DRAFT

Technical Solutions Pilot Study Report

Tulare Lake Basin Disadvantaged Communities Water Study

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Prepared for:

Tulare County

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ABBREVIATIONS/ACRONYMS

µg/L ..... micrograms per liter (same as ppb)
1,2,3-TCP 1,2,3-Trichloropropane
BOD ..... Biochemical Oxygen Demand
CDPH ..... California Department of Public Health
CF ..... Coagulation and Filtration
CT ..... Contact Time
DAC ..... Disadvantaged Community
DBCP ..... Dibromochloropropane
DBP(s) ..... Disinfection By-Product(s)
E. coli ..... *Escherichia Coli*
HAA(s) ..... Haloacetic Acid(s)
HAA5 ..... Sum of 5 Haloacetic Acids
ICF ..... Iron Coagulation Filtration
IX ..... Ion Exchange
KW ..... Kilowatt
KWh ..... Kilowatt hours
MCL ..... Maximum Contaminant Level
MG ..... Million Gallons
mg/L ..... milligrams per liter (same as ppm)
MGD ..... Million Gallons per Day
N ..... Nitrogen
NO_3 ..... Nitrate
NOM ..... Natural Organic Matter
NPDES ..... National Pollutant Discharge Elimination System
NTU ..... Nephelometric Turbidity Units
PCBs ..... Polychlorinated Biphenyls
pCi/L ..... picocuries per liter
pH ..... - log Hydrogen Ion Concentration

ABBREVIATIONS/ACRONYMS (CONT.)

POE ..... Point-of-Entry
POU ..... Point-of-Use
ppb ..... parts per billion
ppm ..... parts per million
RO ..... Reverse Osmosis
RWQCB ..... Regional Water Quality Control Board
S.U. ..... Standard Units
SDAC ..... Severely Disadvantage Community
SBA ..... Strong Base Anions
TBD ..... To be Determined
THM(s) ..... Trihalomethane(s)
TLB ..... Tulare Lake Basin
TOC ..... Total Organic Carbon
TSS ..... Total Suspended Solids
TTHM(s) ..... Total Trihalomethane(s)
UIC ..... Underground Injection Control
USEPA, EPA ..... United States Environmental Protection Agency
UV ..... Ultraviolet
VFD ..... Variable Frequency Drive
WDR(s) ..... Waste Discharge Requirement(s)
WTP(s) ..... Water Treatment Plant(s)
WWTP ..... Wastewater Treatment Plant
ZLD ..... Zero Liquid Discharge

EXECUTIVE SUMMARY

The Tulare Lake Basin Study area contains 533 communities. Of these, 370 communities are classified as a Disadvantaged Community (DAC) or as a Severely Dis-Advantaged Community (SDAC). Those classified as DAC or SDAC (collectively referred to as DACs) will be the focus of this technical evaluation. Of the 370 DAC communities, 117 recorded at least one drinking water maximum contaminant level (MCL) exceedance from 2005 to 2010.

The exceedances recorded were from a wide variety of contaminants including coliform bacteria, arsenic, nitrate, total trihalomethanes, uranium, fluoride, dibromochloropropane (DBCP), perchlorate and polychlorinated biphenyls (PCB). These contaminants were either present alone or in combination with other contaminants.

Because treatment facilities are costly to construct and maintain, it is generally preferred to resolve water contamination issues by means other than treatment. The generally preferred solution is to find a better quality source of water that does not require treatment. Many communities will choose to drill a new well to obtain better quality water or connect to a neighboring water system. However, that is not always feasible, especially in areas that have widespread, known water quality contamination issues. If a high quality water source can be found, it can replace the contaminated supply or it can sometimes be blended with the contaminated source to provide water that meets water quality standards without treatment. This pilot study focuses on technical solutions for communities that have exhausted all other less costly alternatives.

If a source with acceptable drinking water quality cannot be found, it may be necessary to provide a treatment system. Sometimes it may be advantageous to build a centralized treatment system to treat the water from several nearby communities. This report examines these treatment systems and their potential use to remove the contaminants present in the study area. **The findings and recommendations in this report are based only on a list of drinking water MCL exceedances and are therefore general and preliminary in nature**. Determining the appropriate treatment approach for individual systems will require a more detailed evaluation of water quality and system-specific constraints that are beyond the scope of this report.

All treatment systems generate liquid and/or solid waste streams that must be disposed. The disposal options will depend on the type of treatment system used. Disposal options include non-mechanical and mechanical dewatering, discharge to a sewer, deep well injection, evaporation, trucking or zero liquid discharge. The treatment of residuals can be accomplished at the water treatment plant site or at a centralized site that treats wastes from multiple treatment plants. This pilot study also focuses on technical solutions for water treatment residual disposal that may remove obstacles for treatment or may reduce the overall cost of treatment.

In order to minimize the capital and operations & maintenance costs, a water treatment system should ideally treat water used primarily for potable and in-home use. If a large

portion of a drinking water supply is used for non-potable purposes, a dual water distribution system can be considered as a technical solution that may reduce treatment costs. One distribution system would convey non-potable water for irrigation, landscaping, farming, etc. and separate system would convey potable water.

Water conservation and energy conservation are technical solutions that can reduce the cost of water. Minimizing potable water demand will minimize the cost of treatment facility construction and operation.

Energy conservation will also minimize the energy cost associated with operating a water treatment plant. Energy conservation can be achieved through the use of energy efficient pumps, pumps with variable speed drives, and energy efficient motors. Renewable energy from biogas or solar is another option to reduce energy costs.

This report suggests that demonstration projects be developed to show how many of the technical solutions presented and discussed can be implemented. Suggested technical solution demonstration projects to be applied to the TLB include:

- Blending
- Dual water distribution systems
- Biological nitrate removal
- Joint residual handling, management and disposal
- Lower cost water treatment technology
- Water and energy efficiency technology

These specific demonstration projects will be further developed upon approval of the selected communities. The first step will be to identify communities where the demonstration projects may apply.

1 TECHNICAL SOLUTIONS REVIEW

The Technical Solutions Pilot Study is one of four pilot studies that are part of the Tulare Lake Basin (TLB) Disadvantaged Community Water Study. This pilot study focuses exclusively on technical solutions to water and wastewater compliance and capacity issues faced by the many communities within the study area. A greater emphasis has been placed on drinking water issues than on wastewater issues for this pilot study. This is because the number of DACs impacted by drinking water issues is much greater than the number of DACs impacted by wastewater issues. Many DACs in the study area utilize single-family septic systems for wastewater disposal. This is investigated in detail in the pilot study for Individual household systems. Most DACs in the study area utilize a centralized community drinking water system.

Generally, technical solutions are a "last resort" because they involve construction of various expensive facilities, including treatment plants and require ongoing operations and maintenance costs that almost always exceed those associated with non-technical solutions. Usually the best strategy to keep costs low for a community is to first consider "non-technical, non-structural, non-physical" solutions or a new "source" before considering the technical solutions outlined in this pilot study. This is especially true when treatment must be considered because it has continuous operating and maintenance costs that other solutions may avoid. Management solutions, new sources and point-of-use (POU) / point-of-entry (POE) water treatment devices are considered in the other three pilot studies.

Technical solutions considered in this pilot study Include:

- Water treatment as required to meet Federal EPA and California Department of Public Health (CDPH) drinking water standards and regulations. The study considers conventional, established water treatment technologies as well as developing technologies. The study focuses on treatment technologies applicable to the most common drinking water contaminants present in the Tulare Lake Basin and on lower cost systems appropriate to the community water systems.
- Wastewater treatment technologies as required to meet Regional Water Quality Control Board (RWQCB) waste discharge requirements (WDRs). The focus is on the use of "appropriate" technology that provides cost-effective wastewater treatment and reliable compliance with WDRs.
- Blending of a poorer quality water source with a better quality water source to meet drinking water standards.
- Water and energy use efficiency. Use of water and energy efficiently will lower system operating costs to the consumers. This solution may include the utilization of renewable energy such as solar and bio-methane as well as retrofits to install more energy efficient pumps, electric motors and aeration systems.
- Joint or regional residuals management. The technical feasibility of treatment systems is often dependent on the ability to safely and cost-effectively dispose of residuals, including sludge, concentrate, brine and spent media from treatment

processes. The cost of residuals disposal/regeneration/treatment can be a large fraction of the cost of treatment. The ability to handle residuals at low cost is a key to the on-going success of a treatment system.

- Dual water distribution. Generally, water suppliers distribute water to customers through a single pipe distribution system. The same water is used for drinking as well as outside irrigation. Drinking water must meet the highest standards and therefore all water must meet the highest standard at the water service connection. With a dual water distribution system, water can be delivered for outside irrigation use that does not meet drinking water standards. The use of a contaminated well or recycled wastewater for outside irrigation can reduce volume of water to be treated and thus lower treated water cost. This is off-set by the cost of a second distribution system and the required management and skill level to operate and maintain a dual system.
- Developing technologies. There are a number of developing technologies that address some of the shortfalls of conventional treatment technology, especially with respect to residuals management and disposal. Some of the newer technologies are able to treat multiple contaminants with a single treatment system. Biological denitrification for removal of nitrates in water is one such developing technology that may work well in the Tulare Lake Basin.

The selection of appropriate technical solutions requires site specific engineering analysis. One major factor with respect to treatment process selection is the unique water chemistry of each water supply. Just because a treatment system works well at one location does not necessarily mean it will work well in a different location, even within the same community. Other factors to be considered include the size/capacity of the system, number of water sources, water use patterns, existing water infrastructure in place, land availability, and many others.

It is the intent of the study to focus primarily on technical solutions applicable to the Tulare Lake Basin and the contaminants most often occurring in the water supply. Thus, with respect to water treatment, the study focuses foremost on nitrate and arsenic MCL exceedances and Total Coliform Rule violations. Other contaminants present in the TLB that exceed their respective MCLs include uranium, fluoride, perchlorate, trihalomethane (THM), dibromochloropropane (DBCP) and polychlorinated biphenyls (PCB). Most water supplied to disadvantaged communities in the TLB is groundwater and thus this study focuses more on groundwater than surface water supply. All communities that utilize surface water have treatment systems that include coagulation, filtration and disinfection. A major water quality issue for surface water treatment systems is the formation of disinfection by-products (DBPs), including THMs, largely because chlorine, used for disinfection and oxidation, reacts with natural organic matter (NOM) in the raw water.

2 CONTAMINANTS EXCEEDING DRINKING WATER MCLS

California drinking water regulations specify primary standards and secondary standards for water contaminants. The primary standard maximum contaminant levels (MCLs) are health based standards. These standards are considered necessary for the immediate and long term protection of human health. Secondary MCLs are consumer acceptance contaminant levels. Secondary standards relate to the aesthetics of the water and include such parameters as turbidity, color, odor and total dissolved solids. This study focuses on compliance with primary standards, which represent the minimum standard for human consumption. Some contaminants are considered to be acute contaminants because they can have an immediate effect on health. Other contaminants are chronic, meaning that their effect is cumulative over a long period of time.

For example, bacterial contamination, as indicated by coliform or fecal coliform violations, can result in almost immediate gastro-intestinal illness such as diarrhea. When bacterial contamination is discovered, “do not drink” and “boil water” orders are immediately issued. In contrast, arsenic contamination is chronic and has a cumulative effect over a lifetime. Its health effects probably will not be immediately noticed by the consumer.

A database of the communities in the Tulare Lake Basin study area was searched to determine those communities that have exceeded a primary drinking water maximum contaminant level (MCL). This database was composed of drinking water monitoring data from two periods, 2005-2007 and 2008-2010. The information in the database was supplied by CDPH and the Community Water Center. An exceedance was based on an analysis of drinking water monitoring data submitted from communities to CDPH. The fact that there was a single or multiple exceedance of a MCL for a certain constituent does not necessarily equate to a violation of drinking water standards. The specific circumstances of the violation must be considered.

Compliance for constituents that are chronic contaminants is determined on a running annual average. For example, a violation of the arsenic water quality standard is determined by the running average of 12 consecutive months (or four quarters) of sampling. A single quarterly or monthly sample which exceeds the MCL, does not in itself cause a violation of the standards. For nitrate, perchlorate and coliform, which are acute contaminants an initial exceedance must be confirmed by a second sample. If the average of those two samples is in exceedance of the water quality standard, then the system is in violation. The term ‘exceedance’ used in this report implies that at least one sample for a single contaminant from a single source reported a constituent at a level above the MCL.

The database included a total of 533 individual unincorporated communities. Of the 533 communities, 370 have been classified as a Disadvantaged Community (DAC) or as a Severely Disadvantaged Community (SDAC). Those classified as DAC or SDAC will be

the focus of this technical evaluation. Of the 370 DAC/SDAC entities, 214 (58%) have water sampling data. In this report, both DACs and SDACs will be collectively referred as DACs.

Of the 211 DACs entities with reported sampling data, 117 (55.4%) have a reported MCL exceedance. The MCL exceedances were based on samples reported between 2005 and 2010. The database does not include sources that became inactive prior to 2005 as a result of water quality issues.

2.1 Contaminants

The 117 MCL exceedances were composed of nine contaminants present either alone or in combination. These contaminants were coliform, arsenic, nitrate, trihalomethane (THM), uranium, fluoride, dibromochloropropane (DBCP), perchlorate, and polychlorinated biphenyls (PCBs).

2.1.1 Coliform

Coliform bacteria are bacteria that are ubiquitous and naturally present in the environment and are used as an indicator that other, potentially-harmful, bacteria may be present. Coliform presence is an indicator of possible fecal contamination of a water source. A coliform violation is a potentially serious public health threat and must be immediately followed up with repeat sampling for confirmation. A water system is considered to have violated the coliform MCL if the following occurs:

- For a public water system which collects at least 40 samples per month, more than 5.0 percent of the samples collected during any month are total coliform-positive; or
- For a public water system which collects fewer than 40 samples per month, more than one sample collected during any month is total coliform-positive; or
- Any repeat sample is fecal coliform-positive or *E. coli*-positive; or
- Any repeat sample following a fecal coliform or *E. coli*-positive routine sample is total coliform-positive.

Fecal coliform and *E. coli* are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Such microbes may cause short-term effects, such as diarrhea, cramps, nausea, headaches, or other symptoms. They may pose a special health risk for infants, young children, some of the elderly, and people with severely compromised immune systems.

Coliform bacteria were the contaminant most often recorded as violating a MCL. A coliform MCL exceedance was recorded in at least one of the samples in 59 of the 117 (50.4%) DAC entities with MCL exceedances. Of these 59, 33 entities had only coliform bacteria MCL exceedances. The remaining 26 entities had coliform bacteria in combination with another contaminant.

2.1.2 Arsenic

Most arsenic in groundwater in the TLB is naturally occurring and comes from the dissolution of arsenic containing sediments. Until the 1950s, arsenic was also a major component of agricultural insecticide. Anthropogenic arsenic sources are not considered a significant source of contamination in the TLB.

USEPA has classified arsenic as a human carcinogen, based primarily on skin cancer risks. Some people who drink water containing arsenic in excess of the MCL over many years may experience skin damage or circulatory system problems, and may have an increased risk of cancer. The current USEPA and California drinking water MCL for arsenic is 10 µg/L (ppb). The current MCL was effective in 2008. The previous MCL was 50 µg/L.

An arsenic MCL exceedance was recorded in at least one of the samples in 33 of the 117 (28.2%) DAC entities with MCL exceedances and 8.9% of all DACs. Of these 33, 13 entities had only arsenic MCL exceedances. The remaining 20 entities had arsenic in combination with another contaminant.

2.1.3 Nitrate

Nitrate (NO_3) is one of the major anions in natural waters and its background or natural levels in the TLB are believed to be well below the drinking water standard, but according to the EPA web site (http://water.epa.gov/drink/contaminants/basicinformation/nitrate.cfm) and the report, Addressing Nitrate in California's Drinking Water (also known as the Harter Report - http://groundwaternitrate.ucdavis.edu), localized groundwater nitrate concentrations in the TLB are believed to be elevated due to leaching and oxidation of nitrogen from fertilizer application, dairies, feed lots, food processing wastes and or septic tank leach fields. Nitrate is of great concern because it is an acute contaminant.

Nitrate converted to nitrite in the body causes two chemical reactions that can lead to adverse health effects: induction of methemoglobinemia, and the potential formation of carcinogenic nitrosamides and nitrosamines. Infants, especially less than one year of age, who drink water containing nitrate in excess of the MCL may quickly become seriously ill, and if untreated, may die from methemoglobinemia. Methemoglobinemia is a medical condition in which high nitrate levels interfere with the capacity of the infant's blood to carry oxygen; symptoms include shortness of breath and blueness of the skin. Elevated nitrate concentrations may also affect the oxygen-carrying ability of the blood of pregnant women and the elderly. The current California drinking water MCL for nitrate is 45 mg/L as NO_3. The USEPA drinking water MCL for nitrate is 10 mg/L as N. The federal and state standards are equivalent when reported in the same units. Although nitrate has acute health effects, there have been no documented incidences of acute nitrate health effects in the TLB (CDPH pers comm.) This is likely a result of the diligence by the CDPH in enforcing nitrate standards and the built-in safety factor in the standards set by CDPH.

A nitrate MCL exceedance was recorded in at least one of the samples in 29 of the 117 (24.7%) DAC entities with MCL exceedances and 7.8% of all DACs. Of these 29, nine entities had only nitrate MCL exceedances. The remaining 20 entities had nitrate in combination with another contaminant.

2.1.4 Trihalomethanes (THM)

THMs are a group of halogenated organic compounds that include chloroform, dibromochloromethane, dichlorobromomethane, and bromoform. THMs are formed when dissolved organic material in a water system is exposed to chlorine in water treatment processes. THMs are one of a class of contaminants, known as disinfection by-products (DBPs) that are formed during the disinfection process. Some people who drink water containing THMs in excess of the MCL over many years may experience liver, kidney, or central nervous system problems, and may have an increased risk of cancer.

Natural organic material (NOM) is often present in surface water sources in sufficient quantity to form THMs that exceed the MCL. Generally groundwater contains low concentrations of NOM and therefore THM formation is less of a problem. The formation of THMs from surface water supplied from the California Aqueduct is more problematic than water obtained more directly from the western slope of the Sierra Nevada Mountains (Friant-Kern Canal, Kern River). The current USEPA and California drinking water MCL for total trihalomethane (TTHM) is 80 µg/L (ppb).

A TTHM MCL exceedance was recorded in at least one of the samples in 17 of the 117 (14.5%) DAC entities with MCL exceedances and 4.6% of all DACs. Of these 17, 15 entities had only TTHM MCL exceedances. The remaining two entities had TTHM in combination with another contaminant.

The regulated DBPs include THMs and haloacetic acids (HAA). There are five haloacetic acids (HAA5) whose total is subject to the MCL HAA5 limit of 60 µg/L (ppb). The database used for this report showed one DAC entity had a HAA5 exceedance. This entity also had THM exceedances. This entity serves a population of 50.

2.1.5 Uranium

Most uranium in groundwater comes from the dissolution of naturally occurring uranium containing rocks and sediments.

Uranium is a known kidney chemotoxin and a suspected human carcinogen. Some people who drink water containing uranium in excess of the MCL over many years may have kidney problems or an increased risk of getting cancer. The current California drinking water MCL for uranium is 20 pCi/L (picocuries/liter). The federal standard is 30 µg/L.

An uranium MCL exceedance was recorded in at least one of the samples in 19 of the 117 (16.2%) DAC entities with MCL exceedances and 5.1% of all DACs. Of these 19, one entity had only uranium MCL exceedances. The remaining 18 entities had uranium in combination with another contaminant (predominately arsenic).

2.1.6 Fluoride

Fluoride occurs naturally in most soils and in many water supplies. Some fluoride in water is considered beneficial for dental health. The state drinking water standards identify the optimum beneficial range of fluoride concentrations based on temperature. However, too much fluoride can be harmful. The California drinking water MCL for fluoride is 2 mg/L and the Federal EPA standard is 4 mg/L. Some people who drink water containing fluoride in excess of the federal MCL of 4 mg/L over many years may get bone disease, including pain and tenderness of the bones. Children who drink water containing fluoride in excess of the state MCL of 2 mg/L may get mottled (discolored) teeth. Long-term health effects of elevated levels of fluoride include dental and skeletal fluorosis.

A fluoride MCL exceedance was recorded in at least one of the samples in 4 of the 117 (3.4%) DAC entities with MCL exceedances and 1% of all DACs. All 4 entities had fluoride in combination with another contaminant.

2.1.7 DBCP

DBCP (dibromochloropropane) is the active ingredient in a nematicide, Nemagon, also known as Fumazone. Until 1977, DBCP was used as a soil fumigant and nematicide on over 40 crops in the United States. Since 1977, the use of DBCP has been prohibited in California. DBCP may still be present in soils due to runoff/leaching from former use on soybeans, cotton, vineyards, tomatoes, and tree fruit.

Acute exposure to DBCP by ingestion produces gastrointestinal distress and pulmonary edema. USEPA has classified DBCP as a probable human carcinogen. Some people who use water containing DBCP in excess of the MCL over many years may experience reproductive difficulties and may have an increased risk of cancer. The current USEPA and California drinking water MCL for DBCP is 0.2 µg/L

A DBCP MCL exceedance was recorded in at least one of the samples in 4 of the 114 (3.4%) DAC entities with MCL exceedances and 1% of all DACs. Of these 4, one entity had only DBCP MCL exceedances. The remaining 3 entities had DBCP in combination with another contaminant.

2.1.8 Perchlorate

Perchlorate is an inorganic chemical that can originate from both natural and manmade sources. Perchlorate is used in solid rocket propellant, fireworks, explosives, flares, matches, and in a variety of industries. Perchlorate is also naturally occurring in some fertilizers. It is reported that nitrate fertilizer, containing perchlorate, originating from Chile has been widely used in California since 1923. (http://perchlorateinformationbureau.org/perchlorate-basics). Perchlorate can get into drinking water as a result of environmental contamination from historic aerospace or other industrial operations that used or use, store, or dispose of perchlorate and its salts. However, the absence of such industries in the TLB suggests that perchlorate

may be either associated with fertilizer application, it is naturally occurring or it occurs as a result of chemical reactions.

Perchlorate interferes with the iodide uptake of the thyroid gland which can decrease the production of thyroid hormones. These thyroid hormones are needed for prenatal and postnatal growth and development, as well as for normal metabolism and mental function in adults. The current California drinking water MCL for perchlorate is 6 µg/L.

A perchlorate MCL exceedance was recorded in at least one of the samples in 5 of the 117 (4.3%) DAC entities with MCL exceedances and 1.4% of all DACs. Of these 5, 2 entities had only perchlorate MCL exceedances. The remaining three entities had perchlorate in combination with another contaminant.

2.1.9 PCB

PCBs (polychlorinated biphenyl compounds) are any of the over 200 chemicals that contain chlorine atoms attached to a biphenyl molecule. PCBs were widely used as coolant fluids in transformers, capacitors, and electric motors. Because of PCBs' environmental toxicity and classification as a persistent organic contaminant, PCB production was banned in 1979. PCBs enter a drinking water system by improper waste disposal or leaking electrical equipment. PCBs are probable human carcinogens. The current USEPA and California drinking water MCL for PCBs is 0.5 µg/L. Some people who drink water containing PCBs in excess of the MCL over many years may experience changes in their skin, thymus gland problems, immune deficiencies, or reproductive or nervous system difficulties, and may have an increased risk of cancer.

A PCB MCL exceedance was recorded in at least one of the samples in 2 of the 117 (1.7%) DAC entities with MCL exceedances and 0.5% of all DACs. Both entities had PCB in combination with another contaminant.

2.1.10 Summary of MCL Exceedances

Of the 117 DAC entities with MCL exceedances, 74 had exceedances for a single contaminant. The remaining 43 entities with MCL exceedances had exceedances of multiple contaminants.

2.2 Sizes of DACs with MCL Exceedances

The 117 DAC entities with MCL exceedances ranged in number of connections from zero to over 2,000. In reviewing Table 2-1, as mentioned above, an MCL exceedance does not necessarily indicate a violation or that the system is out of compliance with standards. These exceedance tables, however, are used to assess the need for eliminating and preventing existing or future water quality issues.

Table 2-1 shows the DAC entities by size with the number having MCL exceedances:

Table 2-1: Summary of DAC Entities with MCL Exceedances

Number of Connections	No. of Entities	No. with MCL Exceedances	Percent with MCL Exceedances
Unknown	3	0	0.0%
Less than 15	72	9	12.5%
15 to 50	134	42	31.3%
51 to 200	92	26	28.3%
201 to 500	33	16	48.5%
501 to 2000	29	17	58.6%
Greater than 2000	7	7	100.0%
TOTAL	370	117	31.6%

Table 2-2 shows the breakdown of MCL contaminant exceedances by county.

Table 2-2: MCL Contaminant Exceedances by County

Contaminant	Fresno Co.	Kern Co.	Kings Co.	Tulare Co.	Totals
Coliform	5	6	1	21	33
Arsenic	3	3	5	2	13
Nitrate	1	1	0	7	9
THM	13	1	0	1	15
Uranium	0	0	0	1	1
Fluoride	0	0	0	0	0
DBCP	0	1	0	0	1
PCB	0	0	0	0	0
Coliform with					
Arsenic	2	2	0	1	5
Nitrate	0	1	0	9	10
Uranium	1	1	0	0	2
PCB	1	0	0	1	2
THM	0	0	1	0	1
Arsenic & Uranium	0	9	0	0	9
Nitrate & Uranium	0	1	0	0	1
Nitrate & DBCP	0	1	0	1	2
Uranium & Fluoride	0	1	0	0	1
THM, Nitrate & Perchlorate	0	0	0	1	1
Arsenic, Fluoride & Uranium	0	1	0	0	1
Coliform with					
Arsenic & Uranium	0	1	0	0	1
Nitrate & Arsenic	0	1	0	0	1
Nitrate & Uranium	0	0	0	1	1
Nitrate & DBCP	1	0	0	0	1
Arsenic & Perchlorate	0	0	0	1	1
Nitrate & Perchlorate	0	0	0	1	1
Arsenic, Nitrate, Uranium & Fluoride	0	2	0	0	2

2.3 Future Water Quality Regulations

2.3.1 Revisions to the Total Coliform Rule

The existing Total Coliform Rule (TCR) regulations will remain in effect until March 31, 2016. Starting on April 1, 2016, water systems must comply with the revised TCR requirements. The basic monitoring requirements will remain the same but the new regulation links monitoring frequency to water quality and system performance by:

- Providing criteria that well-operated small systems must meet to qualify and stay on reduced monitoring;
- Requiring increased monitoring for high-risk small systems with unacceptable compliance history; and
- Requiring some new monitoring requirements for seasonal systems such as campgrounds and some state and national parks.

The new regulation establishes a health goal and a MCL for E. coli and eliminates the MCL for coliform, replacing it with a treatment technique for coliform that requires assessment and corrective action.

The revised rule is establishing a health goal of zero for E. coli, a more specific indicator of fecal contamination and potentially more harmful pathogens than total coliform. Many of the organisms detected by total coliform methods are not of fecal origin and do not have direct public health implication.

Under the new treatment technique for coliform, total coliform serves as an indicator of a potential pathway of contamination into the distribution system. A water system that exceeds a specified frequency of total coliform occurrence must conduct an assessment to determine if any sanitary defects exist and, if found, correct them. In addition, under the new treatment technique requirements, a water system that incurs an E. Coli MCL violation must conduct an assessment and correct any sanitary defects found.

2.3.2 1,2,3-Trichloropropane (TCP)

There is currently no California or federal MCL for TCP. The State has developed a public health goal for TCP of 0.0007 µg/L and is in the process of developing an MCL. The public health goal is based on carcinogenic effects observed in animals. TCP has been used as a solvent and degreasing agent and in the synthesis of other compounds such as epichlorohydrin and certain polymers. TCP also occurs as a byproduct in the production of chemicals and certain pesticides (Telone II). Pesticide use appears to be the origin of most of the contamination throughout the TLB.

As of 2011, CDPH had identified 336 drinking water sources with TCP levels of 0.005 µg/L or higher. Most of the reported detections resulted from sampling required by the State's Unregulated Contaminate Monitoring Rule (UCMR) that was in effect from January 2001 through December 2003. The rule did not require that systems with fewer than 150 service connections perform the monitoring and systems that tested early in

the UCMR period used analytical techniques with detection limits significantly higher than the current detection limit of 0.005 µg/L. Of the 336 identified contaminated sources, approximately 186 are located within the TLB study area. Because the smallest water systems were exempt from the rule and some of the systems that did comply used methods with high detection limits, it is anticipated that many more sources are contaminated than have been identified. There also appears to be a clear pattern of contamination where rural water systems located in agricultural areas (predominately DACs) are at greater risk of contamination than urban water systems which tend to be larger and better funded.

CDPH anticipates releasing a draft MCL for TCP for public comment in 2014. Until then, utilities with contaminated sources face the challenges of not knowing what MCL they will need to comply with and not being provided with any guidance on best available treatment technologies (BATs) to remove TCP from the water. BATs are only identified when the MCL is established. Based on treatment research to date, only granular activated carbon (GAC) treatment will be feasible for TCP removal at most water systems. This regulatory uncertainty is of greatest concern for water systems that are currently faced with the need to treat for one or more other contaminants (e.g. arsenic). These utilities are being forced to take corrective action for one contaminant, often involving installation of treatment, knowing that they may need to modify their new treatment process within a few years to comply with the upcoming TCP regulation.

2.3.3 Hexavalent Chromium (Chromium-6)

There is currently no California or federal MCL for chromium-6. The State has developed a public health goal for chromium-6 of 0.02 µg/L and is in the process of developing an MCL. The public health goal is based on carcinogenic effects observed in animals. Chromium-6 occurs in drinking water as a result of both natural and anthropogenic sources. Many anthropogenic sources have been identified including the manufacture of metal plating, paint pigments, and wood preservatives and leaching from hazardous materials sites. It is likely that most of the chromium-6 found in TLB drinking water is from naturally occurring deposits.

Chromium-6 has been widely detected throughout the state. Approximately one-third of all drinking water wells monitored as part of the CDPH UCMR regulation had levels of chrome-6 in excess of the 1 µg/L detection limit. Most detections occurred in Los Angeles, San Bernardino, and Fresno Counties. Similarly to TCP, water systems smaller than 150 service connections were exempt from the UCMR chromium-6 monitoring. However, unlike TCP, agricultural activity is not expected to be a significant source of chromium-6 contamination and therefore, the UCMR monitoring results should better represent the chromium-6 occurrence and distribution of levels in DAC water systems. Table 2-3 summarizes CDPH monitoring results from 2000 through November 13, 2012. The table shows that the majority of detections were at levels below 5 µg/L and 86% of detections were at levels below 10 µg/L. Within the TLB study area, the highest level detected was 34.6 µg/L at the East Niles CSD in Kern County. In general, the TLB accounts for a large percentage of the overall number of detections,

but most detections were in the lower ranges with almost 90% falling into the 1 – 5 µg/L range.

Table 2-3 Chromium-6 Peak Detections in Drinking Water Sources (2000 – 2012)

Peak Level (µg/L)	No. of Sources	No. of TLB Sources
1 – 5	1,596	690
6 - 10	496	71
11 - 20	247	7
21 - 30	66	2
31 - 40	17	1
41 - 50	5	0
> 50	4	0

CDPH anticipates releasing a draft MCL for chromium-6 for public comment in July of 2013. The impact of this contaminant on TLB DAC water systems will depend on the final proposed MCL.

2.3.4 Other Future Regulations

The EPA and State of California are constantly evaluating existing MCLs and exploring the adoption of MCLs for currently unregulated chemicals. Any future MCLs would take over five years before promulgation and then several more years before compliance would be required.

3 WATER QUALITY DATABASE

The database used to evaluate DAC water quality issues contains limited numeric information about the water quality in the water systems listed. The information included in the database is consists primarily of simplified numeric data. It does not provide explanation or comment on the possible unique circumstances associated with the data. There are many details that are not included in the database that would be beneficial in further analyzing the water quality issues and potential solutions. These additional details are described in the following sections.

3.1 Water Systems with No Water Quality Data

The database contains water quality data for 211 of the 370 DAC systems that have water systems permitted by CDPH in the study area. Thus, there are 156 DAC systems that have no sample data in the database. For these 156 systems without water quality data, it is not possible to determine if there are water quality issues associated with the systems. The 156 systems have a total population of 59,958. These 156 systems make up 21.1% of the DAC population in the study area. It may be the case that some of these systems could be supplied water from a larger system on a contracted basis. The database does not indicate which systems are supplying water to other systems. Water systems that are not permitted by CDPH or by the local county health department, such as individual wells for single family homes, are not included in the database. The lack of data for individual, unregulated systems precludes the precise determination of the population of TLB DACs affected by MCL violations.

3.2 Details of the MCL Exceedances

The database currently only indicates that a water system has an MCL exceedance for the listed contaminant. There is no information regarding the magnitude of the MCL exceedance or the frequency of the exceedances. The database also does not provide information on wells that may have been abandoned or placed on standby for emergency use only because of MCL violations. Thus the database is not a good measure of the overall water quality issues faced by DAC communities.

The magnitude of exceedance may influence the choice of potential treatment technologies, as it may impact treatment system run times, chemical feed rates, volume of waste produced, and concentration of contaminants in the waste streams. These will all impact capital and O&M costs. If further details of the MCL exceedances cannot be obtained, certain assumptions would need to be made in order to evaluate capital and O&M costs.

3.3 Data Regarding Other Water Quality Parameters

The database contains no details of the general mineral or general physical characteristics of the water (e.g. pH, alkalinity, total dissolved solids, etc.); and contains no details of other contaminants other than those that violated an MCL. Violations of

Secondary standards are not documented. Certain natural water quality characteristics and contaminants cause interference with some treatment technologies. This may render some forms of treatment impractical. For example, silica, phosphate, and vanadium are known to interfere with the arsenic adsorption treatment process. Therefore, the use of adsorption for arsenic treatment for a system with elevated concentrations of silica, phosphate, and/or vanadium would not be recommended. The lack of other water quality parameters makes it difficult to determine whether a particular treatment system will be applicable to a specific water system.

3.4 No Water Production Information

The database does not contain any information regarding the volume of water produced and consumed at the listed water systems. Thus, it is impossible to reliably determine the size of a treatment system that may be needed to address a system's water quality issues. This, in turn, will affect the estimate of waste produced. These factors will affect any projected capital and O&M costs. Population data for each water system is included, and thus typical per capita water use within the TLB can be used to estimate water production. This type of estimate, however, would not account for large commercial, institutional or industrial water users, such as schools, parks and industry that may be present in the community.

3.5 Incomplete Treatment Plant Details

The database indicates the number of treatment plants in each water system and what contaminant is treated. For example, arsenic treatment or nitrate treatment. However, there is no information on the treatment process utilized.

3.6 Database Use

Because of the limitations discussed above, the primary use of the database is to statistically evaluate drinking water contamination issues in the TLB. The results are valid only for the period of time reviewed and thus may not accurately reflect current conditions. Accordingly, the primary value of the database search is to indicate the general occurrence of the problems faced by DACs, to identify the magnitude of the problems and general location and to identify the major contaminants.

Technical solutions for each water system must be developed with complete water system and water quality information. Each water source water quality is unique. Each water system is unique. There is no "standard" solution that will apply for each water system with a given contaminant issue.

4 BLENDING

Blending may be a viable option for some water systems not meeting drinking water standards if they have access to nearby better quality water sources. Simply stated, blending is combining and mixing poorer quality water with better quality water to meet drinking water standards. CDPH currently allows blending as a form of "treatment" to meet drinking water standards. Blending utilizes a second source of water that has sufficient volume and better water quality to dilute existing water source contaminants such that the combined water meets the drinking water standards. Blending is an attractive alternative because it has very low ongoing operations and maintenance costs relative to treatment.

For example, an existing well with a 200 gpm production may have a nitrate concentration of 60 mg/L, which exceeds the MCL for nitrate of 45 mg/L. A target blended nitrate concentration below the MCL of 45 mg/L would be established. For the purpose of this example, it is assumed that the target would be 36 mg/L, which is 80 percent of the MCL. In order to accomplish this, a new source of water with a nitrate concentration of 30 mg/L or less would need to produce 800 gpm to result in a blended concentration of 36 mg/L. Sometimes a community water system may have multiple wells with one or two that do not meet the MCL for a contaminant. If a method of blending and mixing can be developed, the contaminated well can be utilized to extend the water supply capacity.

Because most inorganic contaminants are non-reactive in water, the benefits of blending can be mathematically determined using the equation below:

$$[C]_b = \frac{([C]_1 * [Q]_1 + [C]_2 * [Q]_2)}{([Q]_1 + [Q]_2)}$$

Where,

$[C]_b$ = concentration of blended sources

$[C]_1$ = concentration in source 1

$[C]_2$ = concentration in source 2

$[Q]_1$ = flow from source 1

$[Q]_2$ = flow from source 2

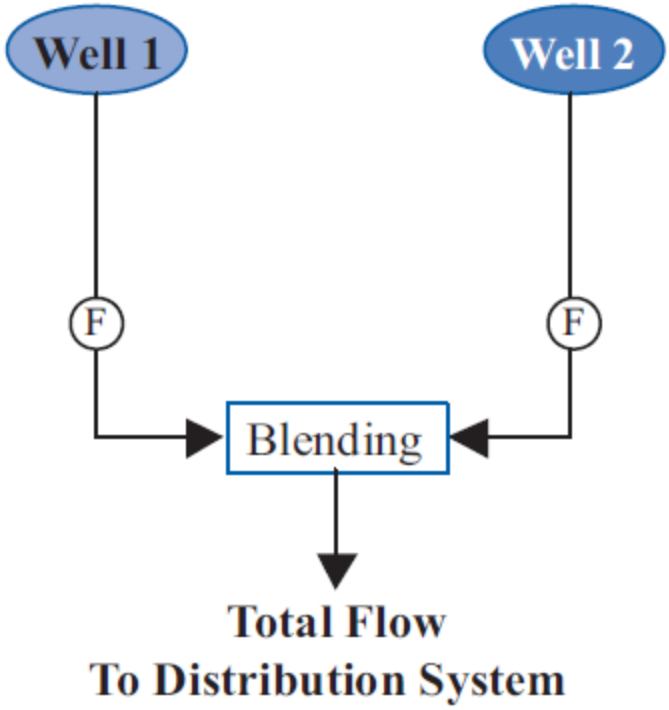
Finding a better quality source of water may not be a feasible option for all water systems since better quality ground water or surface water may not be available. Finding another source of ground water would involve knowledge of the existing aquifer and drilling test holes with associated water quality sampling. If a source of groundwater is found, the well would need to be developed and put into production.

A blending system requires that the two water sources be piped to a common location for mixing/blending before the water can enter the distribution system.

Blending requires that the flow from each source be metered and mixed in the correct proportion to meet the target blended concentration. A means of proportioning the flow must be devised to achieve the target blend concentration. This may include variable speed pumps and/or automatic proportioning valves. Normally, blending will use two water sources that have consistent water quality. Otherwise, the process may be unreliable and may need to utilize “real time” measurement of the constituent of concern. Real time monitoring will probably be required regardless of water quality stability when blending the acute contaminants nitrate or perchlorate. Blending may occur directly in a pipeline or a tank may be utilized. A plan for blending will require CDPH approval prior to implementation. A schematic conceptual diagram for a blending system is shown in Figure 1. A sampling program will be required to verify that the blended water meets the water quality standards.

The cost of a blending system will vary depending on factors such as distance between sources and the ability to utilize existing infrastructure. If an existing well, that is in compliance with water quality standards, and a contaminated well are nearby to each other and they have the right proportionate capacity, the costs may be quite low. If a new source (water well) must be developed and the distance is great, the costs can be very high. The initial capital costs for blending, in some cases, may exceed the costs of a treatment system; however, the lower long term O&M costs associated with blending will usually make blending a preferred option if it can be successfully implemented. Each proposed blending system will be unique and thus the cost for such a system must be individually estimated.

Figure 1 – Example Blending System



For the Figure above, it is assumed Well 1 is an existing well that does not meet water quality standards. The new well (Well 2) is of better quality and meets water quality standards. However, the flow from both wells is needed to meet peak demands. Water from the New Well (Well 2) and Well 1 will each enter the water blending tank. Each well line is equipped with a flow meter.

5 TREATMENT OPTIONS

5.1 Coliform

The presence of Coliform bacteria was the most commonly reported water quality contamination issue in the TLB. Depending on the cause, it may be one of the easiest and lowest cost contaminants to control, or it may be one of the most difficult. Coliform violations are an indicator that pathogenic bacteria or virus may be present. A Coliform violation is considered an acute contamination issue because it may immediately infect persons drinking or contacting the water. Coliform violations generally fall into one of the following categories:

1. Transient contamination resulting from a documented short term event in the water system (e.g. water main break, maintenance work, etc.). This will often involve total coliform detections without any fecal coliform or *E. coli* detected. Water at the source (e.g. well) may not be contaminated.
2. Chronic contamination of a well source caused by naturally occurring coliform in the soil around the well. This will usually manifest itself through frequent total coliform detections at the well and within the distribution system.
3. Chronic contamination of a well source caused by poor sanitary conditions at the wellhead and/or an ineffective sanitary seal around the well casing. This may involve the detection of fecal coliform and/or *E. coli*.
4. Bacterial re-growth within the distribution system of a surface water supplied system.

The first category of violations is preventable and typically easy to resolve. They can be prevented by implementing proper maintenance practices and by properly disinfecting distribution system components following maintenance or replacement. Resolution typically involves either permanently or temporarily chlorinating the water entering the distribution system.

The second category of contamination does not pose a threat to public health, but generates an MCL violation under the original TCR. Under the Revised TCR, total coliform detections will no longer automatically trigger an MCL exceedance. Under either rule, it can be anticipated that CDPH will require an investigation to confirm the origin of the contamination, and will likely require that disinfection (e.g. chlorine contact or UV) be added to the well.

The third category of contamination poses the greatest threat to public health and is the hardest to resolve. Some wells within DACs may not have been constructed to waterworks standards because they were originally constructed as agricultural wells or for other purposes other than producing drinking water. Common deficiencies are the absence of a sanitary seal and the top of the casing being located at, or slightly above the surrounding grade. The well may also be located in a floodplain. In either case, the well is at risk for surface water (e.g. storm runoff) contamination. It is often difficult and expensive to correct these deficiencies after the well has been constructed. The only

alternatives to improving the sanitary protection of the existing well are to construct a new well, or to treat the water.

The fourth category of contamination is caused by loss of chlorine residual in a distribution system supplied with treated surface water. Water distribution systems are not sterile, even if system wide chlorination is practiced. For example, build-up on pipe walls and sediment at the bottom of storage tanks shields bacteria from the effects of disinfection. If the chlorine residual in the water in the distribution drops too low, these bacteria can be re-introduced into the bulk water and trigger total coliform detections. The solution to this problem is to modify the systems procedures to prevent the loss of chlorine residual. Example solutions include increasing the chlorine dosage at the source, boosting the chlorine in the distribution system, cleaning storage tanks, and replacing old pipes.

Occasionally, a coliform exceedance may be caused due to improper sampling techniques. It is actually quite easy to fail a coliform test due to bad sampling practices if the sampler has not been trained in proper sample handling or if the sample collection tap is poorly designed. The possibility of contamination during sampling is one reason a coliform bacteria exceedance requires a re-test to confirm the exceedance. The presence of suspended particles in water, as measured by turbidity, greatly increases the probability of coliform contamination because the suspended materials may shield bacteria from direct contact with the disinfectant.

5.1.1 Chlorination

Depending on the cause of the coliform bacteria contamination, some combination of procedural changes, infrastructure improvements, and disinfection will be required to resolve the problem. Temporary or permanent disinfection using chlorine will be required in almost all cases.

Chlorination is the most common method of disinfection currently practiced in the United States. Injection of chlorine into water will result in the inactivation of a very high percentage of pathogenic organisms provided that there is an adequate dose and contact time. The combination of chlorine dose and contact time is commonly designated by the acronym “CT”, which represents the chlorine concentration in mg/L times the contact time in minutes. Chlorine gas and liquid sodium hypochlorite solution are the most common forms of chlorine used. Other forms of chlorine, such as chloramines or chlorine dioxide can also be used, but their use is far less common. The use of chlorine gas has reduced significantly in recent years because of safety issues related to potential accidental release of chlorine gas into the atmosphere. Sodium hypochlorite is now by far the most commonly used drinking water disinfectant chemical. Despite its popularity, sodium hypochlorite, particularly in its 12.5% concentrated form, is a difficult chemical to work with and injection systems can experience frequent failures if not properly designed and operated. Normally, a chlorine solution is injected at the well head for groundwater systems. In a surface water treatment plant, chlorine may be injected at multiple locations. Chlorine may also be injected within a water distribution system to boost the residual concentration, typically at water reservoirs (storage tanks) or at booster pumping stations.

Chlorine is added until a “free” chlorine residual is measured leaving a source. A free chlorine residual is reached when the addition of more chlorine results in a proportional increase in measured free chlorine. The presence of free chlorine residual indicates that enough chlorine has been added to satisfy the water’s chlorine “demand”. The initial demand is created by organic and inorganic constituents in the water which react with the chlorine. Examples of constituents that generate a chlorine demand include iron, manganese, TOC, ammonia and hydrogen sulfide. Free residual chlorine in the water supply is considered to be a safeguard against contamination that may subsequently occur in the distribution system or customer plumbing systems. Drinking water regulations require that treated surface water contain a minimum disinfectant residual of 0.2 mg/L throughout the distribution system. Groundwater systems do not always require disinfection; however, some systems have installed disinfection systems because of past coliform violations or as a preventative measure. CDPH will require mandatory disinfection of groundwater if there are frequent TCR violations.

Chlorine acts as an effective disinfectant only if it comes in direct contact with the organisms to be killed. Turbidity can prevent good contact and act to shield the pathogens.

Almost all water sources contain background natural organic matter (NOM). If NOM is present in the water, it is almost certain that the addition of chlorine will form disinfection by-products (DBPs), such as trihalomethanes (THMs) and haloacetic acids (HAA), which are regulated drinking water contaminants. Generally, the NOM present in groundwater is at relatively low levels and thus the formation of DBPs is not of significant concern. However, NOM is often present in surface water supplies at significantly higher levels and thus the formation of DBPs is often a concern. If DBP levels at the discharge of a surface water treatment plant are near their respective MCLs, a water supplier must consider the use of alternative disinfectants or must enhance the removal of NOM and/or DBPs in the treatment process. This is because DBPs (including THMs) will continue to form in the distribution system, so a concentration near the MCL at the plant discharge will likely lead to an exceedance in the distribution system where compliance is determined.

One way to mitigate the formation of DBPs is to use a form of combined (not free) chlorine called chloramines for residual disinfection in the distribution system. Chloramines are produced by adding chlorine and ammonia to water in a precise ratio. Chloramines do not produce DBPs as abundantly as free chlorine. However, chloramines are not effective at satisfying regulatory CT requirements within a surface water treatment plant and because they are less potent disinfectants and contain ammonia, which can result in biological nitrification within the distribution system. The use of chloramines as a residual disinfectant necessitates strict and labor intensive monitoring and maintenance of the distribution system if nitrification is to be avoided. An experienced operator is also required to assure that the correct ratio of ammonia and chlorine is maintained at the point of dosing. For these reasons, chloramination will typically not be a viable alternative for DAC systems.

5.1.2 Alternative Disinfection

There are alternatives for disinfection other than chlorination. Some of these alternatives include ultraviolet (UV) light, ozone and other chemicals such as bromine, iodine, and chlorine dioxide. Even though these alternative disinfection processes will reduce pathogens in the water at the treatment plant, they do not leave a residual in the water entering the distribution system. It is important to provide residual disinfection to help protect the distribution system from coliform contamination. Thus, chlorine (of some form) will be required to provide chlorine residual in the distribution system.

For most of the DACs included in this evaluation, UV disinfection systems are likely the only feasible alternative disinfection technique because it requires minimal operator interaction. Additionally, if several DACs group together to provide a centralized treatment system, the designer of this larger centralized treatment system may want to consider these alternate forms of disinfection.

5.1.3 Typical Chlorination System

A chlorination feed system, as might be utilized for typical water well in the TLB will include a sodium hypochlorite solution storage tank, a chemical feed pump and an injection quill. The injection quill injects chlorine solution directly into the discharge pipeline of the well pump. The chemical feed pump is wired to start and stop when the well pump starts and stops. Because the well water quality and pumping rate are relatively constant, there is no need for flow paced or compound loop chemical feed controls. For transient non-fecal coliform bacteria contamination, temporary or permanent disinfection of the distribution system using free chlorine residual will be required. In those cases, no CT requirement must be met. However, if the source is determined to be contaminated and CDPH mandates permanent disinfection treatment at the source, a CT requirement will be imposed and it is likely that not enough contact time will be provided in the distribution pipeline between the source and the first consumer to meet it. If that is the case, a chlorine contact tank or pipeline contactor will be needed.

A temporary chlorination system (without a contact tank) can be installed in an emergency situation in less than a day if a local supplier has the solution tank and pump in stock. Cost for a temporary system up to 1000 gpm well capacity would be approximately $2,500. A permanent disinfection system with additional contact time may cost up to $100,000.

5.2 Arsenic

Arsenic is the third most common contaminant with MCL exceedances in the TLB. However, arsenic affects the broadest base of systems in terms of population affected and number of connections affected. Arsenic is a naturally occurring contaminant that is ubiquitous in nature. The presence of arsenic that exceeds the MCL is almost exclusively a groundwater issue. Surface water sources treated in the TLB do not contain arsenic at levels greater than the MCL. Arsenic in groundwater is regional. Its

presence is much greater in west side and southern part of the San Joaquin Valley than in other areas. According to CDPH, Kern County has the highest number of active water sources with peak arsenic detections greater than the MCL. Its presence is more common in deep groundwater rather than shallow groundwater. However, the possibility of arsenic contamination exists for almost any well drilled in the TLB.

Depending on oxidation-reduction conditions in the groundwater aquifer, either arsenite (As +3) or arsenate (As +5) will be the predominant species of arsenic. Arsenate is the predominant species under aerobic conditions. Arsenite is the predominant species under anoxic conditions with pH greater than 8 S.U.. To remove arsenic from water the arsenic must be in the arsenate (As +5) state. In order to accomplish this, the pH must be lowered to below approximately 7.0 S.U. and the arsenite must be oxidized to convert most of the arsenic to arsenate. The oxidation can be accomplished by the addition of chlorine, potassium permanganate, hydrogen peroxide or aeration. After oxidation, the following treatment processes can be used to remove the arsenate from the water.

5.2.1 Arsenic Treatment Alternatives

Arsenic treatment alternatives include the following broad categories that are generally applicable in the TLB:

- Adsorption processes, including iron-based adsorbents and activated alumina;
- Iron Coagulation filtration (CF) or oxidation/filtration;
- Ion exchange (IX).

CF and adsorption are currently the most commonly applied technologies in the TLB. The selection of the best technology for a community requires a site specific engineering analysis that considers the size of the system, peak and average water production rates, water chemistry and presence/absence of other contaminants or interfering constituents, location, technical and managerial capability and other factors.

5.2.2 Adsorption

5.2.2.1 Activated Alumina

Activated alumina can be effective in removing arsenic and it can also be used for the removal of fluoride. It is not commonly used because of the operational complexity of regenerating the activated alumina. Regeneration requires multiple steps including pH reduction, backwashing and final pH adjustment. It is not recommended for DAC communities unless fluoride removal is also required. Iron Based and Other

The adsorptive media most commonly used for arsenic treatment are iron-based (e.g. iron oxide and granular ferric hydroxide), although titanium based materials are also commercially available. The primary advantage of iron based adsorption treatment over the other treatment technologies is simplicity of operation. The media is placed inside pressure vessel contactors and there are no moving parts associated with the

adsorption system. Backwashing of the media bed is usually only required infrequently and most currently used systems do not regenerate the media. When the arsenic levels leaving the treatment system approach the MCL, (breakthrough), the spent media is removed and replaced with new media. As with other arsenic treatment technologies, it is almost always necessary to add acid to depress the pH to approximately 7 and chlorinate the water prior to treatment. It may also be necessary to raise the pH back up after treatment in order to avoid corrosion problems in the distribution system. Several naturally occurring ions will interfere with this treatment process. The most common interfering constituents are silica, phosphate, and vanadium. High concentrations of interfering or competing constituents may significantly reduce the media life and may significantly affect the economic viability of the process.

Despite the relative simplicity of the process, there have been several documented failures involving adsorptive treatment plants not meeting performance predictions established during design. The media is expensive and DAC systems will likely struggle to pay for an unplanned media replacement that they have not budgeted for. This has resulted in increased scrutiny by regulatory and funding agencies whenever this process is proposed. It is highly recommended that a full pilot study be performed prior to constructing an adsorption treatment plant. Piloting this technology can be time consuming and expensive. A pilot study can take up to a year to perform. However, it is essential to determine the expected life of the media so that accurate operations costs can be determined.

5.2.3 Ion Exchange (IX)

For groundwater systems with TDS less than 500 mg/L and less than 150 mg/L sulfate, ion exchange (IX) for arsenic removal can be considered; however, implementation of IX treatment for arsenic removal is rarely the most cost effective alternative. In the IX process, water is passed through a 2.5 to 5 feet deep bed of chloride-form strong base anion exchange resin. The chloride on the resin is exchanged for the arsenic and the arsenic is retained within the resin. When the resin is exhausted, it is regenerated with a high strength chloride solution (brine) to remove the arsenic from the resin and reinstate the chloride. The regeneration waste stream will be high in arsenic and TDS/EC and will require off-site disposal.

High concentrations of arsenic have the potential to lead to short resin run times (the time until regeneration is required) and arsenic breakthrough. Arsenic breakthrough happens when the resin is not thoroughly regenerated and some of the arsenic not removed passes into the treated water stream. Arsenic breakthrough can also happen in the presence of particulate iron.

Sulfate affects the run length of the resins. Sulfate is exchanged with the resin preferentially over arsenic. Therefore, any sulfate in the water will take up capacity of the resin meaning the full resin capacity is not available to arsenic.

5.2.4 Iron Coagulation Filtration

The iron coagulation filtration (ICF) system uses iron, usually in the form of liquid ferric chloride, to co-precipitate arsenic. The arsenic is first oxidized to the arsenate (As+5) state, usually with chlorine addition. In the arsenate state, the arsenic will adsorb onto the iron hydroxide precipitates which are subsequently removed in a filtration process. Most arsenic treatment systems will utilize pressure filters; however, conventional gravity filters and membrane filters will work as well. Various media can be used in the granular filtration processes – typical media include silica sand, manganese greensand, anthracite and proprietary media. The effectiveness of the coagulation filtration system depends on the raw water quality, pretreatment chemicals used, and effectiveness of the backwashing of the filter media.

The filtration equipment used in the ICF process is identical to that of more conventional water treatment processes such as surface water treatment. As such, the filters must include a method for backwashing and rinse-to-waste with the associated backwash water handling system. Backwash intervals typically range from 6 to 12 hours. All ICF filtration processes will incorporate several open-close actuated valves in order to accommodate filter backwashing.

Because of the multiple chemical feed systems required (e.g. acid, sodium hypochlorite, ferric chloride, and potentially caustic) and the number of moving parts and active controls in the system, ICF treatment plants tend to be not cost effective for very small water sources (< 100 gpm).

ICF systems are especially applicable to larger water treatment systems, where multiple contaminants must be removed (e.g. manganese, iron, hydrogen sulfide, color in addition to arsenic) and where arsenic concentrations in the groundwater are high (greater than 20 to 25 µg/L). In these systems the use of adsorption or IX would lead to rapid exhaustion of the media or inefficient removal of co-contaminants. ICF is not affected by the presence of sulfate, high TDS and other water constituents to the same extent that they interfere with adsorption or IX.

The ICF process produces an iron/arsenic sludge from the filter backwash process. The filter backwash is usually captured in a tank where the sludge settles to the bottom. The clarified water higher up in the tank is recycled back to the treatment process leaving a more concentrated sludge. Depending on the amount of arsenic removed, and the solids concentration achieved, the sludge may be classified as hazardous waste. If the waste is not hazardous, it may be possible to discharge to a sewer, if available. Otherwise it will need to be thickened and possibly dewatered and disposed at an off-site facility. There are a limited number of sites that can accept arsenic sludge as a hazardous waste. Disposal of the arsenic sludge is a major cost factor in the selection of this treatment process.

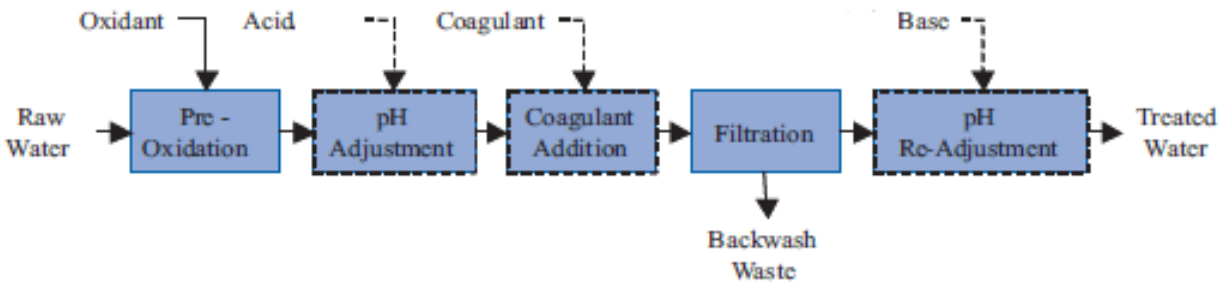
An ICF arsenic water treatment plant requires a relatively high skill level for effective operation. In theory, the system should be capable of operating automatically and unattended most of the time. However, in practice, many of these systems require more frequent operator intervention in order to operate efficiently and reliably. The installation of a treatment system will require an operator with at least a T2 or T3

license. Most simple water systems that use only chlorine for routine disinfection require only a T1 licensed operator.

A typical flow diagram for an ICF system is shown in Figure 2. The capital cost (equipment only) is in the range of $0.50 to $1.00 per gallon per day of capacity. The actual construction costs will be 3 to 4 times the equipment costs. Operating costs are between $500 and $700 per million gallons treated.

There are several ICF systems of various capacities currently operating in the TLB.

Figure 2 – Coagulation Filtration Flow Diagram



5.3 Nitrate

The treatment of water for nitrate removal in the Central Valley has been extremely challenging and has been rarely done. The most commonly available nitrate removal treatment technology, ion exchange (IX), generates a significant volume of concentrated "brine" waste that is difficult to dispose. The lack of an environmentally sound and economical means of disposing brine waste has been a major impediment to use of IX for nitrate removal. Reverse osmosis (RO) can also be used for nitrate removal and may be an advantageous means of treatment if there are other ionic contaminants in the water or there is a high total dissolved solids (TDS) level. RO produces a concentrate side stream of high TDS water that, like brine, is difficult to dispose in an economical and environmentally sound manner. Because the Tulare Lake Basin is an enclosed basin, with no outlet to the ocean, increased mineralization of groundwater is a major, basin wide water quality concern. The RWQCB has adopted a water quality plan (Basin Plan) that essentially prevents the discharge of salts, brine, and concentrates in the TLB. Some communities in southern California have constructed "brine" sewer outfalls that carry mineralized, salty water to wastewater treatment plants that discharge to ocean outfalls. These brine outfalls provide an environmentally safe and economic means of disposing waste streams from nitrate treatment plants. Consequently, whereas IX or RO for nitrate remove is rare or absent in the TLB, it is more common in southern California.

Within the TLB, when there are nitrate contamination issues in the water supply, it has been more practical to abandon wells and locate another source, than to treat and handle the waste. Recently, multiple suppliers have proposed and are testing the use of biological nitrate removal treatment processes. These treatment technologies

promise to resolve the brine and concentrate waste disposal issues by utilizing microorganisms to metabolize the nitrate to nitrogen gas. These technologies have experienced some early success, yet one of the major remaining questions is how reliable the processes are going to be, especially in a DAC setting where constant oversight of the treatment process is not practical. Biological nitrate removal processes are currently under review by CDPH.

Unlike the other contaminants discussed in this study, it is questionable whether there is a current, CDPH approved, viable technology for nitrate removal treatment suitable for the DACs impacted by this contaminant.

5.3.1 Ion Exchange (IX)

Ion exchange (IX) for nitrate treatment is currently the simplest and lowest-cost method for removing nitrate from groundwater. The process is mature, well developed and can provide consistent, reliable low nitrate water. As discussed above, the major impediment to its use is disposal of brine utilized to regenerate the IX resins.

The nitrate removal IX process consists of vessel(s) containing resins formulated specifically for nitrate removal. Water flows through the vessel and exchanges a negatively charged chloride ion for a negatively charged nitrate ion on the resin surface. Chloride-form strong-base anion exchange resins are used for nitrate removal. The resins are housed in pressure vessels. The pressure vessels sizing and number of vessels will vary depending on the flow rate to be treated. When the resin is nearly exhausted (no further capacity to exchange nitrates), it will be regenerated with a concentrated brine (sodium chloride) solution.

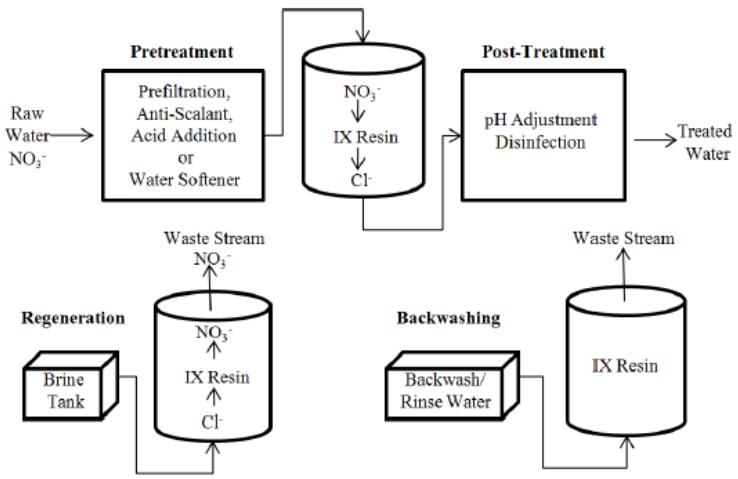
The resins used for nitrate treatment also remove other negatively charged ions. The general affinity of standard anion exchange resins is, in order of greatest to least affinity: perchlorate, sulfate, arsenate, nitrate, chloride, and bicarbonate. Therefore the sulfate (and perchlorate if present) content in the raw water will influence the volume of water that can be treated prior to nitrate breakthrough. For waters with high sulfate levels, nitrate selective ion exchange resins are available. The nitrate selective resins have the following order of ion affinity: nitrate, sulfate, arsenate, chloride, and bicarbonate.

The nitrate and salt-laden regeneration waste cannot be disposed of into useable groundwater or surface waters, including irrigation ditches, because the high salt and nitrate content would impair the beneficial uses of the receiving water. The disposal of these wastes would require an NPDES permit or issuance of Waste Discharge Requirements from the Regional Water Quality Control Board. The high concentration of salts will preclude the issuance of these permits in the TLB. It may, however, be possible to dispose of this type of waste through deep well injection into a deep saltwater zone.

A typical flow diagram for a nitrate ion exchange system (from the Drinking Water Treatment for Nitrate as submitted to the California Legislature aka the “Harter Report”) is shown in Figure 2. The construction costs (equipment and site improvements) will be between $0.30 and $1.21/1000 gallons capacity. Operating costs are between $460 and $4,650 per million gallons treated.

The McFarland Mutual Water Company in the City of McFarland constructed an IX nitrate removal system in the 1990's. Its use was soon abandoned because of brine disposal issues. There are no known IX treatment plants for nitrate removal currently operating in the TLB.

Figure 3 – Nitrate Ion Exchange Flow Diagram



5.3.2 Biological Denitrification – Emerging Technology

Biological denitrification exploits the ability of certain naturally-occurring bacteria to metabolically convert nitrate to inert nitrogen gas under anoxic conditions (absence of oxygen). Biological denitrification uses an organic carbon substrate, such as methanol, ethanol or acetic acid, as an electron receptor for the reaction. The carbon dosed water passes to the denitrification reactor where reduction of nitrate occurs. Microbes utilize the nitrate as a respiratory electron acceptor in the oxidation of the organic carbon substrate. Some biological denitrification systems in development may also have the potential to remove other contaminants, such as perchlorate, DBCP, 1,2,3-TCP, PCE, and chromium-6. As discussed previously, biological denitrification does not produce brine, concentrate or concentrated nitrate as a waste product nor does it significantly affect the total dissolved solids (TDS) or electrical conductivity (EC) of the treated water. The denitrification process results in the reduction of nitrate to nitrogen gas, which is degassed from the water and discharged to the atmosphere. The only waste products from biological denitrification are from filter backwashing and biological solids wasting. These waste streams can be disposed in an environmentally sound manner in the TLB.

Biological denitrification is an emerging technology and several process designs are currently being evaluated. The process is not currently approved by CDPH, but it is actively undergoing development and pilot testing. Most reactors fall into one of three categories: 1) fixed bed; 2) fluidized bed; and 3) membrane bioreactor. All reactors have to incorporate a means of cleaning the filter or support medium to remove excess biomass. Because organic carbon is added to the water, dissolved oxygen is reduced,

and the growth of bacteria is enhanced, significant post-treatment is required. Typically this involves re-aeration followed by filtration or alternatively aerated filters can be used.

The main concerns with biological denitrification are the potential for contamination of the treated water with bacteria, residual organic carbon in the treated water and the possibility of nitrite formation as a byproduct of incomplete treatment. Post treatment with clarification and/or filtration is necessary to remove any bacteria carried-over from the biological process. The presence of carbon sources, such as methanol, may also be considered undesirable on health grounds. Biological denitrification processes require a long start up period of up to six weeks in order for the biomass to establish itself. However, once initial start-up is complete and the de-nitrifying bacteria are well established, the developers of these processes claim that the systems can operate intermittently. A high degree of monitoring and control is required to ensure proper operation of the process. The economics of biological denitrification is dominated by the cost of the carbon source (methanol, ethanol or acetic acid). As with any biological treatment system, the process is dependent on a continuous and reliable “food” (carbon) source.

The primary advantage of this system in the TLB over other processes such IX or RO is the complete absence of a brine or concentrate waste stream. There are currently no environmentally acceptable or economical acceptable means of brine or concentrate disposal in the TLB. Biological denitrification offers the possibility of using a process that produces only a biological waste solids stream, which can be permitted in the TLB.

5.4 Disinfection Byproducts (DBPs)

Disinfection byproducts are formed when organic material in water is exposed to chlorine or other disinfectants. Organic material is normally present at higher concentrations in surface water systems than groundwater systems. For water systems that use only chlorine for disinfection, as most DACs do, two classes of disinfection byproducts are typically formed: 1) trihalomethanes (THMs) and 2) haloacetic acids (HAA). Total trihalomethanes (TTHM) and a total of five haloacetic acids (HAA5) are regulated with MCLs of 80 µg/L and 60 µg/L, respectively. The communities that had TTHM exceedances were surface water systems or were combined ground and surface water systems.

Technical enhancements intended to reduce the formation of DBPs generally fall into four categories:

1. Changing sources or improving source water quality;
2. Enhancing the removal of background naturally occurring organic matter (NOM), also known as DBP precursors, prior to disinfection;
3. Changing disinfection practices to reduce the rate at which DBPs are formed; and,
4. Removing DBPs after they have formed.

It is almost always more efficient and cost effective to implement the first three strategies than the fourth.

5.4.1 High-Pressure Membranes (Reverse Osmosis)

High pressure, high rejection ("tight") membranes, such as nano-filtration or reverse osmosis (RO) membranes, are highly effective at removing organic material that can react with chlorine to form THMs and HAAs. RO is also effective at removing THMs and HAAs after they have formed, however it is rarely cost effective to do so.

Membrane systems require extensive pretreatment to prevent fouling by particulate matter, scaling or biofouling. High pressure membrane systems use differential pressures significantly greater than those typically used in surface water treatment to force water through a membrane and therefore tend to be very energy intensive. The retained solids are concentrated in a reject or waste stream that is discharged from the membrane system.

Membranes must be backwashed periodically to dislodge particles that have accumulated on the membrane surface. The backwash water, which will be high in contaminants, will need to be disposed of appropriately. The membranes will require chemical cleaning to reduce membrane fouling.

Due to the complexity and capital/O&M costs associated with membrane treatment, it is only feasible for larger communities treating at least one million gallons per day.

5.4.2 GAC

Granular Activated Carbon (GAC) contactors can be used to treat water that has been previously filtered or supplied directly from a well water source. The GAC acts as both an adsorbent and as a filtering medium. The decision to use GAC should be based on a study to determine the time until the constituent(s) reaches "break though" (the point at which the constituent exceeds the targeted removal when it exits the GAC filter). Breakthrough time, also known as time to exhaustion of the media, will determine the economics of the system. When the GAC is exhausted, it must be replaced or regenerated. The effective life of GAC can be anywhere between a few months and three years depending not only of the concentration of organic material but on other substances that may be also be adsorbed.

GAC filters must be backwashed periodically for effective filtration and adsorption. If the filters are not adequately cleaned, both filtration and adsorption capacity will be lost, and mud balls will begin to form. This backwash water must be disposed of properly.

5.4.3 Enhanced Coagulation Filtration

Filtration is used to remove turbidity and organic matter. The more effective the process is in removing organic matter, the lower the concentration of DBPs produced. Filtration may occur in conventional gravity filters or in pressure filters. Gravity multimedia filtration is considered conventional treatment. Conventional treatment includes coagulation, rapid mixing, flocculation, and sedimentation, followed by filtration. With

pressure filters, direct filtration is often utilized, which skips the sedimentation step. Enhanced coagulation/filtration is often utilized in surface water treatment plants.

The filter media can consist of graded sand, anthracite coal and/or GAC, or a combination of the three media. Multi-media filtration usually consists of graded sand and anthracite. Depending on the raw water quality and chemicals added before filtration, organic matter that may form DBPs can be removed using conventional treatment. The filters require backwashing periodically to maintain contaminant removal capacity of the media. Conventional treatment requires significant operator attention to ensure all processes are operating correctly. Conventional treatment is normally feasible for plants of one million gallons per day or larger. Pressure filtration is often used in smaller capacity treatment plants.

5.4.4 Alternative disinfection

Since chlorine used for disinfection can lead to DBP formation, alternative disinfection process can be used that produce fewer DBPs. The most common alternative disinfection processes include ultraviolet (UV) radiation, ozonation, and chloramination. Even with an alternative disinfection process, some chlorine addition is generally required to provide a chlorine residual in the distribution system.

For UV disinfection to work properly, the turbidity of the water should be less than 1 NTU. Natural organic matter (NOM), hardness, and other minerals can foul UV lamps causing a decrease in UV effectiveness. Dissolved inorganic constituents, such as iron, can precipitate on the lamps and decrease performance. The capital cost of UV systems makes them feasible for plants treating more than one million gallons per day.

Ozone must be generated on-site as it is needed because it cannot be stored. Ozone is generated by passing an electrical current through air or pure oxygen. Ozone is commonly dispersed into water using a fine bubble diffuser. There must also be a system to collect ozone off-gas. Ozone generating installations must include a thermal or catalytic ozone destroyer. Ozone is so highly corrosive that only certain materials can be used in constructing treatment plant equipment. Ozone can also be effective in the treatment of hydrogen sulfide and other contaminants that produce taste and odor problems. It is commonly used in Europe but it is not widely utilized in the United States.

Chloramination is a disinfection process that utilizes a mixture of chlorine and ammonia to produce chloramines. The ammonia reacts with chlorine thus eliminating free residual chlorine and making the free chlorine unavailable to further react with organic matter. Chloramines are less effective than free residual chlorine in disinfection; however they form fewer DBPs. In most water systems that use chloramines as the principal disinfectant, the ammonia is added at a point downstream from the initial chlorine application so that microorganisms, including viruses, will be exposed to free chlorine for a short period before chloramines are formed. Chloramination must be carefully controlled and monitored to prevent nitrification in the distribution system,

5.5 Uranium

5.5.1 Adsorption

There is a vendor (WRT) that manufactures an adsorptive media designed specifically to remove uranium from drinking water. The process removes uranium by passing the water through a fluidized bed of a proprietary adsorptive media in a pressure vessel. This system is unique in that the treatment system supplier enters into a contract with the water agency to dispose of the low level naturally occurring radioactive material (NORM) waste generated by the process. Because WRT is the only supplier that has the necessary licenses to handle the NORM disposal, this system is currently the only adsorptive system approved by the California Department of Public Health.

5.5.2 Ion Exchange (IX)

The most stable state of uranium in groundwater is as UO_2^{2+}, which forms soluble complexes with carbonate, CO_3^{2-}. Under neutral and slightly alkaline conditions, UO_2^{2+}, combines with bicarbonate and carbonate anions to form uranyl carbonates which have a strong affinity for ion exchange resins. Strong base anion (SBA) exchange resins have been shown to have the most capacity for uranyl carbonates. Similar to arsenic removal using IX, the uranium is exchanged for chloride. Typical run lengths for uranium IX are in the range of 30,000 to 50,000 bed volumes. Ion exchange for uranium removal works within a pH range of 6 to 8 SU (Standard Unit). However there is a substantial decrease in the resins capacity for uranium at pH's below 7. Additionally, the concentrations of sulfates and chlorides in the water will affect the capacity of the resin.

When the resins are regenerated, the waste water will contain elevated levels of uranium that may make it difficult to dispose of the waste water.

5.5.3 RO Membranes

RO membranes can be used to remove uranium from water. Typically, a cartridge filter precedes the high pressure pump needed to pump to the RO membranes. Additionally there would be systems for scale inhibitor and the cleaning/flushing system. Typical concentrate reject for an RO system can range from 20 to 50 percent of the feed water. The high RO reject rates cause's two potentially significant problems. The first is that the water source must be capable of supplying up to twice the amount of water needed by the system. The second problem is waste disposal. The concentrate reject will be high in contaminants and salinity and may not be able to be discharged to a wastewater treatment plant. This may mean large evaporative ponds or deep-well injection will be needed to dispose of the reject. In areas with limited groundwater availability, other treatment processes that do not waste as much water may need to be considered, even if those processes are more expensive.

5.6 Fluoride

There are no systems in the TLB that have fluoride as the only MCL exceedance. There are several systems that have fluoride with other contaminant exceedances; at least 3 in Kern County violated the State MCL of 2.0 mg/L. The federal standard for fluoride is 4.0 mg/L. CDPH can allow a variance in the fluoride standard following a procedure that requires public notification and approval.

5.6.1 Adsorption – Activated Alumina

Activated alumina, an inorganic adsorbent, is an excellent medium for fluoride removal. Alumina is superior to any synthetic anion-exchange resin because fluoride has a higher ion affinity with alumina, whereas with resins, fluoride is the least preferred of the common anions.

The pH of the raw water must be adjusted to between 5.5 and 6.0 and then passed through the activated alumina bed. Following exhaustion, the medium is backwashed and then subjected to a two-step regeneration with base followed by acid. The spent-regenerant brines are normally neutralized and sent to a lined evaporation pond for interim disposal. The ultimate disposal of high-fluoride salt residues is a problem that still remains unsolved.

5.7 DBCP

5.7.1 GAC

The cities of Fresno and Clovis have used GAC for wellhead treatment of DBCP. Granular Activated Carbon (GAC) contactors can be used to treat water that has been previously filtered or directly from a water source. GAC can be used for any sized system. The GAC vessels can range from units that serve a single building or home up to units to serve a large city. The GAC acts as both an absorbent and a filtering medium. The decision to use GAC will depend on a study of how long the adsorption qualities of the GAC will last, how much it will cost to remove exhausted material, and how much it will cost to have the old material either reactivated or replaced with new material. The effective life of GAC can be anywhere between a few months and three years depending not only of the concentration of DBCP but on other substances that may be removed too.

The GAC filters must be backwashed periodically for effective filtration and adsorption. If the filters are not adequately cleaned, both filtration and adsorption capacity will be lost, and mud balls will begin to form. This backwash water must be disposed of properly since it will contain elevated levels of DBCP.

5.8 Perchlorate

5.8.1 Ion Exchange (IX)

Perchlorate has a very high affinity for the common polystyrene SBA resins. Perchlorate exchange is similar to nitrate removal by ion exchange, except that perchlorate has a much higher affinity for resins than nitrate.

5.8.2 GAC

GAC can be used for perchlorate removal similar to DBCP removal.

5.9 PCB

There are no identified systems in the TLB area that have PCB only as a contaminant. However, there are several systems have PCB in combination with other contaminants.

5.9.1 GAC

GAC can be used for PCB removal similar to DBCP removal. However, if there is turbidity in the water, pre- and post-filtration may be needed around the GAC units. PCB's will attach to colloidal material or carbon fines and pass through the carbon bed without being adsorbed.

6 SUMMARY OF TREATMENT TECHNOLOGIES EVALUATIONS

Table 6-1 summarizes some of the pros and cons of the treatment technologies discussed above.

Table 6-1: Summary of Treatment Technologies

Treatment Technology	Pros	Cons
Chlorination	Inexpensive, simple, common	May form DBPs if organics are present. Safety of handling. Adds to mineralization of water.
Adsorption	Easy to operate	Non-selective; often requires pH adjustment for optimum performance
		Difficult to predict performance and time to exhaustion
		Requires replacement or regeneration of media. Disposal of media may be issue for some contaminants.
		De-sorption possible
Ion Exchange (IX)	Well established technology	Other contaminants can foul or compete for adsorption
	Effective for nitrate and hardness removal	Moderately complex to operate; requires regular regeneration
		Chromatographic peaking / dumping
		Brine disposal is a major issues
Coagulation Filtration (CF)	Cost effective for larger systems	High operator involvement; requires regular backwashing
	Effective and proven technology	High O&M costs
		Disposal of backwash water and solids

Treatment Technology	Pros	Cons
Membranes (RO, NF or MF)	Effective at removing multiple contaminants	Other contaminants can foul, interfere, or require pretreatment
	Removes TDS and is effective at removing many secondary contaminants	High capital cost; High operator involvement
		For RO and NF, low water recovery (high reject flow)
		High O&M costs
		Concentrate disposal (RO and NF)
GAC	Easy to operate	Moderate capital cost
	Effective at removing a wide range of organics	Challenges with GAC regeneration. Virgin replacement GAC most commonly used.
	Does not add to mineralization of water	Nitrate dumping
Gravity multimedia filtration	Effective and proven technology	High capital cost
		High operator involvement
		Backwash and solids handling
Alternate Disinfectants	Reduced DBP formation	More costly than chlorine; some have no residual disinfection capability
		Complexity; potential for nitrification with chloramines
		O&M Costs potentially higher
Biological Denitrification	Ability to discharge/dispose backwash and solids in TLB; no brine or concentrate issues	Unproven technology that has not yet been approved by CDPH; Requires supply of carbon based feed stock; uncertain performance in intermittent operation; high cost of carbon source

6.1 Combinations of Treatment for Multiple Contaminants

Table 6-2 shows the contaminants and contaminant combinations present in the Tulare Lake Basin sorted by number of connections.

Table 6-3 shows the treatment possibilities for the various contaminant combinations present in the Tulare Lake Basin. The preferred treatment process is shown with parentheses.

Figure A1, in Appendix A, shows a flow chart to evaluate the possible technical solutions that may be applicable to a particular community.

Table 6-2: Contaminant Combinations

Water System Size	Coliform	Arsenic	Nitrate	THM (SW)	Uranium	Fluoride	DBCP	Perchlorate	PCB
Less than 15 connections			4	4					
15 to 50 connections	17	2	1	7				2	
51 to 200 connections	11	1	2	3					
201 to 500 connections	3	4		1	1				
501 to 2000 connections	2	4	2						
More than 2000 connections		2					1		
Total	**33**	**13**	**9**	**15**	**1**	**0**	**1**	**2**	**0**

Water System Size	Coliform and Arsenic	Coliform and Nitrate	Arsenic and Uranium	Coliform and Uranium	Nitrate and Uranium	Coliform and THM	Nitrate and DBCP	Coliform and PCB	Uranium and Fluoride
Less than 15 connections		1							
15 to 50 connections	1	4	2	2				1	
51 to 200 connections		5	2		1		1		
201 to 500 connections	1		1				0	1	1
501 to 2000 connections	2		3			1	1		
More than 2000 connections	1		1						
Total	**5**	**10**	**9**	**2**	**1**	**1**	**2**	**2**	**1**

Water System Size	THM, Nitrate & Perchlorate	Arsenic, Fluoride & Uranium	Coliform, Arsenic & Uranium	Coliform, Nitrate & Arsenic	Coliform, Nitrate & Uranium	Coliform, Nitrate & DBCP	Coliform & Arsenic & Perchlorate	Coliform & Nitrate & Perchlorate	Arsenic, Nitrate, Uranium & Fluoride
Less than 15 connections									
15 to 50 connections	1		1		1				
51 to 200 connections									
201 to 500 connections		1				1			1
501 to 2000 connections								1	1
More than 2000 connections				1			1		
Total	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**2**

Table 6-3: Treatment Possibilities

Connections	Coliform	Arsenic	Nitrate	THM (SW)	Uranium	Fluoride	DBCP	Perchlorate	PCB
Less than 15 connections	----------	----------	(3)	5,(6,7),8	----------	----------	---------	----------	-------
15 to 50 connections	(1), 8	(2),3,5	(3)	5,(6,7),8	----------	----------	---------	3,(6)	-------
51 to 200 connections	(1), 8	(2),3,5	(3)	5,(6,7),8	----------	----------	---------	----------	-------
201 to 500 connections	(1), 8	2,3,(4),5	----------	5,(6,7),8	(2),3	----------	---------	----------	-------
501 to 2000 connections	(1), 8	2,3,(4),5	(3),5	----------	----------	----------	---------	----------	-------
More than 2000 connections	----------	2,3,(4),5	----------	----------	----------	----------	(6)	----------	-------

Connections	Coliform & Arsenic	Coliform & Nitrate	Arsenic & Uranium	Coliform & Uranium	Nitrate & Uranium	Coliform & THM	Nitrate & DBCP	Coliform & PCB	Uranium & Fluoride
Less than 15 connections	----------	(1), 8 and (3)	----------	----------	----------	----------	----------	----------	----------
15 to 50 connections	(1),8 and (2),3,5	(1), 8 and (3)	(2) / 3 / 5	(1),8 and (2),3	----------	----------	----------	(1),8 and (6)	----------
51 to 200 connections	----------	(1),8 and (3)	(2) / 3 / 5	----------	3 / (2 and 3)	----------	(3 and 6)	----------	----------
201 to 500 connections	(4 only) / 1,8 and 2,3,4,5	----------	(2) / 3 / 5	----------	----------	----------	----------	(1),8 and (6)	(2),3
501 to 2000 connections	(4 only) / 1,8 and 2,3,4,5	----------	2,3 / (2),3 and (4)	----------	----------	8 / 5,(6,7 and 1)	(3)/5 and (6)	----------	----------
More than 2000 connections	(4 only) / 1,8 and 2,3,4,5	----------	2,3 / (2),3 and (4)	----------	----------	----------	----------	----------	----------

Connections	THM, Nitrate & Perchlorate	Arsenic, Fluoride & Uranium	Coliform, Arsenic & Uranium	Coliform, Arsenic & Nitrate	Coliform, Nitrate & Uranium	Coliform, Nitrate & DBCP	Coliform, Arsenic & Perchlorate	Coliform, Nitrate & Perchlorate	Arsenic, Nitrate, Uranium & Fluoride
Less than 15 connections	----------	----------	----------	----------	----------	----------	----------	----------	----------
15 to 50 connections	(3, 6)	----------	(1),8 and (2) or 3 or 5	----------	1,8 and 3/(1),8 and (2 and 3)	----------	----------	----------	----------
51 to 200 connections	----------	----------	----------	----------	----------	----------	----------	----------	----------
201 to 500 connections	----------	(2) / 2 and 3 / 2 and 3 and 5	----------	----------	----------	(1), 8 and (3, 6)	----------	----------	(3) / 3 and 2 and 5
501 to 2000 connections	----------	----------	----------	----------	----------	----------	----------	(1 and 3 and 6)	(3) / 3 and 2 and 5
More than 2000 connections	----------	----------	----------	(1),8 and (3),5	----------	----------	(1) and 3,(6) and 2,3,(4),5	----------	----------

1 = chlorination (gas or liquid)
2 = adsorption
3 = ion exchange
4 = coagulation filtration
5 = membrane
6 = GAC
7 = gravity multimedia filtration
8 = alternative disinfection (amines, UV, ozone)
( ) = generally preferred treatment system

7 EXISTING TREATMENT SYSTEMS IN STUDY AREA

Of the 117 systems with MCL exceedances, 34 employ some form of technical solution to their water quality. These technical solutions and the numbers employing that solution are:

- Chlorine only – 19
- Blending – 4
- Coagulation filtrations for iron/manganese – 2
- Coagulation filtration for arsenic – 2
- Granular activated carbon – 2
- Treatment listed with no additional details – 2
- Treatment systems for nitrate and perchlorate – 2

Table 7-1 shows the existing treatment systems by contaminant in the study area. It should be noted that the existing treatment system may not be applicable to treat the pollutant(s) that caused an exceedance. For example, 8 out of 9 systems with arsenic and uranium have chlorine for treatment. Chlorine, by itself, will not remove arsenic and uranium.

Twenty of the 117 systems are currently under compliance orders either from CDPH or the EPA. A compliance order means the system has been given a deadline to show compliance with the water quality standards or else face increased enforcement actions or fines. Details of those systems with compliance orders are shown in Table 7-2.

Some of these systems are currently receiving funding from the state to explore options for addressing their particular water quality issues. Of the 117 systems that recorded at least one exceedance, 43 currently have some sort of state funding (SRF, Prop 84 and/or Prop 50). Not counting those systems that had coliform only exceedances, 40 systems out of 84 systems (47.6%) have funding. Those systems that have funding are already exploring alternatives to achieve compliance. Based on Table 7-2, 44 systems of those 84 (52.4%) systems (not counting coliform only exceedances) do not have funding at this time. The most systems that indicate no funding in place have exceedances for TTHM (14 systems), arsenic and uranium (8 systems), and nitrate (5 systems).

Table 7-1: Existing Treatment in Study Area

Pollutant	# of systems	# having treatment	Existing Treatment
Coliform	33	0	
Arsenic	13	1	Blending
		3	Chlorine only
		1	Coagulation filtration for iron/manganese
		1	Coagulation filtration for arsenic
		1	Ion exchange for arsenic. Greensand for iron/manganese
Nitrate	9	1	Blending
		1	Chlorine only
		2	Treatment listed (?)
THM	15	0	
Uranium	1	0	
DCBP	1	0	
Perchlorate	2	2	Treatment listed for nitrate and perchlorate
Coliform and arsenic	5	1	Arsenic treatment
		1	Chlorine only
Coliform and nitrate	10	1	Chlorine only
Arsenic and uranium	9	8	Chlorine only
Coliform and uranium	2	0	
Nitrate and uranium	1	1	Chlorine only. Uranium in active well. Nitrate in standby well.
Coliform and THM	1	1	Chlorine only
Nitrate and DBCP	2	2	Chlorine only
Coliform and PCB	2	0	
Uranium and fluoride	1	0	
THM & nitrate & perchlorate	1	0	
Arsenic & fluoride & uranium	1	1	Ion exchange, activated alumina, greensand
Coliform & arsenic & uranium	1	0	
Coliform & nitrate & arsenic	1	1	GAC for benzene
Coliform & nitrate & uranium	1	0	
Coliform & nitrate & DBCP	1	1	GAC
Coliform & arsenic & perchlorate	1	1	Chlorine only
Coliform & nitrate & perchlorate	1	0	
Arsenic & nitrate & uranium & fluoride	2	1	Reverse osmosis and blending
		1	Blending and uranium and fluoride. Coagulation filtration for iron/manganese
TOTALS	117	34	

Table 7-2: Systems with Compliance Orders and Funding

Pollutant	# of systems	# with orders	Compliance Order	Funding
Coliform	33	0		3
Arsenic	13	7	for arsenic	10
Nitrate	9	1	for nitrate	4
THM	15	1	for THM	1
Uranium	1	0		1
DCBP	1	0		0
Perchlorate	2	0		0
Coliform and arsenic	5	3	for arsenic	5
Coliform and nitrate	10	2	for nitrate	9
Arsenic and uranium	9	1	for nitrate and uranium. Will consolidate.	1
Coliform and uranium	2	1	for uranium	1
Nitrate and uranium	1	1	for nitrate and uranium	1
Coliform and THM	1	1	for THM	0
Nitrate and DBCP	2	2	for nitrate and DBCP	2
Coliform and PCB	2	0		0
Uranium and fluoride	1	1	for fluoride	1
THM & nitrate & perchlorate	1	1	for THM, nitrate, and perchlorate	0
Arsenic & fluoride & uranium	1	0		0
Coliform & arsenic & uranium	1	1	for arsenic and uranium. Will consolidate.	1
Coliform & nitrate & arsenic	1	1	for arsenic and nitrate	1
Coliform & nitrate & uranium	1	0		1
Coliform & nitrate & DBCP	1	0		0
Coliform & arsenic & perchlorate	1	1	for arsenic	1
Coliform & nitrate & perchlorate	1	1	for nitrate	0
Arsenic & nitrate & uranium & fluoride	2	0		0
TOTALS	117	26		43

8 EVALUATION OF POTENTIAL TECHNICAL SOLUTIONS

8.1 General

Technical solutions are often the last alternative considered for compliance with drinking water standards because they may require significant capital investment and a long-term commitment to operate and maintain constructed facilities. There are no water quality contaminant issues in the TLB that cannot be resolved with the implementation of the right technical solution. However, technical solutions are not always cost-effective or sustainable by the communities. It takes significant technical, managerial and financial capability to implement and successfully operate a treatment system. Not all DAC water systems have this capability.

All water systems are unique and will require individual engineering and financial analysis to arrive at the best solution for drinking water quality compliance. There is no "cookbook" with a "recipe" to follow to select a technical solution. The following sections describe some of the technical and non technical issues that must be considered when developing a solution to a water quality contaminant issue.

8.2 Non Technical Issues

- Technical, managerial and financial capability to implement, finance and operate the proposed technical solution
- Is the project sustainable?
- Can the system be operated and managed locally, without significant outside technical support?
- Will the community "buy in" to the system? Is there cultural acceptance?
- Will there be sufficient financial reserves to repair or replace depreciated facilities?

8.3 Examine Other Water Quality Constituents

Every water supply source has unique water chemistry. Apart from knowing what MCL exceedances have occurred at a water system, other water quality parameters will be important factors in evaluating and costing potential treatment systems. A full Title 22 sampling and chemical analysis should be performed to aid in evaluating treatment options for each water system. The analysis should also consider contaminants of emerging concern, such as chromium-6 and TCP.

8.4 Summary of Items to Consider

The following is a partial list of information that needs to be evaluated prior to evaluating potential treatment systems.

- Water demands for system – average daily flow, peak daily flow, peak hourly flow, and fire flow.
- Ability to treat water quality concerns including MCL exceedances and other water quality concerns
- Residuals/waste water management
- Operator skills required
- Capital cost (per gpd)
- O&M costs (per mgd/year)
- Additional infrastructure (building, tanks, etc.)

9 IMPLEMENTED TREATMENT SOLUTIONS

Following are several examples of communities within the study area that had MCL exceedances. The following sections detail the water quality issues faced and the explanation of the recommended treatment systems. These examples are provided to give an example of how selected DACs addressed their water quality issues.

9.1 Riverdale – New Well and Coagulation Filtration for Arsenic

The existing water supply facilities include 3 wells, Numbers 2, 4, and 5. Well 2 is no longer used due to decreased water quality and increasing groundwater depth. Well 4 is only used during periods of peak demand and in emergency situations due to decreased water quality. Well 5 is the only actively used well and has a pumping capacity of 1,000 gpm. The primary water quality issues are arsenic and color.

A new well (Well No. 6) is proposed with the intent of obtaining at least 1,000 gpm to replace the capacity of existing Well 4 and maintain the present water supply capacity. The new well will be designed and constructed to avoid arsenic concentrations above 10 ppb, if possible. However, based on other wells in the area, it appears unlikely that a zone of under 10 ppb arsenic yielding at least 1,000 gpm can be found. Treatment is expected to be needed at the future Well 6 site.

Pilot studies have indicated that coagulation-filtration (CF) is effective in removing arsenic and color to meet drinking water standards.

The water treatment plant would require the following systems to be installed: three filter vessels, chemical storage building and injection system (for sodium hypochlorite, ferric chloride or ferric sulfate, polyaluminum chloride or alum, sulfuric acid and sodium hydroxide), backwash pump, reclaimed water tanks and pump, sludge storage, sludge dewatering equipment, sludge drying beds, new motor control cabinet and electrical controls with canopy, light poles and antenna for radio communication, and a larger backup generator to serve the treatment system in addition to the existing well. A 285,000 gallon steel treated water storage tank and booster pumps would also be installed. The Project site, including the treatment plant and well site areas, would be graded to direct any storm water runoff to an approximately 5,000 square foot onsite storm water retention pond.

Two maintenance personnel would perform most maintenance and operation tasks, including weekly site visits at a minimum. Well and treatment operations would be automated but operations may require an average of two employee visits per day. General maintenance of the well and treatment plant would also include weed abatement, trash removal and fence maintenance.

9.2 Caruthers – New Well and Coagulation Filtration for Arsenic

The existing water supply facilities include 4 wells, Numbers 1, 3, 4, and 5. The depths of Wells 1, 3, 4, and 5 are 150, 415, 520, and 750 feet, respectively. Well No. 1 (flow

rate of 350 gpm) is not used except in the summer months. Well No. 4 (flow rate of 650 gpm) is only used sparingly due to arsenic concentrations above 20 ppb. The four (4) wells have a pumping capacity of 3,050 gpm, which is adequate for the current population.

Based on the 2000 Census the District has a population of 2,103 people. There are 672 service connections. Total water use in 2010 was 232 million gallons. The average annual water use for the District from 2006 to 2010 was 239 million gallons, which equates to an annual average daily per capita water use of 312 gallons per person per day (gpcd). The high value is due in part to landscape irrigation facilities for the local school systems and fair grounds. These areas are irrigated with potable water.

The water system is presently operated with two water supply wells. The operator manually selects the lead well. The lag well will turn on if the water system pressure falls below an established limit. Generally, one well is sufficient to meet water system demands, with the exception of summer months.

If the new well exceeds the arsenic concentration that is sufficient for blending, but below the MCL of 10 ppb, a coagulation filtration (CF) plant will be constructed on the new well site to treat water from the existing Well No. 5 and potentially treat the water from the new well (Well No. 6), if needed. Once Well No. 6 is in production, a pilot study of various CF processes will be performed. The CF treatment process requires additional equipment to be installed; a backwash tank, a pre-oxidation chemical feed, a pH adjustment chemical feed, additional on site electrical, and a control building. The project will include construction of treatment vessels, chemical feed and storage facilities, automated process equipment, piping and electrical, and sewer service facilities. This will also require the construction of piping and valves from Wells No. 5 and No. 6 to the treatment plant, to the storage tank, and backwash tank. In addition, a drain from the backwash tank would be required for removing the accumulated solids and a small amount of non-recyclable water to a sewer connection to the community sewer system

The treatment system will be designed to remove arsenic. Other contaminants in the water such as TDS and vanadium will not be removed in the proposed treatment system. The overall quality of the treated water will not change significantly from the present quality except that arsenic will be below the MCL.

9.3 Hillview – Sierra Lakes – Adsorption for Uranium and Coagulation Filtration for Arsenic

The primary water quality issues at Hillview are uranium, iron and manganese. The raw water from Well # 7 will be piped in an 8” diameter pipeline from the wellhead to Well # 5 site for uranium removal. The 8” diameter pipe will enter the treatment building and split into (2) 4” diameter pipes and connect to each of the uranium treatment systems. When the media is exhausted, it will be exchanged disposed by WRT. The treated water will be piped from each of the treatment plants in 4” diameter pipes and exit the treatment building to a new 8” diameter pipeline. This will connect to the existing 8” diameter pipe adjacent to well # 5 for distribution to the Sierra Lakes (2) raw water

storage tanks. An 8” diameter pipeline will also be installed as a bypass to the uranium treatment system outside of the treatment building.

The (2) existing raw water storage tanks will remain at the Sierra Lakes tanks site. A 4 “ diameter pipeline will be constructed from well # 4 to the existing raw water storage tanks and remain as a bypass line for the uranium treatment plant. In addition well # 3 has an existing bypass pipeline to the existing raw water storage tanks. This operation will be verified by the Hillview plant operator.

The existing aeration tank for well # 4 will be removed. The existing backwash tank for the iron and manganese removal plant will be removed. The iron and manganese treatment plant will be removed. The iron and manganese treatment plant will be removed and salvaged to a location determined by the owner. A new 4 “ diameter pipeline will be constructed from the well # 4 to the new uranium treatment plant inside of the new building and connected to the uranium treatment system. The treated water will be piped from the treatment plant in a 4” diameter pipe and exit through the floor of the treatment building and be connected to the (2) existing raw water storage tanks.

The existing distribution system from the (2) 40,000 gallon existing water storage tanks will remain as a bypass to the iron, manganese, and arsenic removal treatment system.

The water from the raw water storage tanks will be piped in an 8-inch diameter pipe. A four-plex booster pump skid with VFD drive motors will be installed to pump the raw water through the CF system inside the treatment building. The iron manganese and arsenic removal treatment system will consist of 4 vessels. Backwash of one filter will be accomplished by the treated water from the other three filters. The backwash will be discharged into a 20,000 gallon backwash tank that is outside of the treatment building. The backwash water will be decanted from the tank with a decant pump and run back through the coagulation filtration plant. A sludge pump will remove sludge from the backwash tank and distribute it to the sludge container. The sludge will be vacuumed from the sludge container and disposed of at the Oakhurst Wastewater Treatment Plant. A polymer will be added to the sludge to further dewater the sludge through a pump from a polymer storage tank. The sludge must be classified as non hazardous waste before disposal to the WWTP. The decanted water from the sludge container will be pumped with a decant pump and returned to the CF plant. The treated water from the CF plant will be discharged to the new 80,000 gallon treated water storage tank. The treated water from the storage tank will be gravity fed to an existing 6” diameter pipeline. The treated water will also be gravity fed to an existing 10” diameter pipeline to the existing 420,000 gallon storage tank. The treated water will also be pumped to the existing Sierra Lakes reservoir with a booster pump.

10 CENTRALIZED WATER TREATMENT

Centralized treatment systems should be considered when there are neighboring systems with similar water quality issues. This would have the advantage of allowing the communities involved to share capital and operations & maintenance costs. There are typically significant economies of scale in constructing and operating larger treatment systems jointly. Often, the time required for operating a system may be largely independent of the size of the system. Consequently, considerable saving in personnel costs can be attained with joint systems.

The physical location of the treatment plant relative to the participating communities would depend on the availability of land, the location of the water sources to be treated, and on the length of transmission pipelines that would be required. A consolidated treatment project involving multiple communities may encounter significant resistance from one or more communities, especially where there is a perception that the benefits and impacts are not evenly distributed or where one of the communities does not perceive that they have an issue that will be resolved by the project.

A variation on the centralized water treatment approach would be to have a centralized water treatment plant that would supply treated water to nearby water systems with the intent of them blending the treated with their existing water to meet water quality standards.

10.1 Conceptual Centralized Treatment Systems

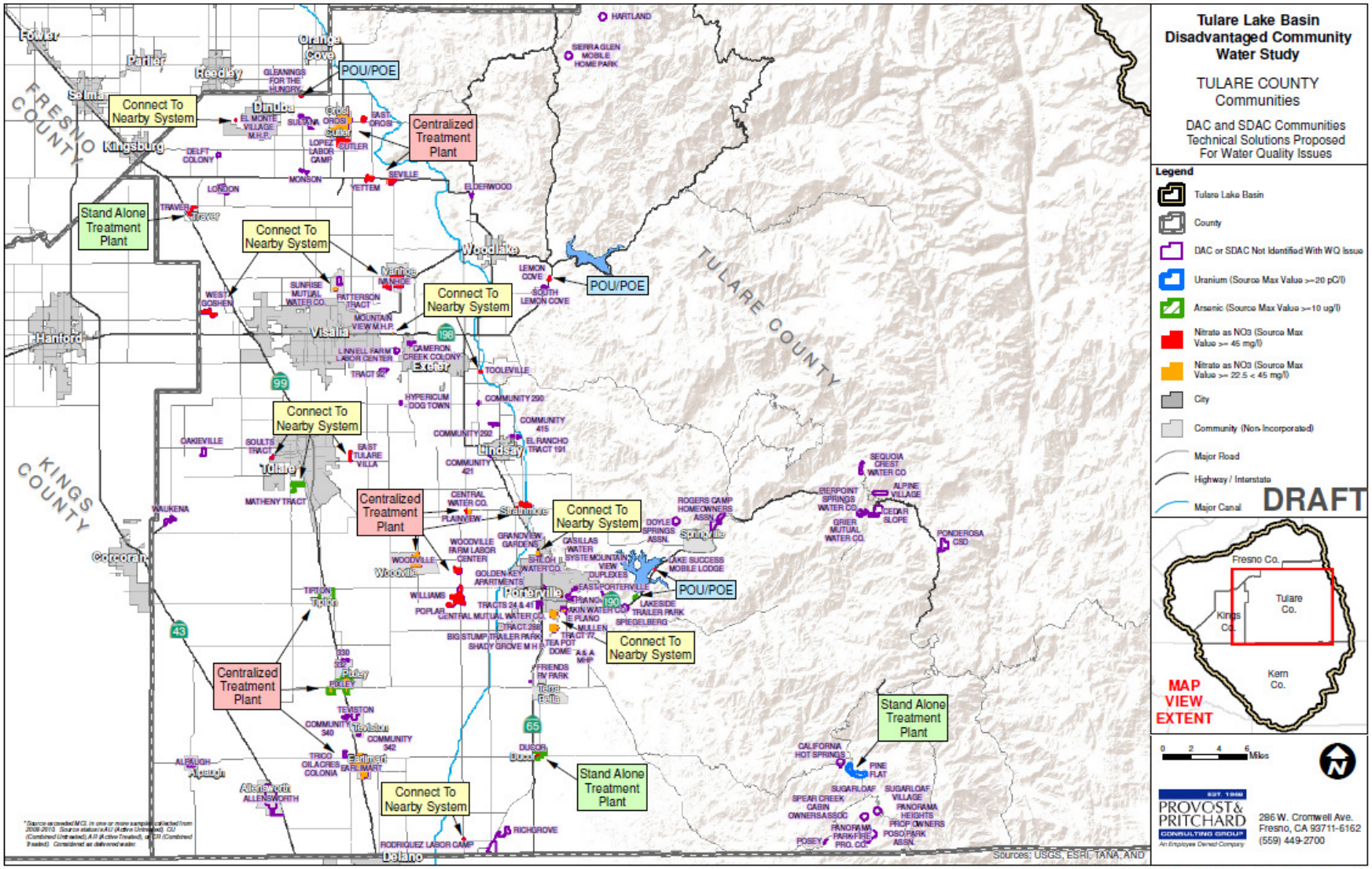
The water system database was reviewed to identify “concept” centralized treatment systems. The locations of the DAC communities were plotted on a map along with their respective contaminants of concern. Those communities that are located near a larger water system were not evaluated for centralized treatment since a more reasonable solution would be connecting to the larger water system. The remaining systems were evaluated to determine if there were two or more systems near each other (within 5 miles) with similar contaminant issues. Based on these criteria, the following are possible centralized water treatment systems that could be evaluated further:

- Tulare County: 3 centralized water treatment systems.
- Fresno County: 1 centralized water treatment system.
- Kern County: Several centralized water treatment systems in the Lake Isabella area.
- Kings County: No centralized water treatment systems.

Those water systems that are not near a larger water system or near another community with similar water issues, should consider installing a treatment system to serve just their system or install POU/POE systems for individual homes.

Figures 4 to 7 show the locations of proposed centralized water treatment systems.

Figure 4 - Tulare County Proposed Centralized Water Treatment Plant Locations



4/4/2013 : V:\Clients\Tulare County - 1399\139911\1-Tulare Lake Basin Water Study\GIS\Map\Pilot Tech Solutions\techsolutions_tularecco.mxd

Figure 5 - Fresno County Proposed Centralized Water Treatment Plant Locations

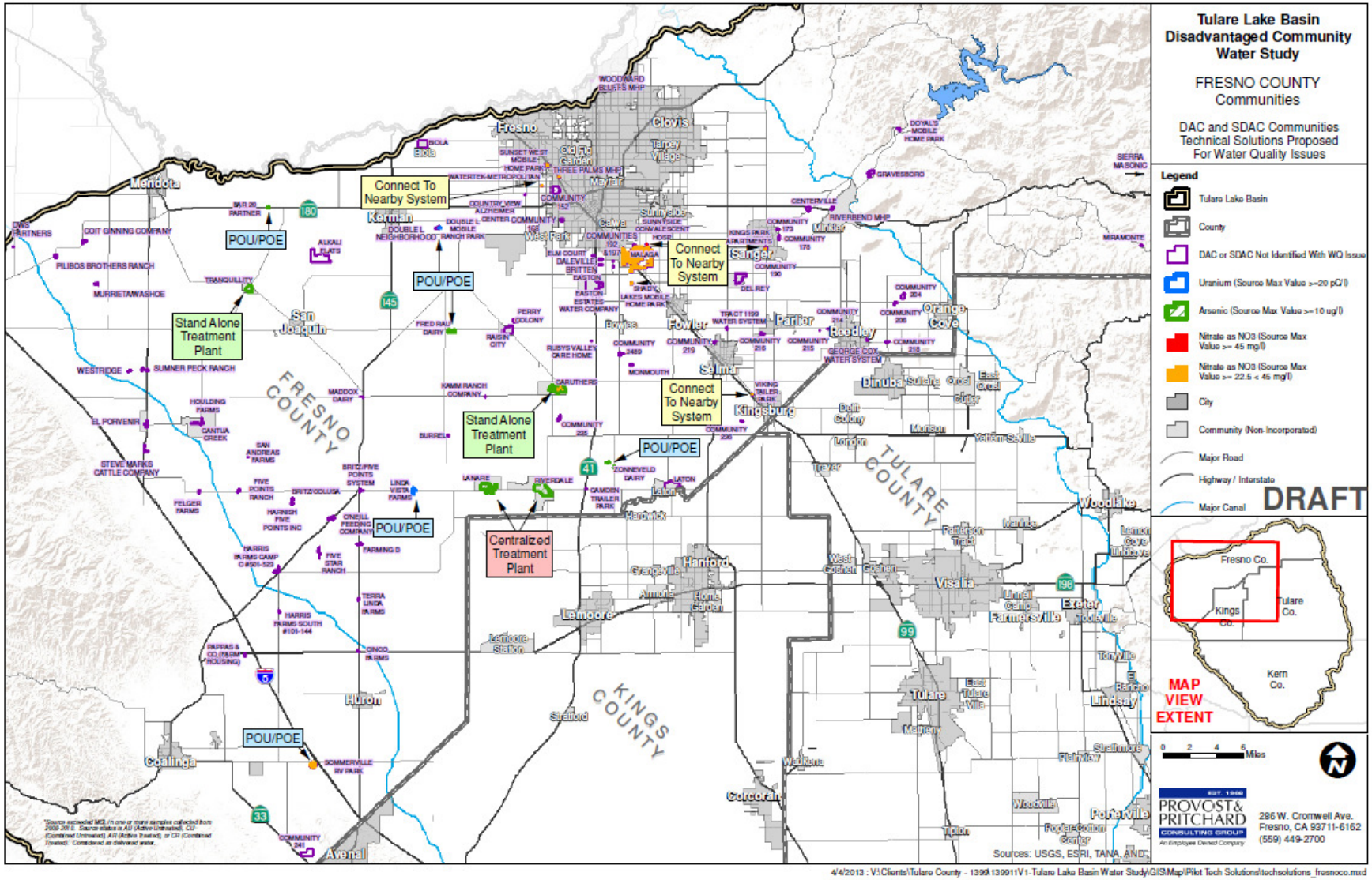


Figure 6 - Kern County Proposed Centralized Water Treatment Plant Locations

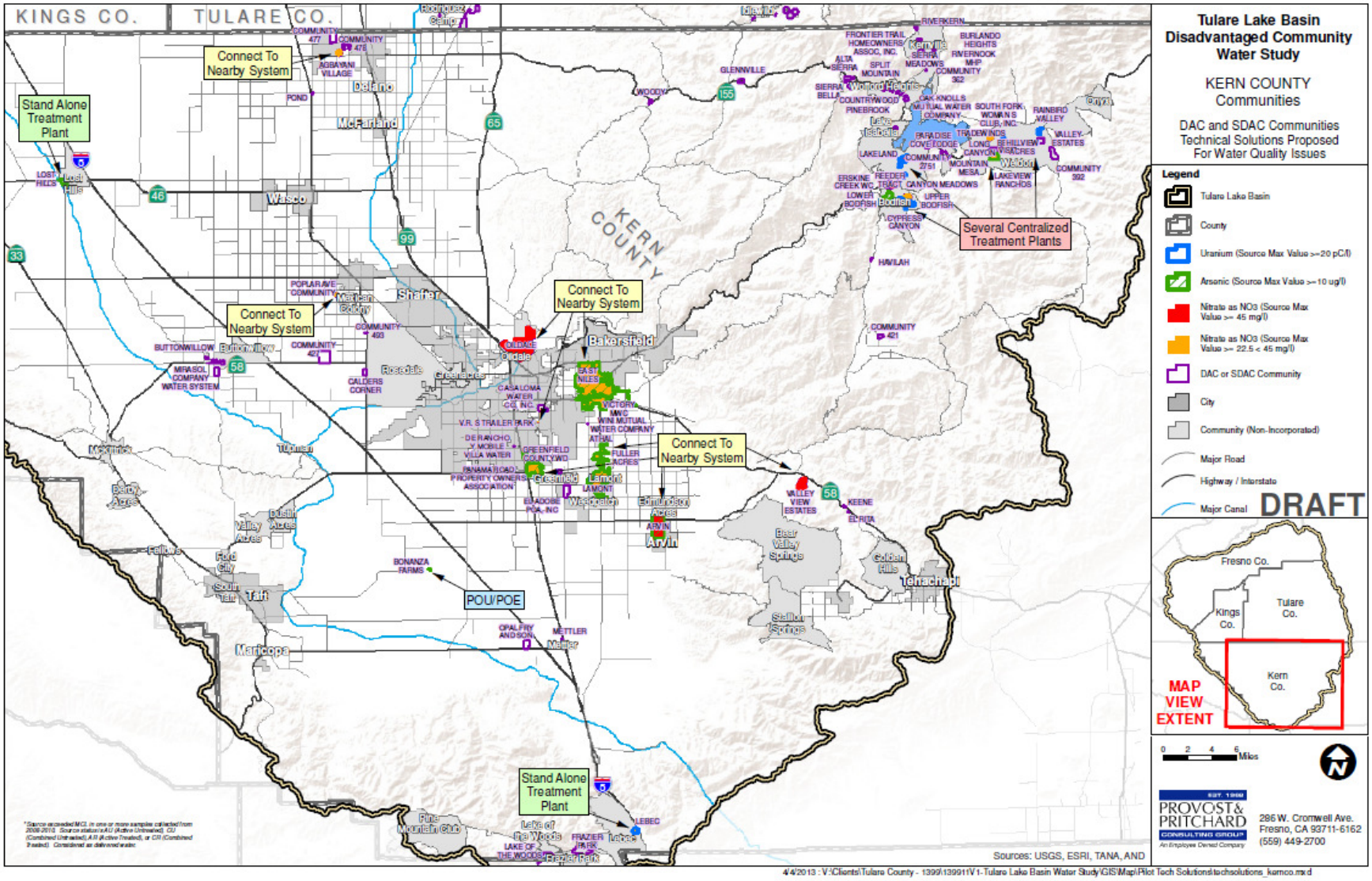
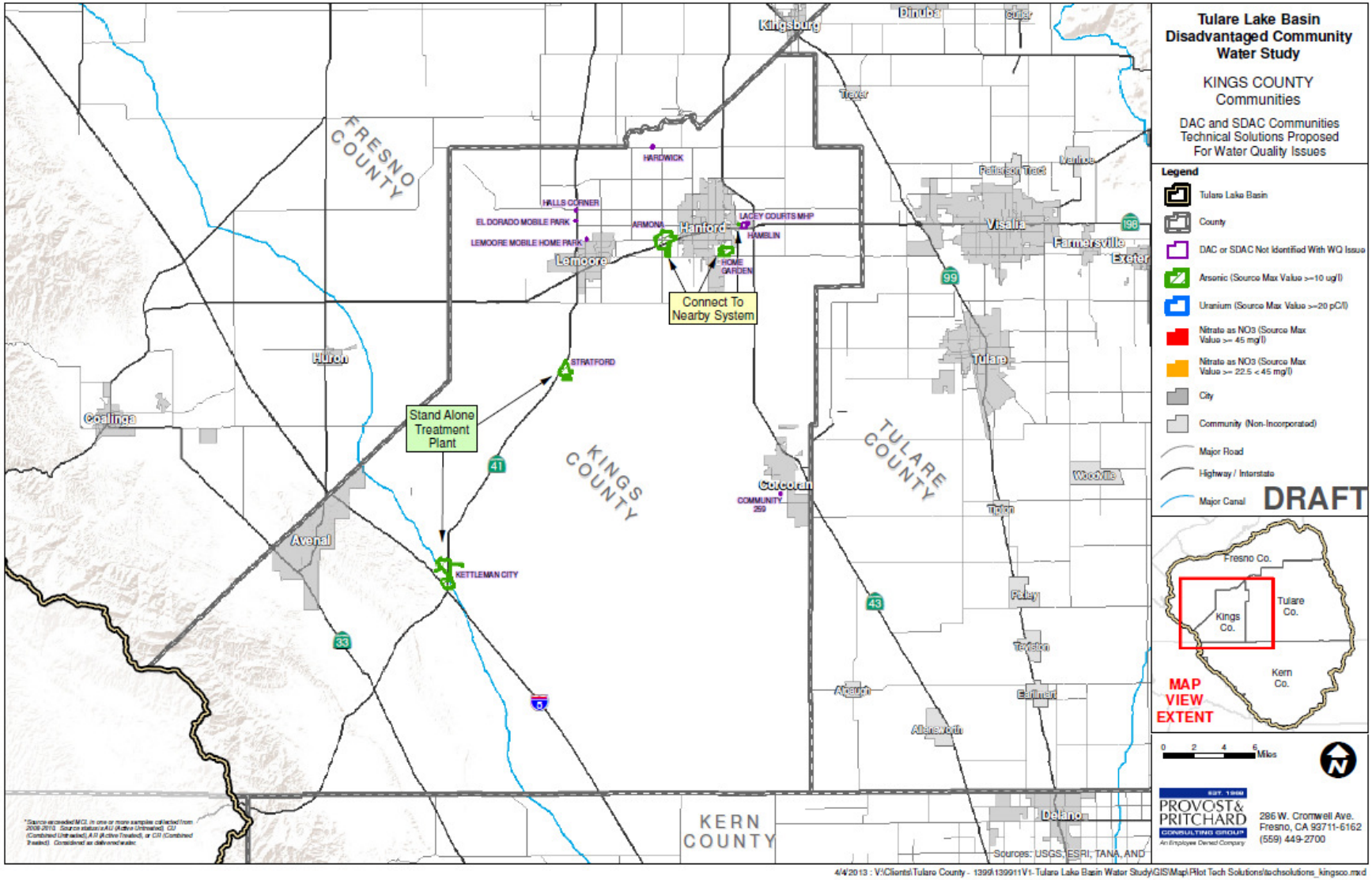


Figure 7 - Kings County Proposed Centralized Water Treatment Plant Locations



11 DUAL WATER DISTRIBUTION SYSTEMS

Drinking water systems, must deliver water to the consumer's tap that meets all State and Federal drinking water quality standards. However, a significant portion of the water delivered is used for non-potable purposes. The water may be used for landscape irrigation, agricultural crops, farm animals, pasture irrigation or activities such as washing cars. The water used for these non-potable purposes does not need to meet drinking water standards. Sizing a treatment system and paying O&M costs to treat water largely used for non-potable purposes does not make economic or environmental sense. Efforts should be made to make sure, to the extent feasible; the treatment system is used to supply mostly potable and indoor uses.

One of the most effective ways to limit the use of potable water for non-potable uses is to install water meters and implement a tiered volumetric rate schedule. Another benefit for consumption based rates, particularly for DACs, is that it accounts for the higher water usage rates that occur in multi-family homes, extended family homes, and homes with occupied outbuildings served off of hose bibs. However, in rural communities, with larger parcel size, there may be a desire to have a water system that can provide irrigation water at a reasonable cost for farm animals, gardens and micro scale farming.

In some communities facing significant cost for treating water to meet drinking water standards, it may make economic sense to utilize a **dual water distribution system**. One system would be used exclusively for indoor use. A separate second system would be supplied with non-potable water for outside use and for fire flow. Having a separate non-potable water system would lessen the potable water demand to the water just needed for potable purposes.

Typically, indoor water use varies from about 50 to 100 gpcd. Many rural communities have an overall per capita water use of 200 to 300 gpcd. Thus, it is possible to provide a potable water only system that is 25 to 33 percent the overall size of a typical water system. Where costly treatment is required, this will result in significant savings to the community. However, the treatment system capital and operations cost savings will be offset by the cost of constructing and operating a new independent water system. It is not likely that a dual water distribution system will be cost effective in most water systems because the cost of constructing a dual distribution system will be very large. However, for new construction in a rural, large lot community, or an existing large lot rural system, with significant non potable water use, a dual water distribution system can be considered.

If the community served by the water system also has a wastewater treatment plant, there is the possibility of the treated recycled wastewater being used to supply a non-potable water system. This would involve upgrading the wastewater treatment plant to provide tertiary treated effluent that would meet the California recycled water regulations (Title 22). These upgrades would likely include tertiary filtration and disinfection. Additional infrastructure such as pipelines, pump stations and storage would be needed. The use of recycled wastewater would also have the advantage of conserving water and reducing groundwater pumping.

A smaller potable water system would have lower capital and O&M costs. A detailed cost analysis would need to be performed for each water system to determine the costs of installing meters or a non-potable system versus the cost savings of a smaller treatment system and the associated operational costs.

12 RESIDUALS HANDLING

A major cost component and management issue for water treatment systems is residuals handling and disposal. All water treatment systems produce side stream flows, solids or spent media. The sides stream flows may include filter back wash, precipitated solids, concentrates, brines, dewatered solids and other materials. Spent media such as GAC and adsorptive media are also produced. Some of this material may be classified as hazardous because it contains concentrated metals such as arsenic or uranium. It may also have a high or low pH that will require neutralization. In the case of media used for uranium removal, it may be radioactive and will require special handling. Because of the limited ability to handle hazardous wastes in California, it may be necessary to ship some residuals out of state, at great cost. Other side streams, such as concentrate from RO systems or brines used for IX regeneration, may not be classified as hazardous, but may contain high concentration of salts and minerals which cannot be disposed in the TLB because of environmental water quality regulations.

Water treatment plant waste management will be an integral component of the treatment system itself. The term “residuals” is used to describe all water treatment plant process wastes, either liquid or solid. Water treatment systems produce unique waste streams, each of which has different associated waste handling issues. When examining waste handling several questions must be answered:

- What must be removed?
- Is it hazardous or otherwise regulated?
- Where will it be disposed?
- What treatment is necessary to prepare it for disposal?

Figure A2, in Appendix A, shows a flow chart to evaluate the possible residuals handling solutions that may be applicable to a particular community.

12.1 Solid Waste

Treatment processes such as iron coagulation filtration, gravity filtration and, to a lesser extent, GAC produce a concentrated solids waste stream when the filters are backwashed. The solids produced are from both the raw water and the chemicals added to the water to coagulate suspended and dissolved contaminants that are removed in a filtration process. These solids are settleable and can be removed through further treatment.

The quantity of the solids residuals generated from the water treatment process depends on the raw water quality, dosage of chemicals, performance of the treatment process, method of sludge removal, and backwash frequency.

The solids quantity is usually determined as an annual average based on the yearly volume to be treated. Depending on the specific treatment process utilized, the volume of solids can normally be estimated by knowing the yearly volume of water treated and the amount of calcium hardness removed, magnesium hardness removed, iron added

for treatment (ferric chloride for example), alum or polymer added, and suspended solids removed. The solids concentration from most filter backwashes is around 0.1 percent, although this varies greatly with the process utilized. Often, these residuals can be disposed of at a municipal wastewater treatment plant, liquid decanted and recycled, and/or disposed of in ponds on site.

The solids can also be further thickened to reduce the volume of waste to be disposed. For example, thickening a 1 percent solids concentration sludge to 10 percent solids concentration, a volume reduction of approximately 90 percent is achieved. Therefore, 90 percent less volume is needed to be stored or disposed.

12.1.1 Non-mechanical Dewatering

Non-mechanical dewatering is normally used where land is available and where it can be both economical and efficient for dewatering water treatment plant wastes.

12.1.2 Sand Drying Beds

Sand drying beds are normally rectangular beds with walls and a layer of sand or gravel with underdrain piping. Drainage (via percolation), decanting and evaporation are the dewatering mechanisms. When wastes are applied to the drying beds, free water drains through the sand. Remaining water is removed through evaporation. The residuals can stay in the drying bed until a desired solids concentration is reached. Eventually the dried solids will need to be removed using a front end loader.

The use of sand drying beds will depend on the soils in the area and the amount of evaporation that can be expected.

12.1.3 Solar Drying Beds

Solar drying beds are similar to sand drying beds in terms of operation except they are constructed with sealed bottoms. In these beds all dewatering is accomplished through decant of free water and evaporation. Solar beds have lower maintenance and cleaning since sand does not need to be replaced and the sealed bottoms makes loading and cleaning easier. Because solar beds rely on evaporation, they have a lower solids loading rate compared to sand drying beds.

12.1.4 Dewatering Lagoons

Dewatering lagoons are similar to sand drying beds except they operate at much higher initial loadings, and therefore have longer drying times between cleanings. Dewatering lagoons are equipped with a decant structure and may be equipped with underdrains. The dewatering lagoons are filled over a long time (3 to 12 months) and then allowed to dry for a long period of time while another lagoon is filled.

12.1.5 Mechanical Dewatering

Centrifuges, plate-and-frame filter presses, diaphragm filter presses and belt filter presses can be used, in conjunction with polymer chemicals, to mechanically dewater water treatment plant residuals. Centrifuges and belt presses will produce solids in the 15 to 25 percent dry solids range. Diaphragm and plate-and-frame presses can produce solids between 30 to 45 percent dry solids. The resulting solids are dry enough to truck off-site. The ultimate choice of mechanical dewatering should be based upon pilot studies based on the specific characteristics of the material to be dewatered.

12.1.6 Ultimate Disposal of Solids

The final location for dewatered solids will be based on the chemical characteristics of the material, its dry solids content and its classification as hazardous or non hazardous waste. The chemicals added and the contaminants removed in the water treatment process will affect the ultimate disposal of the solids. If the solids have relatively few contaminants, they may be land applied. Solids exceeding the concentration limits for land application may be accepted for disposal of in a local Class III landfill (municipal solid waste). If the dewatered solids have reached hazardous concentrations, such as for arsenic, the solids will require disposal of in a Class I landfill (hazardous waste).

12.2 Brine and Concentrate Disposal

Certain treatment processes produce a liquid waste stream that contains primarily dissolved solids, minerals and salts. These wastes are called brines or concentrates and include spent brine from IX regeneration, reject water (concentrate) from high pressure membrane systems (RO) and spent regenerant (acid or caustics) from specific adsorption media such as activated alumina.

Conventional methods of brine disposal involve discharge to a wastewater treatment plant, evaporation, deep well injection, septic systems, or zero liquid discharge.

12.2.1 Sewer

If a sewer is available nearby and the wastewater treatment plant can accept the brine or concentrates, disposal to the sewer is the preferred method of disposal. However, in many cases discharge limits imposed on the effluent of the wastewater treatment itself (e.g. total dissolved solids or electrical conductivity) prevent the wastewater treatment plant from accepting the influx of water treatment plant residuals brine. It is unlikely that sewer disposal of brines or concentrate will be possible except for very small water treatment systems and where significant dilution is available in the sewer.

Brine disposal options to wastewater treatment plants are limited in the Tulare Lake Basin area. Trucking of waste brine to coastal wastewater facilities, although costly, is sometimes the only viable disposal option. East Bay Municipal Utility District (EBMUD), in Oakland, California, can accept some high salinity waste.

12.2.2 Deep Well Injection

Deep well injection is another possible option for concentrate disposal. In deep well injection, concentrates are pumped into salty aquifers that are isolated from and below useable drinking water. Within the TLB, deep well injection is widely used for disposal of produced water from oil production. However, there is currently no use of deep well injection for disposal of water treatment concentrates in the TLB. This method requires a UIC permit for well operation and underground injection from EPA. Deep well injection is typically very costly because it usually requires the construction of a well several thousand feet deep. The costs are incurred in the construction of the well, the extensive monitoring that is required, and increased electrical costs to run the injection pumps. It is not likely that a single DAC entity would be financially capable of such construction. However, it may be possible to consider deep well injection for a group of water treatment systems, if the only other opportunity is long-term trucking of concentrates.

12.2.3 Zero Liquid Discharge (ZLD)

A zero liquid discharge system will completely convert liquid wastes into solid wastes that can be trucked offsite. A ZLD system typically includes multiple stages of solids concentration. The first stage is RO which produces a high quality permeate and a concentrate stream. The permeate is returned to the water treatment process and the concentrate moves to the next stage. Following RO treatment, a much smaller volume of waste will be treated in the next stage thus enhancing performance and reducing power consumption. The RO concentrate will be further concentrated further using an evaporation process. After evaporation, the next stage is crystallization. Crystallizers will then evaporate any remaining water past the crystallization point. The condensate can be recycled and the dried crystals can be transported off site for disposal.

The cost of a ZLD system is high and may equal or exceed the cost of the water treatment system. The advantage is that most of the liquid in the waste can be recycled and the solids remaining will be of small volume and can be easily disposed of. As with deep well injection, there are no operating ZLD systems used for concentrate or brine disposal from water treatment in the TLB. ZLD is used in the TLB for disposal of cooling tower waste at some power plants. A ZLD system is very costly to construct and operate. It is not likely that a ZLD system could be constructed and operated by a single DAC entity, however, it may be possible to consider for a group of water systems if there are no other viable options and trucking of liquid concentrate waste outside the TLB is not economically feasible in the long-term.

12.2.4 Solar Evaporation

Solar evaporation is possible in the TLB because evaporation greatly exceeds precipitation on an annual basis. Approximately 4 to 5 acre-feet of water can be evaporated annually for every acre of a solar evaporation pond. Solar evaporation of brines or concentrates will be similar to the operations described in Solar Drying Beds under Non-mechanical Dewatering. Solar evaporation is attractive because it has very

low operating cost and requires no external energy. However, it requires a very large land area and it will require the construction of shallow ponds with a double liner system and continuous monitoring to protect the underlying groundwater. The ability to consider and utilize solar evaporation for brine or concentrate disposal will be site specific and dependent on the volume of concentrate and the availability of land. It will not likely be a viable option for many systems.

12.2.5 Septic System

According to the Drinking Water Treatment for Nitrate as submitted to the California Legislature aka the "Harter Report", several small water systems indicate disposal of brine to an onsite septic system. With a low volume waste stream (depending on chemical composition to avoid negatively impacting septic system function or underlying groundwater), disposal to a septic system can avoid other, more costly disposal options. Disposal to a septic system with on-site disposal is not considered a viable alternative, except for the very smallest systems (individual household) for DAC communities. Generally, regulatory requirements for the protection of groundwater will preclude the use of on-site disposal.

12.3 Brine – Regeneration

12.3.1 Electrochemical (nitrate)

There are brine handling systems currently in development that will allow multiple use of brine to regenerate nitrate IX resins. Currently brine used for IX resin regeneration is used once and cannot be re-used because of the nitrate present. With the system under development, the usual sodium chloride brine is substituted with potassium chloride. The potassium brine is electrochemically regenerated and nitrogen present is converted to nitrogen gas. According to the manufacturer, approximately 50 to 100 regenerations can occur before the brine is spent and requires off-site disposal. If successful, this type of system will significantly reduce the volume of brine disposal and possibly make IX systems for nitrate removal much more viable.

Electrochemical techniques are being developed to remove nitrates from water. Bench scale tests obtained intermediate formation of nitrite using nickel, lead, zinc, and iron cathodes, with ammonia as the final product.

Photochemical methods have demonstrated that light can activate the nitrate ion directly or indirectly via a catalyst for reaction with a reducing agent. However, reducing nitrate with water photochemically is an uphill energy process and not suitable for large scale water treatment.

12.4 Centralized Residuals Treatment

Centralized residuals treatment may be feasible for those communities that are located near each other and share similar treatment systems. For example, Home Garden (a small community in Kings County) has an iron coagulation filtration treatment system for

arsenic removal. Home Garden currently hauls the residuals from the treatment plant to a facility in Arizona. Home Garden does not have a wastewater treatment plant but discharges into the City of Hanford. The City of Hanford (a large community in Kings County) has a wastewater treatment plant that could accept the waste from the Home Garden water treatment plant. It may be possible for these two communities to own and operate a centralized residuals treatment system to treat and dewater their water treatment plant waste. This could allow both communities to share the capital and O&M costs associated with residuals treatment. There would be legal and fiscal issues for the communities to work out regarding a centralized residuals treatment plant.

Any of the previously mentioned residuals handling options could be centralized to serve multiple communities. However, the centralized facility would still have a solids and/or liquid waste stream that would need disposal.

13 WASTEWATER TREATMENT TECHNOLOGIES

In addition to the water treatment issues faced by DAC communities in the Tulare Lake Basin, many communities also face issues with their wastewater. The wastewater issues may stem the community relying on failing or expensive septic systems or wastewater treatment systems that are not capable of meeting applicable effluent limitations. Of the 370 DACs, 38 communities (10.3%) have their own wastewater treatment facility (WWTF). These 38 communities make up a population of 86,391 or 25.2% of the study area population. This implies that up to 74.8% or 256,504 people are not served by a community wastewater treatment facility. Of the 38 wastewater treatment facilities, 25 (65.8%) are listed as having a violation of their Regional Water Quality Control Board (RWQCB) waste discharge requirements (WDRs) in the last three years.

Of the 38 wastewater treatment facilities, 27 utilize some type of pond or lagoon treatment. The lagoon may be aerated by either mechanical surface aerators or submerged diffused aeration systems. Aerated lagoons typically are classified by the amount of mixing provided. A partial mix system provides only enough aeration to satisfy the oxygen requirements of the system and does not provide energy to keep all total suspended solids (TSS) in suspension. Aerated lagoons can reliably produce an effluent with both biochemical oxygen demand (BOD) and TSS < 30 mg/L. However, it may be difficult to meet nitrate discharge concentrations of 5 mg/L or less.

There are two systems that utilize trickling filters. Six communities use an activated sludge treatment system (two oxidation ditch, three traditional activated sludge plants, and one membrane bioreactor). Two systems provide tertiary treatment. One system uses a community septic system.

All 38 treatment systems discharge to land in some form – percolation, evaporation, or leachfields.

13.1 Improvements to Existing Wastewater Facilities

Of the 25 treatment facilities that had a recorded violation, 24 had Category 1 violations and one had both Category 1 and Category 2 violations. Category 1 violations include BOD, chloride, nitrogen, oil and grease and suspended solids. Category 2 violations include organics, pesticides, and chlorine. There were no details as to which pollutant(s) limitation was exceeded for each category.

Of the 13 treatment facilities with no violations over the last three years, 12 were lagoon systems and one was a trickling filter. The 15 lagoon systems that did record a violation most likely violated their WDRs due to TSS or nitrogen (either nitrogen, nitrate or nitrite) issues. To address TSS, an existing lagoon system could add additional lagoon volume to allow the suspended solids to settle or install sand filters to remove any particulate matter that exits the lagoons.

Removal of nitrogen in lagoon systems can be accomplished with sedimentation in clarifiers with solids recycle (similar to a Biolac process) or through retention of solids by use of sequencing batch reactor technology.

The non-lagoon based systems could be improved by adding additional capacity, tertiary treatment (sand filters, biofilters), or improved operations of the existing facilities. Properly sized and operated activated sludge and tertiary treatment systems should be capable of meeting their WDR limitations.

13.2 Servicing Unsewered Communities

Those communities that do not have a wastewater facility have several potential options: construct a wastewater treatment facility to serve their community, join with nearby communities to construct a centralized wastewater treatment facility, connect to an existing nearby wastewater treatment facility, or continue to utilize individual septic systems.

In order to utilize a wastewater treatment facility, the community would need to install a collection system to collect and convey wastewater to the treatment facility. If acres of land are available, an aerated lagoon treatment system with percolation/evaporation ponds would have the lowest capital and maintenance costs.

If space is limited, an activated sludge treatment plant should be considered. Activated sludge plants have higher capital and maintenance costs and require more skilled operators. In activated sludge plants, wastewater is settled in a primary settling tank Extended aeration activated sludge plants often do not utilize primary settling. Wastewater is then fed continuously into an aerated tank/basin, where the microorganisms metabolize and biologically flocculate the organics. The microorganisms (activated sludge) are settled from the aerated mixed liquor under quiescent conditions in the final clarifier and returned to the aeration tank. Clear supernatant from the final settling tank can be discharged. Depending on the quality of the sludge produced, it can be land applied or hauled to a landfill.

14 WATER AND ENERGY CONSERVATION

14.1 Water Conservation

Water is valuable resource in California. Water conservation – using water efficiently and avoiding waste – is fundamental to ensuring water availability in the future. The largest use of potable water inside the home is from inefficient fixtures, mainly the toilet. Outside the home, nearly 40 percent of municipal water is used for watering lawns. Installing newer fixtures inside the home and installing low-water landscaping are just a couple ways to conserve water. There are numerous publications available to communities detailing ways to conserve water and how to encourage their customers to conserve water.

14.2 Energy Conservation

A majority of the energy used by water utilities is for pumping. This pumping could be from wells, pumps used in the treatment process or booster pumps. There are several options to provide more efficient pumps. Most electric utility providers offer rebates and other incentives for making energy efficiency improvements.

Figure A3, in Appendix A, shows a flow chart to evaluate possible energy conservation options that may be applicable to a particular community.

14.2.1 Energy Efficient Pumps

The pump and motor work together to move fluids. The pump's efficiency is greatly influenced by the system it supplies. For an efficient pump, the pump should be sized according to usage requirements and avoid oversizing at all costs, choose low head loss components, design a pipe system layout that reduces pressure drops, and select pumps that perform efficiently with varying flow rates and both high and low head (depending on conditions).

14.2.2 Variable Frequency Drives (VFDs)

A VFD is an electronic controller that adjusts the speed of a motor and the equipment it is connected to, thereby accommodating the fluctuations in demand by running motors slower when full capacity is not needed. Also, as opposed to abruptly turning pumps on and off again, VFDs have the capability of slowly bringing a motor to the appropriate speed so as to reduce mechanical and electrical stress on the motor and equipment, and to reduce pressure surges on hydraulic systems. This can result in lower maintenance and repair costs. VFDs can reduce pump energy use by 50% and can save up to 20% or more on electric usage at water facilities. The advantages of VFDs are that they are reliable, easy to operate, increase the degree of flow control, and since they work with most three-phase electric motors used by throttled pumps, retrofitting is a viable option. The initial cost of a VFD is relatively high (ranging for $3,000 for a 5 hp motor to $45,000 for a 300 hp motor) but payback can occur as early as a few months.

The payback assumes the pump will not operate at full speed for extended periods of time.

14.2.3 Energy Efficient Motors

In most water treatment plants, continuously operated pump motors account for 80-90% of the total energy cost, meaning that their lifetime operational cost can be significantly greater than their original purchase price. Energy efficient motors are only 2-8% more efficient than standard motors, but they usually have longer insulation and bearing lives as well as less vibration, lower heat output, and are more tolerant to overload conditions and phase imbalances. Consequently, their failure rate is much lower. The difficulty with energy efficient motors is deciding whether or not to use them to replace existing motors. Since replacement of motors is costly, the standard rule is that a motor should be immediately replaced with an energy-efficient one if it is being used 8,000 hours or more per year. If used between 4,000 and 8,000 hours per year, the motor should be replaced with an energy efficient motor upon failure.

14.3 Renewable Energy

Renewable (green) energy can be used to offset some of the electrical demands for a water treatment plant. Below are several examples of renewable energy applicable to water treatment plants.

14.3.1 Microturbines

If the community operates a wastewater treatment plant and can collect the bio-gas, microturbines can be used to produce energy from the bio-gas. This energy can be used to supplement the energy needs of a water treatment plant. An individual microturbine produces anywhere from 15 to 300 kilowatts (kW) of energy, they are often grouped to produce the required energy. For comparison purposes, a standard 1 MGD activated sludge treatment plant may have a 2,200 kWh/MG energy demand, a 10 MGD facility may have a 1,200 kWh/MG energy demand, and a 50 MGD facility may have a 1,000 kWh/MG energy demand. Aerated lagoons and trickling filters use approximately 1,500 kWh/MG for a 1 MGD plant.

Microturbines are cheaper to build and run in comparison to larger conventional gas or diesel powered generators. However, they are less efficient than internal combustion engines. The technology is well understood and has been implemented in many applications throughout the U.S. One disadvantage of microturbines is a limit on the number of times they can be turned on. Microturbines also run at a very high speed and high temperatures, causing noise pollution for nearby residents and potential risks for operators and maintenance staff.

Capstone and Ingersoll Rand are two of the larger microturbine manufacturers. Each offers different models of microturbines that depend on the power output that is needed. Costs for these units can range from $30,000 to $250,000, installed, depending on the unit.

14.3.2 Solar Power

Commercially available solar modules are between 5 to 17 percent efficient at converting sunlight into electrical energy. Solar modules generally can produce electric energy in the range from 1 to 160 kilowatts. An individual solar cell will typically produce between one and two watts. A backup storage system should be included with the solar system to store power so that it can be used during low light conditions or at night.

Solar cells can generate electricity with no moving parts, they can be operated quietly with no emissions, they require little maintenance, and are therefore ideal for remote locations. Although solar cells require very little maintenance, they can be difficult to repair when maintenance is needed. Additionally, the initial cost of solar cells is very high.

Currently, installed solar systems cost from $6,000/kW to $10,000/kW. The cost of a solar system depends on the system's size, equipment options, and installation labor costs. If a community has land available for solar cells and there are monetary incentives from the power company or from state and federal sources, solar cells may be a way for communities in the TLB area to offset some of their power usage.

15 DEMONSTRATION PROJECTS

There are a wide variety of water quality issues confronting disadvantaged communities in the Tulare Lake Basin area. Each community is unique in their water quality issues; however, showing how some of the solutions presented in this report may apply to specific communities may provide guidance for other communities. A June 2012 memorandum from the SOAC committee details some of the demonstration projects to be considered. These demonstration studies and some potential communities for the studies are presented in the next sections.

15.1 Dual Water Distribution Systems

15.1.1 Riverdale

- Problem
  - Large amount of water used for non-potable purposes
- Number of connections – 930
- Population – 3000
- Ownership – Public
- Solution
  - Provide a separate system to provide non-potable water.
  - Lower demand on proposed treatment system
- Approximate Capital Cost (application, design, capital facilities) : $TBD
- Capital Cost per connection (population): $TBD
- Challenges:
  - Funding
  - Logistics of providing another water delivery system

15.2 Residuals Handling and Management (onsite and offsite)

15.2.1 Systems around Lake Isabella (offsite)

- Problem
  - Approximately 13 systems around Lake Isabella have nitrate, arsenic, and/or uranium issues. With numerous WTPs possible in the area, a centralized residuals handling facility is a possibility.
- Number of connections – 3668 approximately
- Population – 8815 approximately

- Ownership – All private
- Solution
  - Consider and evaluate a centralized residuals (solids and liquid) treatment facility to service the treatment systems around Lake Isabella
- Approximate Capital Cost (application, design, capital facilities) : $TBD
- Capital Cost per connection (population): $TBD
- Challenges:
  - Management and funding of the centralized treatment system.
  - Legal and startup issues?

15.2.2 Systems around Cutler (offsite)

- Problem
  - Approximately 4 systems (Yettem, Cutler, East Orosi and Seville) located near each other all have nitrate issues. With these communities all sharing the same nitrate issue in the area, a centralized residuals handling facility is a possibility.
- Number of connections – 1452 approximately
- Population –7476 approximately
- Ownership – Public and private
- Solution
  - Provide a centralized residuals (solids and liquid) treatment facility to service the nitrate treatment systems in the area.
- Approximate Capital Cost (application, design, capital facilities) : $TBD
- Capital Cost per connection (population): $TBD
- Challenges:
  - Management and funding of the centralized treatment system.

15.2.3 Stratford (onsite)

- Problem
  - Stratford could have a coagulation filtration treatment system for arsenic removal. The treatment system will generate a solids waste that must be handled. Stratford is remote enough that onsite treatment of the solid waste would likely be necessary.
- Number of connections – 240

- Population –1215
- Ownership – Public
- Solution
  - Provide a residuals treatment system to treat residuals from the Stratford arsenic removal system.
- Approximate Capital Cost (application, design, capital facilities) : $TBD
- Capital Cost per connection (population): $TBD
- Challenges:
  - Additional O&M to treat and dispose of residuals.
  - Where can residuals be disposed of?

15.2.4 Ducor (onsite)

- Problem
  - Ducor could have a coagulation filtration treatment system for arsenic removal and ion exchange for nitrate removal. The arsenic treatment system will generate a solids waste that must be handled. The nitrate system will generate a brine waste to be handled. Ducor is remote enough that onsite treatment of the waste generated would likely be necessary.
- Number of connections – 102
- Population –411
- Ownership – Private
- Solution
  - Provide a residuals treatment system to lower the volume of residuals to be disposed of from the Ducor treatment systems.
- Approximate Capital Cost (application, design, capital facilities) : $TBD
- Capital Cost per connection (population): $TBD
- Challenges:
  - Additional O&M to treat and dispose of residuals.
  - Where can residuals be disposed of?

15.3 Water/Energy Efficiency Technology

15.3.1 Ivanhoe

- Problem

  - Ivanhoe has 6 wells to supply water to their system. There is the possibility the existing pumps and motors can be modified or replaced with more energy efficient units.
- Number of connections – 1174
- Population – 4,474
- Ownership – Public
- Solution
  - Install energy efficient pumps, VFDs, and/ or energy efficient motors.
  - Lower electrical costs associated with pumps.
- Approximate Capital Cost (application, design, capital facilities) : $TBD
- Capital Cost per connection (population): $TBD
- Challenges:
  - Funding
  - Evaluation of existing pumps

15.3.2 Woodward Bluffs Mobile Home Park

- Problem
  - Woodward Bluffs has 1 well to supply water to their system. There is the possibility the existing pump and motor can be modified or replaced with more energy efficient units.
- Number of connections – 167
- Population – 300
- Ownership – Private
- Solution
  - Install energy efficient pumps, VFDs, and/ or energy efficient motors.
  - Lower electrical costs associated with pumps.
- Approximate Capital Cost (application, design, capital facilities) : $TBD
- Capital Cost per connection (population): $TBD
- Challenges:
  - Funding
  - Evaluation of existing pumps

15.4 Less Expensive Water Treatment Technology & Blending

15.4.1 Arvin Community Services District

- Problem
  - Arvin has 6 wells. Some of the wells are high in arsenic and/or nitrates. There is the potential to treat both arsenic and nitrates with ion exchange and then use the remaining wells for blending.
- Number of connections – 3536
- Population – 14,713
- Ownership – Public
- Solution
  - Provide ion exchange for arsenic and nitrates at certain wells. Blend in remaining wells with the treated water.
- Approximate Capital Cost (application, design, capital facilities) : $TBD
- Capital Cost per connection (population): $TBD
- Challenges:
  - Funding
  - Disposal of residual brine wastes.

15.4.2 Lebec

- Problem
  - Lebec has 3 wells. Some of the wells are high in uranium and fluoride. There is the potential to treat uranium and fluoride with adsorption and then use the remaining wells for blending.
- Number of connections – 243
- Population – 1,285
- Ownership – Public
- Solution
  - Provide adsorption for uranium and fluoride at certain wells. Blend in remaining wells with the treated water.
- Approximate Capital Cost (application, design, capital facilities) : $TBD
- Capital Cost per connection (population): $TBD

- Challenges:
  - Funding
  - Disposal of regeneration wastes.

15.5 Biological Nitrate Treatment

15.5.1 Traver

- Problem
  - Traver has 2 wells. Both wells are high in nitrates. Since nitrate is the only pollutant of concern, Traver may be a good site to evaluate biological nitrate treatment.
- Number of connections – 180
- Population – 732
- Ownership – Private
- Solution
  - Biological nitrate treatment to meet the water quality standard for nitrate.
- Approximate Capital Cost (application, design, capital facilities) : $TBD
- Capital Cost per connection (population): $TBD
- Challenges:
  - Funding
  - Operation of the biological system.
  - Land needed for biological system.
  - CDPH approval of biological nitrate removal.

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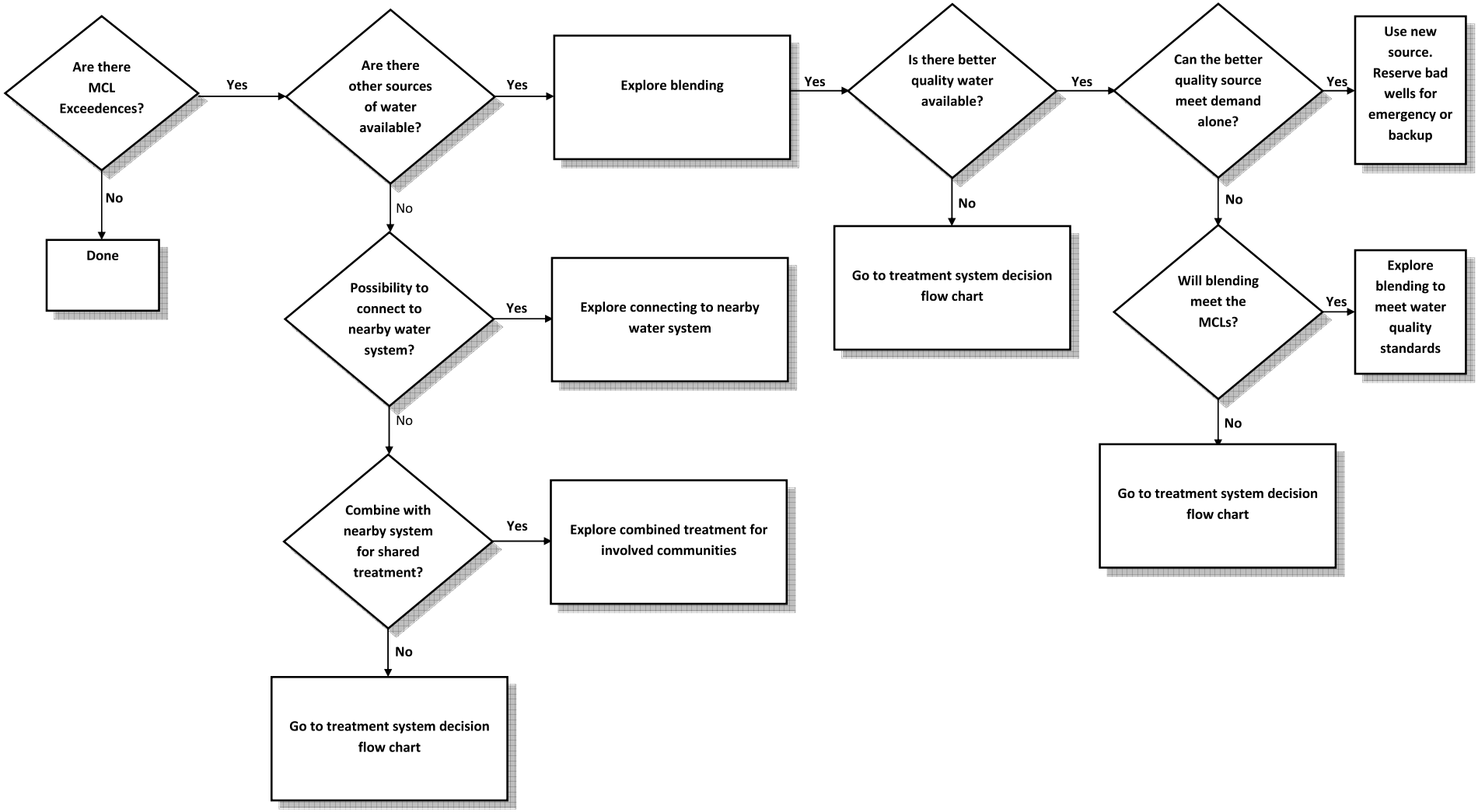
APPENDIX

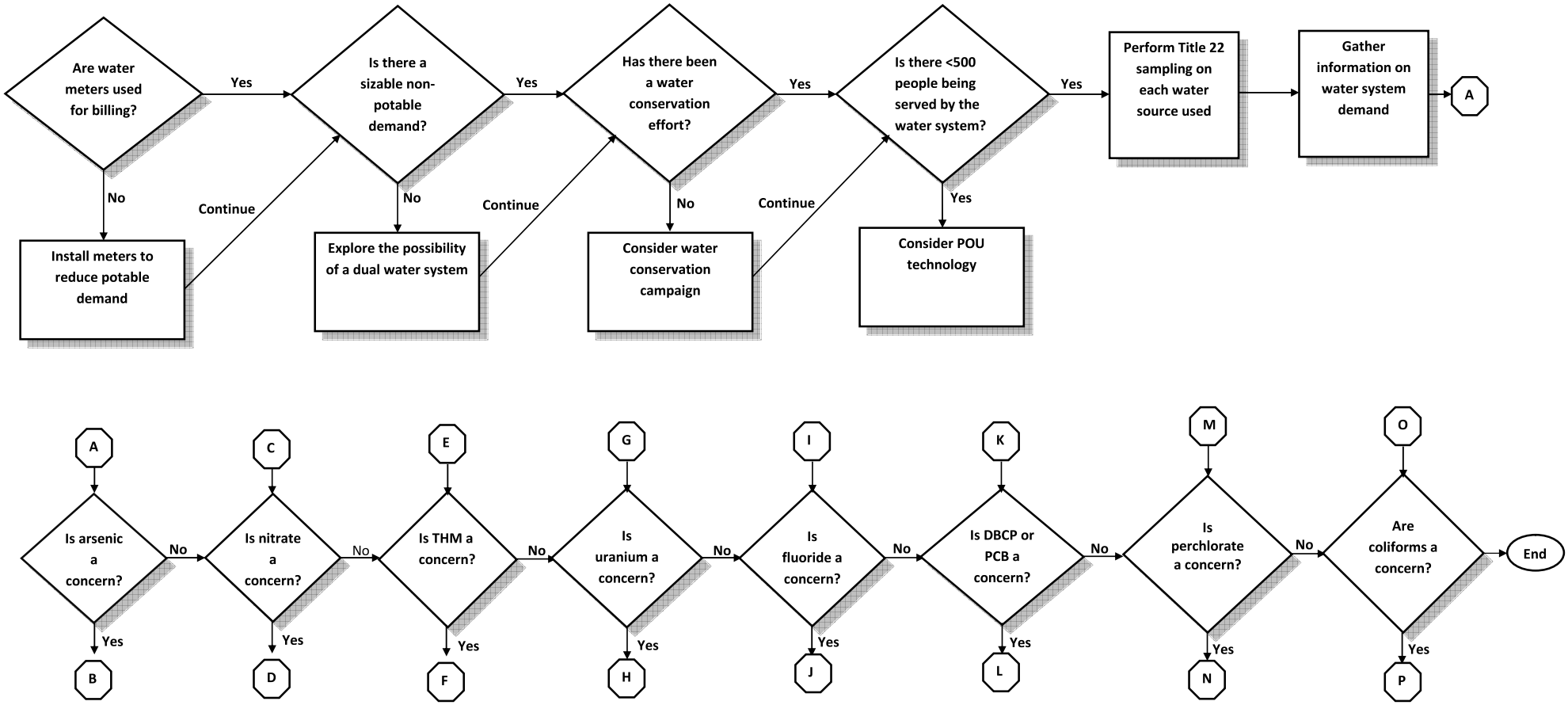
Appendix A, Figure A1

TECHNICAL SOLUTIONS EVALUATION



Appendix A, Figure A1

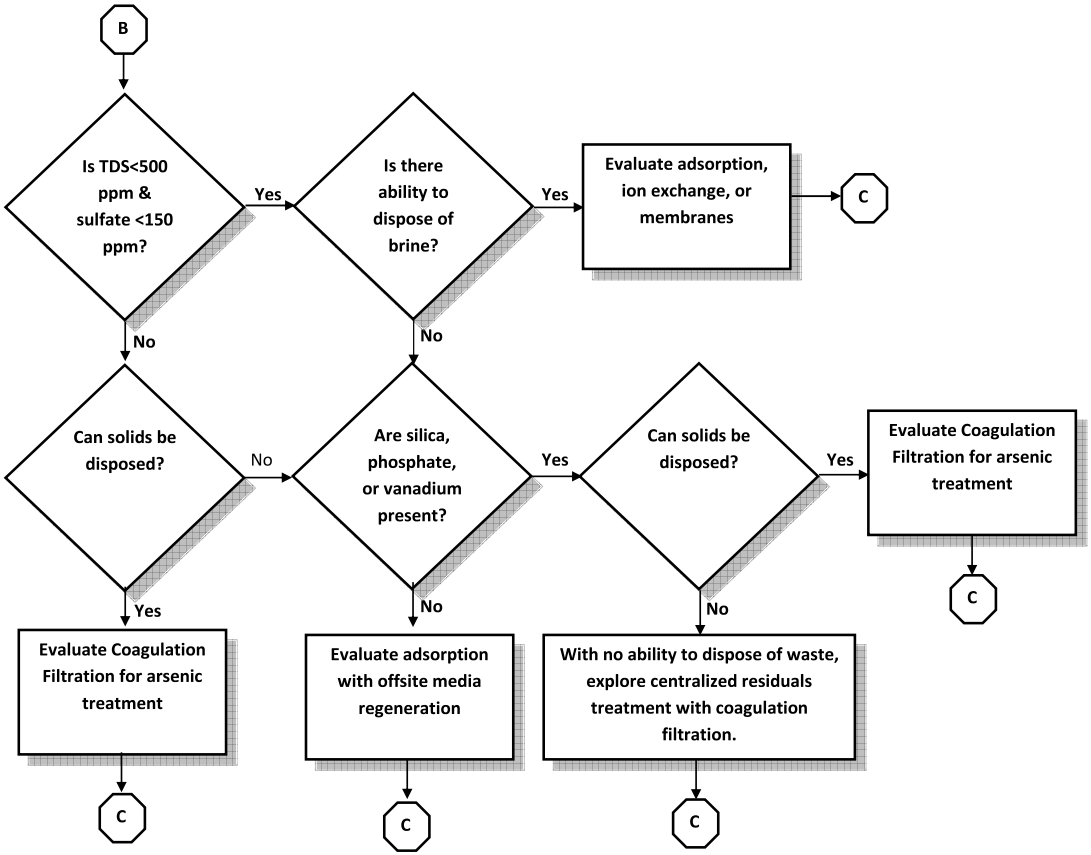
TECHNICAL SOLUTIONS EVALUATION



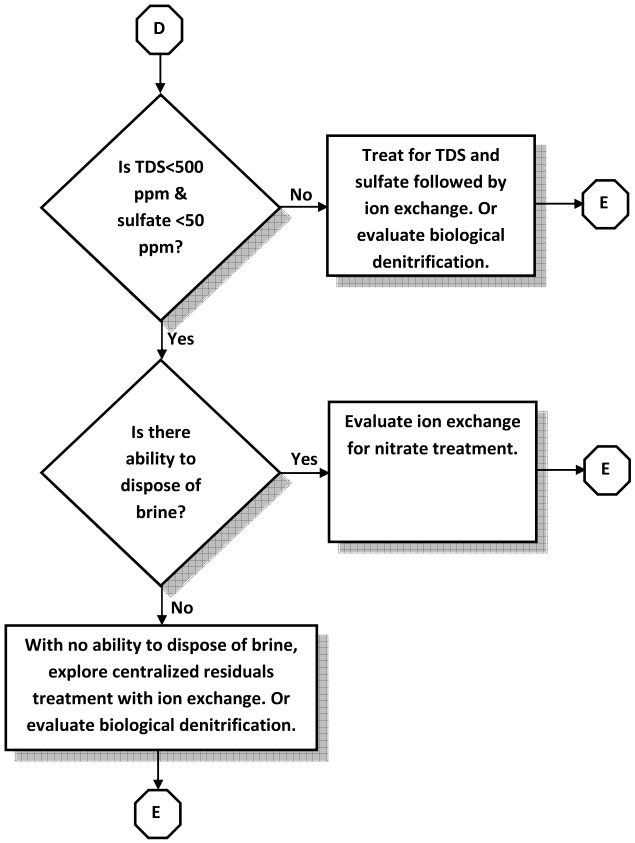
Appendix A, Figure A1

TECHNICAL SOLUTIONS EVALUATION

Arsenic Treatment



Nitrate Treatment



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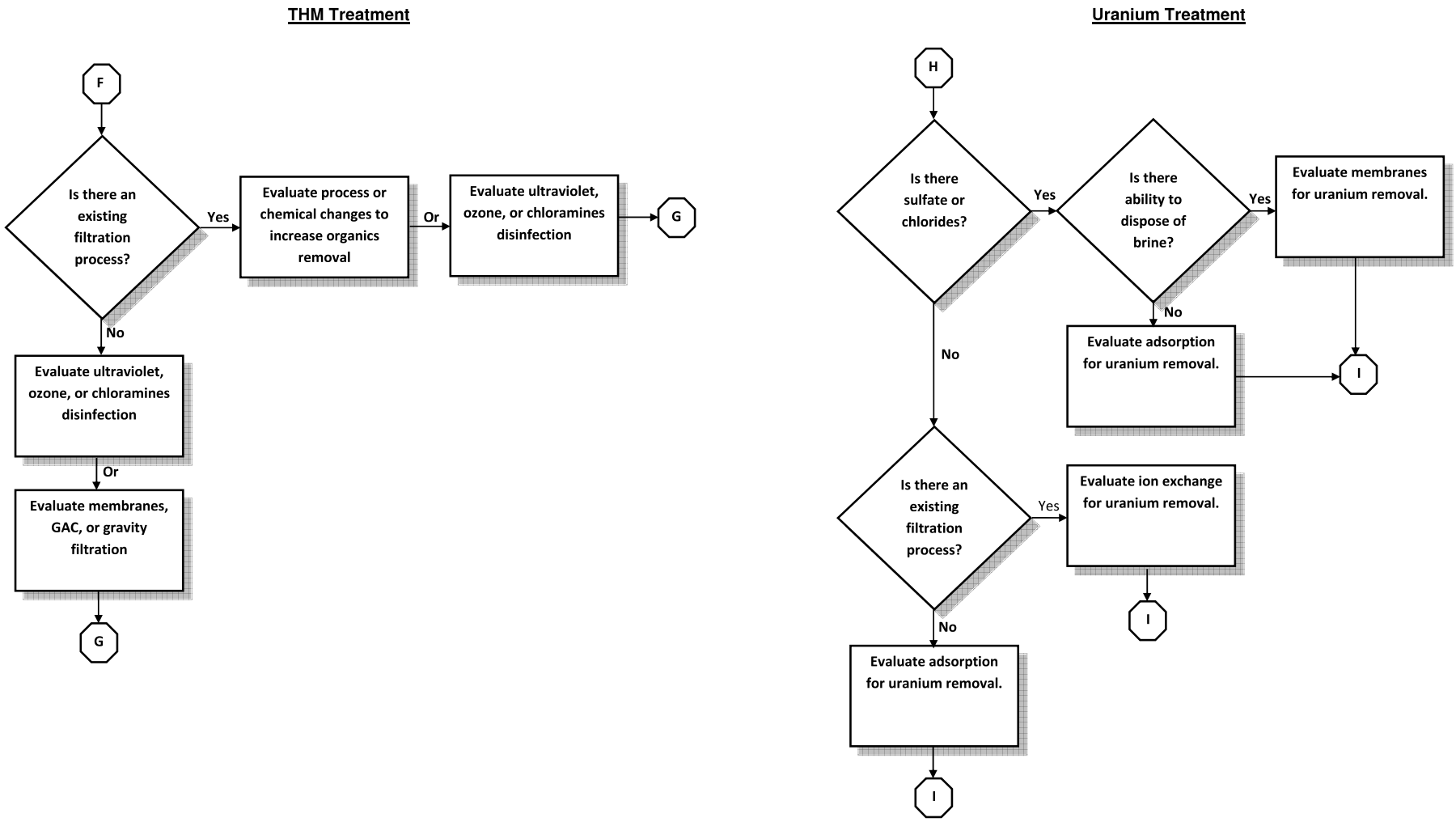

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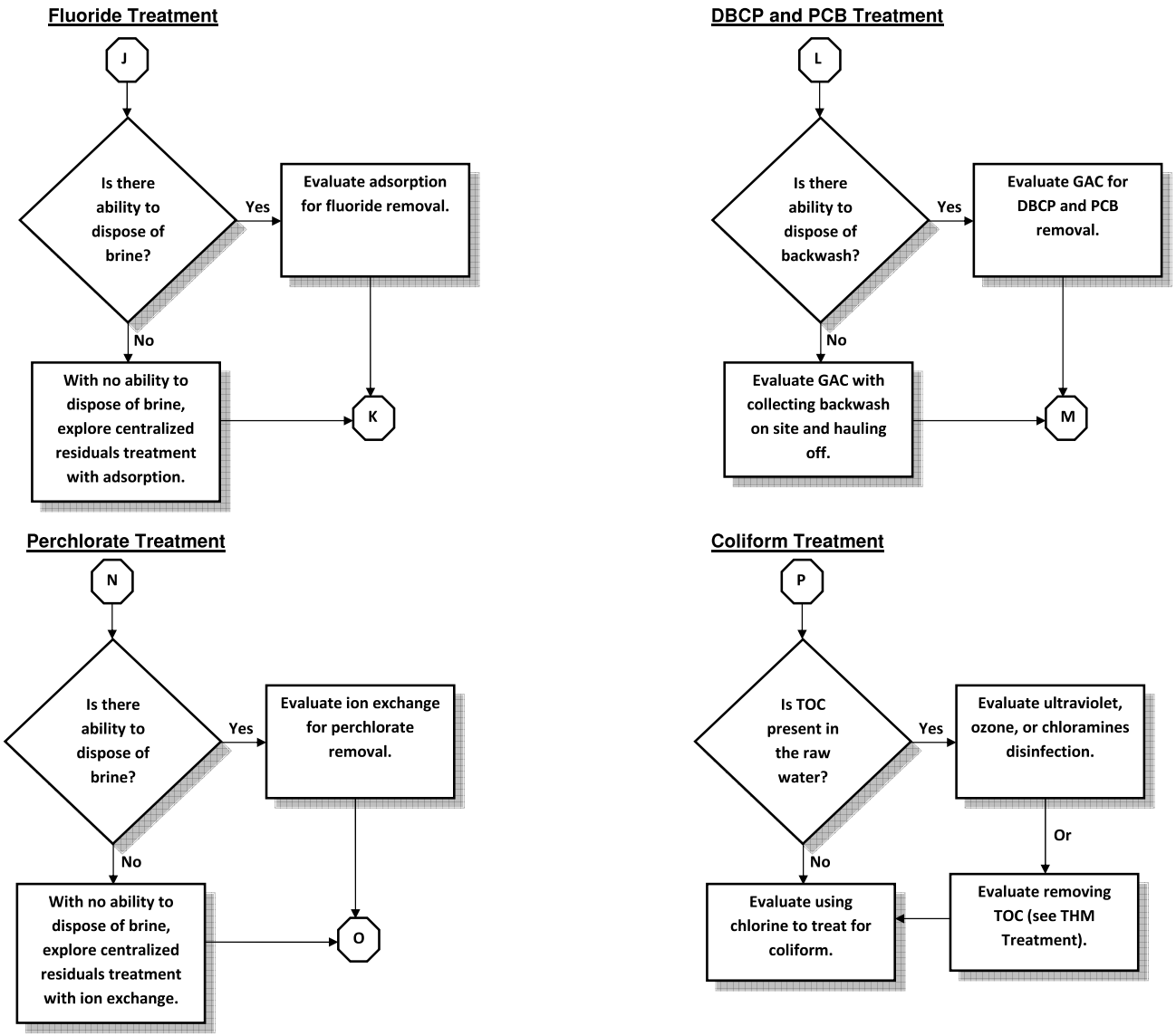
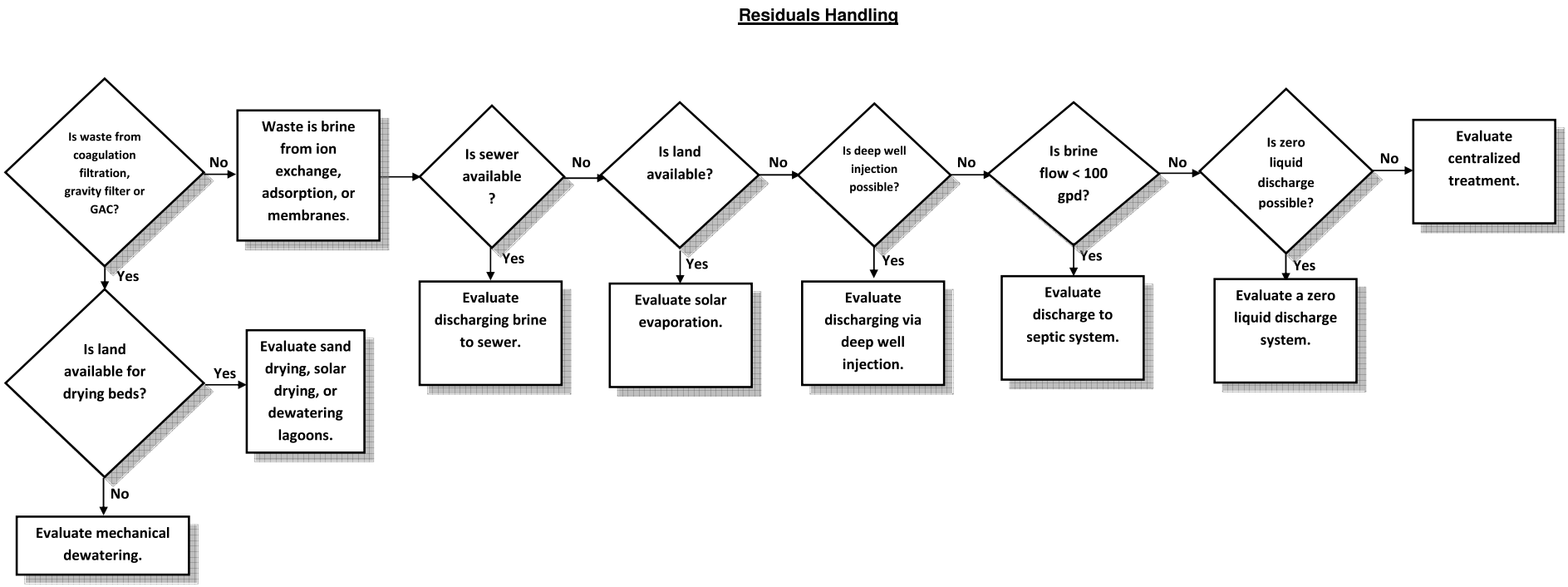
TECHNICAL SOLUTIONS EVALUATION



Appendix A, Figure 2

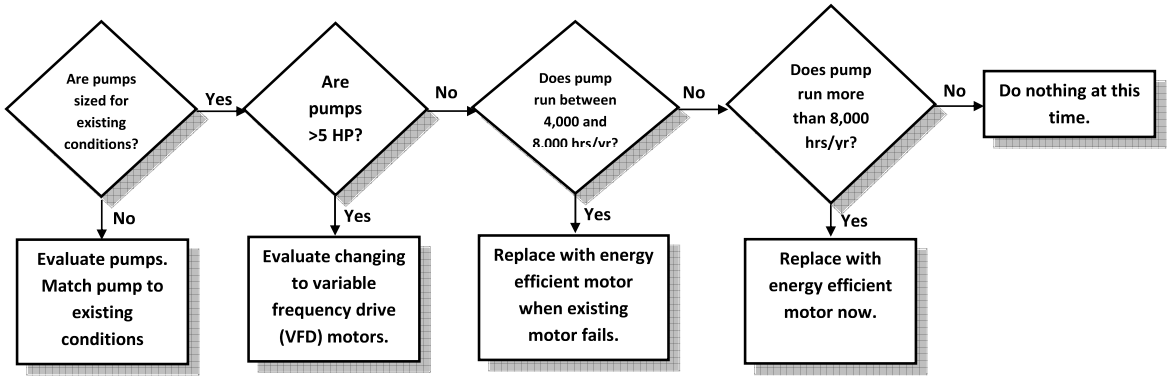
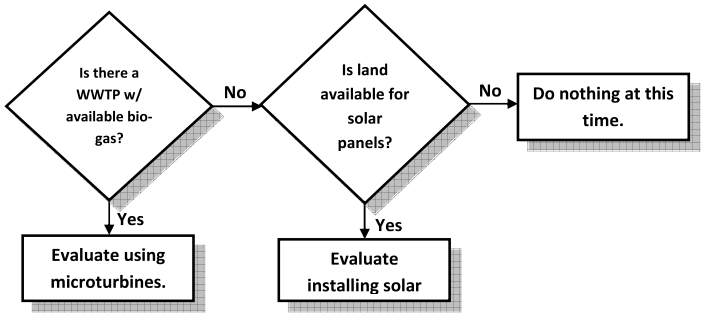
RESIDUALS HANDLING EVALUATION



Appendix A, Figure 3

ENERGY CONSERVATION EVALUATION

Energy Conservation



Renewable Energy