the crop consumptive use of applied water would have ranged from 7,000 to 10,200 acre-feet annually. The range depends on modeled effective precipitation.

The Central Valley Project Improvement Act Draft Programmatic Environmental Impact Statement lists average applied water and evapotranspiration requirements for various crops in 21 Central Valley regions. Since the ratio of the consumptive use of applied water (ET, evapotranspiration) to the amount of water applied to the crop is the irrigation efficiency, and the crop consumptive use of applied water (ETAW) has been estimated (Table A-14), the amount of irrigation water necessary for each crop scenario can be calculated.

Table A - 15 Estimated Applied Water for Crop Mix in the Tracy Area
(acre-feet)

(acre-feet)	ETAW/AW	est. ETAW 1997	est. ETAW 1998	est. ETAW 1999	est. AW 1997	est. AW 1998	est. AW 1999
Pasture	63%	900.61	747.65	823.44	1438.12	1193.86	1314.90
Alfalfa	68%	1602.05	1176.02	1434.62	2357.53	1730.60	2111.15
SugarBeets	68%	874.52	635.94	781.04	1286.49	935.52	1148.97
Field	69%	2679.10	1848.57	2507.48	3864.68	2666.61	3617.12
Truck	68%	1178.73	915.00	1047.29	1725.29	1339.28	1532.90
Tomatoes	69%	1146.86	786.30	966.97	1657.79	1136.59	1397.75
Orchard	68%	667.51	466.73	576.52	981.32	686.15	847.54
Grain	70%	955.71	361.07	909.35	1356.07	512.32	1290.29
Grapes	65%	146.58	102.03	126.54	226.39	157.59	195.45
		10200	7000	9200	14900	10400	13500

Notes: AW = applied water, ETAW = evapotranspiration of applied water, ETAW/AW = irrigation efficiency. ETAW/AW is from AW and ETAW of the CVPIA PEIS,cdRom disk 2, AG ECON, file:CESDAT95.gms. Estimated AW is the estimated ETAW divided by the irrigation efficiency (ETAW/AW).

From 1997 through 1999, an average of 12,900 acre-feet of water production would have been required to grow the described crop mixture on 4,700 acres in the Tracy area. Over the same 3 years the average urban water production was 12,200 acre-feet. At the crop water using extremes, grain would have averaged 4,600 acre-feet of water production while pasture would have demanded nearly 5 times as much water, 22,500 acre-feet (Table A-16).

Table A - 16 Estimated Urban and Crop Scenario Water Usage
(acre-feet)

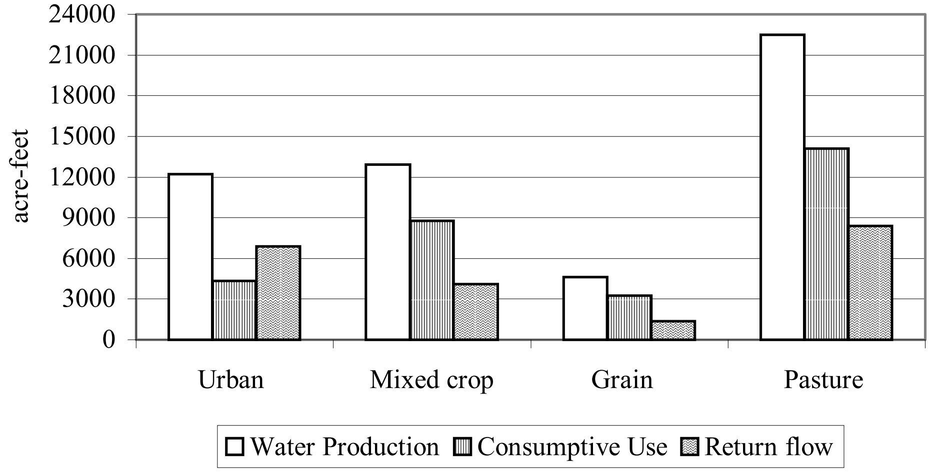
1997	Urban Water Production	Urban CU	Urban Return flow	Mixed crop production	Mixed Crop CU	Mixed crop Return flow	Grain only production	Grain only CU	Grain only Return flow	Pasture only production	Pasture only CU	Pasture only Return flows
JAN	601	10	544	0	0	0	0	0	0	0	0	0
FEB	577	9	522	0	0	0	0	0	0	0	0	0
MAR	945	342	528	1375	942	433	906	638	267	1782	1116	666
APR	1175	598	485	2100	1438	663	2523	1778	745	3152	1974	1178
MAY	1335	576	654	2167	1479	688	1306	920	386	3033	1900	1134
JUN	1362	698	557	3005	2056	949	1223	862	361	3690	2311	1379
JUL	1632	838	665	3050	2078	971	0	0	0	4441	2781	1660
AUG	1556	776	656	2073	1406	667	0	0	0	4109	2573	1536
SEP	1399	570	719	851	571	280	0	0	0	3002	1880	1122
OCT	1132	269	774	272	180	91	0	0	0	1388	870	519
NOV	776	10	705	0	0	0	0	0	0	0	0	0
DEC	589	10	533	0	0	0	0	0	0	0	0	0
	13081	4704	7343	14894	10152	4742	5958	4199	1759	24598	15404	9194
1998												
JAN	586	10	530	0	0	0	0	0	0	0	0	0
FEB	482	9	435	0	0	0	0	0	0	0	0	0
MAR	568	54	469	14	9	5	0	0	0	238	149	89
APR	684	456	174	577	390	187	950	670	281	2395	1500	895
MAY	795	340	392	786	531	255	183	129	54	1770	1108	662
JUN	1126	676	361	2873	1965	908	1117	787	330	3571	2236	1335
JUL	1445	838	493	3050	2078	971	0	0	0	4441	2781	1660
AUG	1497	780	599	2086	1415	671	0	0	0	4128	2585	1543
SEP	1261	558	604	818	549	270	0	0	0	2939	1841	1099
OCT	991	185	728	154	102	52	0	0	0	938	588	351
NOV	672	10	609	0	0	0	0	0	0	0	0	0
DEC	678	10	615	0	0	0	0	0	0	0	0	0
	10785	3925	6009	10359	7039	3319	2251	1586	665	20420	12788	7632
1999												
JAN	629	10	570	157	111	46	689	486	203	0	0	0
FEB	543	9	491	0	0	0	0	0	0	0	0	0
MAR	638	63	524	879	608	271	634	447	187	288	180	108
APR	838	461	310	1108	757	351	1873	1320	553	2420	1516	905
MAY	1289	572	615	2129	1453	676	1289	909	381	3015	1888	1127
JUN	1476	690	670	2966	2029	937	1184	834	349	3646	2283	1363
JUL	1635	838	668	3050	2078	971	0	0	0	4441	2781	1660
AUG	1550	780	647	2086	1415	671	0	0	0	4128	2585	1543
SEP	1356	554	695	809	542	267	0	0	0	2921	1829	1092
OCT	1206	256	855	253	168	85	0	0	0	1320	826	493
NOV	844	68	709	18	11	7	0	0	0	313	196	117
DEC	749	83	606	0	0	0	0	0	0	0	0	0
	12752	4385	7360	13456	9173	4283	5669	3995	1674	22490	14084	8406
Average	**12200**	**4300**	**6900**	**12900**	**8800**	**4100**	**4600**	**3300**	**1400**	**22500**	**14100**	**8400**

Notes: CU = consumptive use. Pasture only and grain only mean a 4700 acres monoculture. The estimated Urban return flows do not include the 7.9% the 7.9% unaccounted water. None of the return flows account for evaporation during conveyance or percolation to groundwater. Crop water production is the sum of each crop consumptve use divided by each irrigation efficiency, every month. For individual crops, the consumptive use is first augmented to cover the entire 4700 acres.

Sources: Urban Water Production - Table A - 1, Estimated Urban CU - Table A - 7, Estimated Crop Water Production - Table A - 15 for irrigation efficiencies and Table A-14.

Average water production, consumptive use of water, and return flows are all highest for a 4700 monoculture of irrigated pasture. This is an upper bound to the possible water requirements and use in the Tracy area. The lowest average water production, consumptive use, and return flows result from the other 4700 acres monoculture, grain. The average urban percentage of water consumptively used is lower than for any of the possible crop plantings, estimated return flows for urban water use in Tracy are higher than consumptive use. Most of the urban return flow quantity is wastewater from indoor water use (Table A-7), about 20% is from outdoor drainage.

Figure A-1 Water Use Scenarios for the Tracy area



Source: Table A-16, the average values.

Assuming no water reuse, average water production is 2.60 acre-feet per acre for urban uses, 2.74 acre-feet per acre for mixed crops, 0.98 acre-feet per acre for grain, and 4.79 acre-feet for pasture. Tracy urban water production is comparable to medium water demand crops, with a lower water efficiency (higher return flows) than is common in the region for agriculture.