DRINKING WATER into the 21st Century

Safe Drinking Water Plan for California
A Report to the Legislature

January 1993
Office of Drinking Water
California Department of Health Services

Governor Pete Wilson
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ABBREVIATIONS AND UNITS

Abbreviations

AAEE	American Academy of Environmental Engineers
AB	Assembly Bill
ACWA	Association of California Water Agencies
AEEP	Association of Environmental Engineering Professors
AEWSD	Arvin-Edison Water Storage District
AL	Action Level
ASCE	American Society of Civil Engineers
ASDWA	Association of State Drinking Water Administrators
AWWA	American Water Works Association
AWWARF	American Water Works Association Research Foundation
BAT	Best Available Technology
CCP	Composite Correction Program
CCR	California Code of Regulations
CDC	Center for Disease Control
CDFA	California Department of Food and Agriculture
CDHS	California Department of Health Services
CEQA	California Environmental Quality Act
COP	Certificate of Participation
CPE	Comprehensive Performance Evaluation
CRWA	California Rural Water Association
CSDA	California Special Districts Association
CVP	Central Valley Project, federal
DBP	Disinfection By-Product
DHCD	Department of Housing and Community Development, California
DOC	Department of Corporations, California
DRL	Detection Limit for Purposes of Reporting
DWR	Department of Water Resources, California
ECWG	Emergency Clean Water Grant
EETS	Environmental Epidemiology and Toxicology Section
ELAP	Environmental Laboratory Accreditation Program, CDHS
FDB	Food and Drug Branch, CDHS
FHA	
FmHA	Farmers Home Administration
FRDS	Federal Reporting Data System
GAC	Granular Activated Carbon

GC	Gas Chromatography
GC-HRMS	Gas Chromatography-High Resolution Mass Spectrometry
GC-MS	Gas Chromatography-Mass Spectrometry
GIS	Geographical Information Systems
GO	General obligation
HHAD	Health Hazard Assessment Division, CDHS
HPLC	High Performance Liquid Chromatography
HSC	Health and Safety Code, California
HUD	Housing and Urban Development, federal
IARC	International Agency for Research on Cancer
ICP-AES	Inductively Coupled Plasma-Atomic Emission Spectrometry
ICP-MS	Inductively Coupled Plasma-Mass Spectrometry
IX	Ionexchange
LACSD	Los Angeles County Sanitation District
LADWP	Los Angeles Department of Water and Power
LAFCO	Local Agency Formation Commission
LEHJ	Local Environmental Health Jurisdiction
LOAEL	Lowest-Observed-Adverse-Effect-Level
MCL	Maximum Contaminant Level
MFT	Membrane Filter Technique
MHP	Mobile Home Parks
MTFT	Multiple Tube Fermentation Technique
MWD	Metropolitan Water District of Southern California
NAS	National Academy of Science
NIPDWR	National Interim Primary Drinking Water Regulation
NOAEL	No-Observed-Adverse-Effect-Level
NTP	National Toxicology Program
O&M	Operation and Maintenance
OCWD	Orange County Water District
ODW	Office of Drinking Water
OPR	Office of Planning and Research, California
OTA	Office of Technology Assessment
PICME	Permits, Inspections, Compliance, Monitoring, and Enforcement
PMCL	Proposed Maximum Contaminant Level
POE	Point of Entry
POU	Point of Use
PQL	Practical Quantitation Limit
PTA	Packed Tower Aeration
PUC	Public Utilities Commission, California
PWTF	Public Works Treatment Fund
PY	Person year
RPHL	Recommended Public Health Level

RO	Reverse Osmosis
RWQCB	Regional Water Quality Control Board
SAP	Scientific Advisory Panel
SB	Senate Bill
SDWA	Safe Drinking Water Act
SDWBL	Safe Drinking Water Bond Law
SDWP	Safe Drinking Water Plan
SOC	Synthetic Organic Chemical
SRF	State Revolving Fund
SWEEPS	Statewide Environmental Evaluation Program System
SWP	State Water Project, California
SWRCB	State Water Resources Control Board
SWTR	Surface Water Treatment Regulation, California
TEM	Transmission Electron Microscopy
TR	Treatment Requirement
TSCD	Toxics Substance and Control Division, CDHS
USDI	United States Department of the Interior
USEPA	United States Environmental Protection Agency
Uv	Ultraviolet
VOC	Volatile Organic Chemical
WQI	Water Quality Inquiry
WQIP	Water Quality Improvement Plan
WQM	Water Quality Monitoring

Microbial Agent and Chemical Names

DBCP	1,2-Dibromo-3-chloropropane
EDB	Ethylene Dibromide
HPC	Heterotrophic Plate Count
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCE	Perchloroethylene (tetrachloroethylene)
TCE	Trichloroethylene
THM	Trihalomethane
TOC	Total Organic Carbon
TTHM	Total Trihalomethanes

Units

10^{-4}	one in ten thousand
10^{-5}	one in one hundred thousand
10^{-6}	one in one million
cf	cubic feet

gpm	gallons per minute
kg	kilogram
μg/L	micrograms per liter
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
MGD	million gallons per day
mL	milliliter
ng/L	nanograms per liter
NTU	nephelometric turbidity units
pCi/L	picocuries per liter
yr	year
psi	pounds per square inch
g	grams
gpd	gallons per day
gpcd	gallons per capita per day
gpm/ft^2	gallons per minutes per square foot

EXECUTIVE SUMMARY

BACKGROUND

California is a populous state that receives minimal rainfall. The supply, delivery, and regulation of drinking water is an important and sensitive issue. To date, the quality of California's drinking water has been good, and the state has been considered a leader in protecting water quality. But population growth, industrial expansion, agricultural intensification, and greater demand for existing water supplies are beginning to make drinking water protection more difficult. Improved laboratory detection capabilities and a better understanding of health risks have created an awareness that certain contaminants pose risks to the public health that were previously unknown or not well understood. This same awareness has also spawned a multitude of laws and regulations regarding drinking water.

This new understanding of the risks associated with drinking water combined with an acute awareness of the vulnerability of California's water supplies brought about by several consecutive years of drought prompted the California Legislature to enact Assembly Bill (AB) 21 (Chapter 823 statutes of 1989), in 1989. Among other things, AB 21 directed the California Department of Health Services (Department) to undertake a comprehensive assessment of drinking water in California: its quality and safety, types of problems, overall health risks, current and projected costs, and current regulatory programs. From this assessment, the Department was directed to develop a plan containing specific recommendations to resolve any problems and improve the overall quality and safety of California's drinking water. This legislative assignment has been completed and is presented in this Executive Summary, a Summary of Conclusions and Recommendations, and the detailed Safe Drinking Water Plan report.

Drinking water is supplied to California residents through a myriad of governmental agencies, cities, districts, private utilities, mutual water companies, private businesses, and individually owned wells. There are over 10,000 public water suppliers (as defined by law) in the state serving water to approximately 29 million consumers. In addition, over 300,000 residents obtain their water from private individual wells. The water utilities range in size from a minimum of 5 service connections to more than 700,000 service connections. Less than 10% of the public water systems in the state serve collectively more than 95% of the state's population. The remaining 90% of the systems serve less than 5% of the population. Approximately 70% of the population obtains its drinking water from surface sources with the remainder relying on ground water supplies.

WATER QUALITY AND HEALTH RISKS

California's drinking water quality is generally of excellent quality. The combination of a low percentage of sources exceeding a maximum contaminant level (MCL) and a high rate of compliance by water systems meeting the drinking water standards indicates that the water being delivered is pure, wholesome, and potable. But, this is not to say that no significant contamination problems exist. These problems, however, tend to be regional and very specific and are discussed in detail in the report. In surface water, for example, the most common and most significant contaminants of concern are microbial pathogens and disinfection by-products. The most prevalent contaminant in ground water, according to the Department's sampling data, is nitrate, which exceeded the drinking water standard in 2.1% of the sources. The agricultural chemical 1,2-dibromo-3-chloropropane (DBCP) exceeded the drinking water standard for DBCP in 1.4% of the wells. Trichloroethylene (an industrial chemical) exceeded the standard in 0.9% of the wells.

The detection of chemical contaminants in ground water sources has resulted in extensive media coverage which has heightened consumer concerns. The public perception of the degree of risk associated with drinking water contaminated with industrial or agricultural chemicals appears to be higher than the actual risks as determined by scientific evidence to date. The risk associated with chlorinated surface water and some of the more recently discovered pathogens, for example, is far greater than the risk presented by chemicals in ground water, yet it receives little public attention or concern. Consumer confidence in public water supplies has appeared to deteriorate in recent years; 50% of the water consumers in many urban areas in the state now use bottled water or home treatment devices. Much of this, according to surveys, is a result of taste or odor problems and perceived health risks. It has been estimated that approximately one billion dollars are spent annually in California for bottled water.

The United States Environmental Protection Agency (USEPA) and the Department recently have adopted numerous new standards and requirements to ensure the safety of drinking water supplies. Additional requirements, including regulations governing surface water treatment, coliform monitoring, lead and copper, and additional contaminants will go into effect within the next few years. California's standards are, in many cases, more stringent than those adopted by the USEPA. At the present time, California is recognized as having the most stringent drinking water requirements in the country. The cost of complying with these new requirements is substantial. It is estimated that initial capital costs for treatment and other improvements will be in excess of two billion dollars statewide. These costs will have a greater impact on smaller water systems.

THE COST OF WATER

According to a survey conducted for this report, the average monthly water bill paid by a California resident is currently $21.30 per month. This cost tends to increase as the size of the water system decreases with small system customers paying an average unit water rate that is 50% higher than that paid by larger system customers. Complying with the new requirements is expected to add $6 to $55 per month, depending on system size, to the current statewide average water bill by the mid-1900s. In spite of these increased costs, water is an undervalued commodity and has not kept pace with cost increases experienced in other utilities such as energy. As a result, drinking water systems, especially the smaller and mid-sized systems, are undercapitalized and find it difficult to finance system improvements, maintenance, and infrastructure.

DRINKING WATER REGULATION

The regulation of drinking water in California has been successfully carried out, as demonstrated by the lack of documented illnesses caused by drinking water. Throughout the nation, there have been 250 outbreaks (61,000 cases of illness) of waterborne gastroenteritis during the past decade. None of these occurred in California community water systems.

Despite this success, the California drinking water regulatory program can, and should be, improved. For example, the regulation of drinking water is currently fragmented between state and local governments. The state regulates public water systems serving more than 200 service connections whereas counties regulate systems serving fewer than 200 connections. This arrangement, which worked reasonably well in years past, has created difficulties in implementing the new requirements. These implementation problems, which relate to adequate resources, accountability, and consistency, have recently led to a threat of primacy withdrawal by the USEPA unless the state laws were changed. AB 2158, (Chapter 1182, Statutes of 1990) enacted in 1990, partially addressed the fragmentation problem between the state and local governments, but further coordination is still needed.

As the report clearly points out, many of the problems regarding compliance with standards, lack of resources, large cost impacts, and risk to consumers relate to the more than 9,000 small water systems that serve less than 200 service connections. Less than 50% of these small systems meet current state drinking water standards and requirements. The situation for small water systems will become much worse as the new requirements are implemented. Nearly one million persons, consisting primarily of workers, school children, and individual residents, are served by these small systems on a daily basis. Given the high rate of noncompliance, these persons, and the millions of visitors using these systems, are subject to risks of waterborne illness from microbial contaminants.

PROBLEMS AND SOLUTIONS

Many of the smaller water systems in California will be unable to comply with new state and federal requirements due to lack of financial resources. Their inability to finance ongoing maintenance and capital improvements is a testament to the lack of adequate planning and financial requirements for public water systems. The fact remains, however, that they are in existence and present what is perhaps the most difficult drinking water problem that needs to be addressed. The report outlines a comprehensive strategy and a series of legislative recommendations to attempt to cope with the problems associated with the small systems. The strategy will help to eliminate the proliferation of new nonviable water systems. This strategy includes recommendations for better planning at the regional or local level, consolidation of existing systems, criteria for creation of new systems, and the provision for technical and financial assistance.

Looking to the future, the Department's assessment indicates a serious lack of coordinated planning for water supply at the local level. The state Department of Water Resources has done a good job of water supply planning on a statewide basis particularly in regards to storage and interbasin transfer. The current deficiency, however, is that adequate consideration has not been given to protecting our water resources from quality degradation associated with certain land uses. Comprehensive planning to ensure reliable drinking water supplies has not taken place on a local or regional level. This is an area which, in the opinion of the Department, is in need of legislative direction.

In summary, California has had a good track record in regulating and managing its drinking water. Improvements, however, must be made for California to cope with its burgeoning population and dwindling water supplies. In order to continue to promote the health of its citizens, California must direct attention toward the following issues:

- Greater integration of water supply and water quality planning and regulatory activities at the state level.
- Recognition of the need to address water supply and drinking water quality in land use planning.
- Coordination of long-range water supply planning at the local and regional level.
- Better master planning for the future by water utilities.
- Addressing the problems of small water systems including the lack of financial and technical resources.
- Developing greater reliability and improved protection of the sources of domestic water supply.
- Improving our knowledge of contaminants and their effect on human health.
- Improving consumer knowledge and understanding of drinking water quality issues.

Specific and more detailed recommendations to address these issues are described in the Summary of Conclusions and Recommendations. Detailed background discussion of the programs, problems, and issues associated with the drinking water program, as well as th basis and justifications for the conclusions and recommendations, are presented in the main report entitled, *"Drinking Water into the 21st Century: Safe Drinking Water Plan for California."*

ACKNOWLEDGMENTS

There are many individuals, organizations, and groups that have contributed to the development of the *Drinking Water into the 21st Century, Safe Drinking Water Plan for California.* The members of the Safe Drinking Water Plan Team are gratefully acknowledged for their contributions in ideas, constructive comments, research, and long hours. Team members chaired the Small Water System Advisory Group and the following subcommittees; Finance, Health Risks, Water Quality Monitoring and Analytical Methods, Information Systems, Water Treatment Technologies, State and Local, and Water Quality.

The assistance and contributions provided by individuals, organizations, and groups participating in the subcommittees are also acknowledged. The individuals, organizations, and groups included: a member of a county board of supervisors; representatives from state, county, and local governmental agencies; representatives from water utilities, engineering consultants, water utility organizations, associations of mutual and private water utilities, water utility assistance organizations, and associations of county governmental agencies; staff from the Department's Division of Laboratories and Health Hazard Assessment Division; and Office of Drinking Water field and technical staff.

The Drinking Water Technical Advisory Committee's assistance, review, and constructive comments contributed greatly to the final development of this report. The water utilities, accredited drinking water laboratories, and local environmental health jurisdictions that participated in the surveys for this report are also acknowledged for their contribution. Finally, the Office of Drinking Water field, technical, and word processing staff are acknowledged for their time and efforts in the review and final construction of this report.

CHAPTER I

INTRODUCTION

The drought in California has brought the crisis of water *quantity* to the forefront of everyone's thoughts. Historically, the most prominent issues in water rights have developed around questions of quantity rather than *quality* because civilizations have always sought title to sufficient water quantity to survive. McGauhey (1968) made the point that the concept of water quality, as a dimensional aspect of water (that requires precise measurement), is of recent origin. Indeed, since about the turn of the century, water quality standards in the United States have been gradually evolving in complexity. With each new set of standards, the ability to define water quality and to ensure that it meets the statutory requirements of being "pure, wholesome, and potable," becomes better refined and more precise.

Water quality standards are not refined overnight, but come about through years of research and experience. As the development of analytical tools enables scientists and public health officials to identify the causes of waterborne disease, and as engineers develop new technologies to remove or prevent these agents from entering the water supply, regulators are becoming better equipped to define, with more precision, the term "pure, wholesome, and potable." Therefore, by necessity, regulation development is a slow evolutionary process.

Water quality problems have been documented throughout history. McGaughey (1968) writes that the first Roman aqueduct was not built in response to a lack of water near the cities, but rather in response to localized contamination of the surface and ground water supplies that were fouled to the point of being aesthetically unacceptable. Much more recently, in 1914 the United States developed the United States Public Health Standards, which stressed bacteriological water quality (AWWA 1971). As these standards were revised in 1925, 1942, 1946, and 1962, they came to include chemical constituents such as lead, fluoride, and arsenic.

In 1974, Congress passed the Safe Drinking Water Act (SDWA). Under the federal SDWA regulatory control of the federal drinking water program was transferred from the United States Public Health Service to the USEPA with the requirement to develop more specific standards for organic chemicals and secondary (aesthetic) compounds. USEPA continued to promulgate water quality standards under Congressional direction with the passage of the federal SDWA Amendments of 1986 (AWWA 1990).

Both the regulators and water utilities recognize that the health benefits of meeting these standards will be reflected by a decreased number of waterborne illnesses (from microbial pathogens and chemical contaminants) related to drinking water. Ever since the first use of chlorine in the early 1900s, as a means to disinfect drinking water for consumption the cases of waterborne illness due to microbial pathogens has dramatically decreased. However, with the increasing concern over chemical contamination the benefits are harder to measure. In the case of reducing chemical contamination, the benefits may not be readily apparent to consumers, since these benefits will be spread over many years as a result of the reduction in the risk of chronic health effects, such as cancer, which sometimes take a lifetime to develop. Therefore, the effectiveness and impact of regulatory programs will not always be observed immediately, and every few years the regulatory agency responsible for drinking water quality standards should examine and evaluate the effectiveness of the program in order to determine future courses of action. The California Legislature has given the Department's, Office of Drinking Water, (ODW) such an opportunity, by requesting the Safe Drinking Water Plan for California.

To improve the drinking water program in California, the Safe Drinking Water Plan for California has outlined individual program elements that will meet this end. These elements, if implemented individually, may not resolve the overall problems outlined. Only through coordinated implementation of all program elements will the drinking water program become a cohesive program with a direction of improving drinking water quality in California. The Department is confident that the program elements outlined herein, in conjunction with the existing program, can provide consumers with the highest quality of drinking water in the nation.

A. HISTORY OF DRINKING WATER PROGRAM IN CALIFORNIA

1. Broad Overview of Water Supply Program

California's drinking water program has deep historical roots in the public health program in California. The State Board of Health was created by the California Legislature in April 1870, as the result of several major disease epidemics. The creation of the State Board of Health established only the second official health agency at the state level in the United States at that time.

The transmission of disease by waterborne agents necessitated the State Board of Health in 1913 to secure the services of Professor C. G. Hyde of the University of California at Berkeley as a consulting sanitary engineer. Due to the success of the sanitary engineering program, the Legislature established the Bureau of Sanitary Engineering along with water and sewage permit laws in 1915.

The Bureau of Sanitary Engineering had numerous responsibilities which included: vector control; recreational water quality; wastewater discharges; beach surveys; shellfish harvesting sanitation; use of reclaimed wastewater; program of sewage treatment plant surveillance; conducting special investigations, studies and grants; and bottled water. Over the years the responsibilities changed due to various factors, but the drinking water program continued to be its main focus.

With the changing of responsibilities over the years, the drinking water program also had its title changed several times. From the Bureau of Sanitary Engineering the program was changed to the Water Sanitation Section then to the Sanitary Engineering Section, to the Sanitary Engineering Branch, to the Public Water Supply Branch, and finally to Office of Drinking Water.

The early laws and regulations governing water systems in California were patterned after the United States Public Health Service Standards. The passage of the federal SDWA of 1974, Public Law 93-523, established mandatory nationwide minimum standards to be established and enforced by the USEPA. In order to be delegated authority for enforcement of the federal SDWA and to continue to maintain its own pre-eminent drinking water program, California adopted its own Safe Drinking Water Act in 1976. Since 1976 the Department has been responsible for the administration of the federal SDWA in California. Under this program, the USEPA has delegated primacy to ODW.

Today ODW has responsibility for over 8,950 public water systems throughout the state. ODW directly regulates over 1,450 large and small public water systems with a staff of about 150 engineers and technicians working in 12 locations around the state. The regulation of over 7,500 small public water systems is delegated to the various Local Environmental Health Jurisdictions (LEHJs) at the county level with a staff level of 45 to 50 person years.

B. INTRODUCTION - HISTORY OF AB 21

On September 13, 1989, the California Legislature passed AB 21 which the governor signed into law on September 25, 1989. This law, which adds several amendments to the California SDWA is referred to as the Safe Drinking Water Act of 1989, Chapter 7, Health and Safety Code (HSC). One of these amendments requires that ODW prepare a Safe Drinking Water Plan on the status of the drinking water program in the State of California with specific recommendations for improvement and a plan to implement those recommendations.

The California Legislature, with the adoption of AB 21, has expressed concern over several drinking water issues that affect all Californians. These issues have been incorporated into the California SDWA under Section 4022, HSC.

1. SDWA Requirements

Section 4022, HSC, specifies the contents and requirements of the Safe Drinking Water Plan which are as follows:

"4022. (a) On or before July 1, 1991, the department shall submit to the Legislature a comprehensive Safe Drinking Water Plan for California.

(b) The Safe Drinking Water Plan shall include, but not be limited to, the following information:

(1) An analysis of the overall quality of California's drinking water and identification of specific water quality problems.

(2) Types and levels of contaminants found in public drinking water systems which have less than 10,000 service connections. The discussion of these water systems shall include the following:

(A) Estimated costs of requiring these systems to meet primary drinking water standards and recommended public health levels.

(B) Recommendations for actions which could be taken by the Legislature, the department, and these systems to improve water quality.

(3) A discussion and analysis of the known and potential health risks that may be associated with drinking water contamination in California.

(4) An evaluation of how existing water quality information systems currently maintained by local or state agencies can be more effectively used to protect drinking water.

(5) An evaluation of the research needed to develop inexpensive methods and instruments to ensure better screening and detection of water borne chemicals, and inexpensive detection methods which could be used by small utilities and consumers to detect harmful microbial agents in drinking water.

(6) An analysis of the technical and economic viability and the health benefits of various treatment techniques which can be used to reduce levels of trihalomethanes, lead, nitrates, synthetic organic chemicals, micro-organisms, and other contaminants in drinking water.

(7) A discussion of alternative methods of financing the construction, installation, and operation of new treatment technologies, including, but not limited to user charges, state or local taxes, state planning and construction grants, loans, and loan guarantees.

(8) A discussion of sources of revenue presently available, and projected to be available, to public water systems to meet current and future expenses.

(9) An analysis of the current cost of drinking water paid by residential, business, and industrial consumers based on a statewide survey of large, medium, and small public water systems.

(10) Specific recommendations, including recommendations developed pursuant to paragraph (6), to improve the quality of drinking water in California and a detailed five-year implementation program."

2. Intent of Safe Drinking Water Plan

In the development of the plan, ODW addressed the 10 specific items listed in Section 4022, HSC, within the timeframe established and with the resources available. The Safe Drinking Water Plan also provides the most current comprehensive assessment of the drinking water issues and problems facing California.

C. SCOPE OF REPORT

To prepare this report a team of ODW staff was established. To address the 10 issues under Section 4022, HSC, each ODW team member presided over a subcommittee developed specifically to deal with one or more of the issues. Each subcommittee consisted of a variety of technical people consisting of ODW and LEHJ staff, engineering consultants, water utility staff, local government officials, and representatives of other state agencies. Each subcommittee produced detailed draft documents dealing with these specific issues, several of which have been finalized and use in this report. The findings, conclusions, and recommendations from these drafts have been incorporated into this plan report. The subcommittees, issues, and chapters that are addressed are listed in Table 1.1.

Table 1.1 Subcommittee Responsibilities

Subcommittee	Section 4022 Issue	SDWP Chapter
Water Quality	(1), (2), & (10)	III & IV
Health Risk	(3) & (6)	V
Water Treatment	(2), (6), & (10)	VI & VIII
Water Quality Monitoring & Analytical Methods	(2), (5), & (10)	VII & VIII
Financial Aspects	(2), (7), (8), (9), & (10)	VIII
Information Systems	(4) & (10)	IX
State & Local	(2), (4), (7), & (10)	II, IV, V, VI, VII, VIII, IX, & X

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CHAPTER II

CURRENT REGULATION OF DRINKING WATER

A. PRIMARY STATE AND FEDERAL AGENCIES INVOLVED IN DRINKING WATER

1. State Regulatory Agencies

The regulation of water supply, water quality, and the various types of water systems that serve drinking water is fragmented in California. The majority of the statutory authority for regulation of drinking water, however, is in the California Health and Safety Code. Under this code, the Department is ODW has primary responsibility for regulating all public water systems. There are three other state agencies which also regulate certain aspects of specific classes of systems including, (1) the Public Utilities Commission (PUC) for investor-owned systems, (2) the Department of Corporation (DOC) for mutually-owned systems, and (3) the Department of Housing and Community Development (DHCD) for mobile home parks. Additionally, the State Water Resources Control Board (SWRCB), the Secretary of State, and the Department of Real Estate, are also involved in activities impacting public water systems. A brief description is provided below for each of the regulatory agencies including their authority and responsibilities related to the regulation of public water systems.

a. Department of Health Services

Office of Drinking Water

ODW is the federally designated primacy agency for the drinking water program in the State of California, is responsible for the enforcement of the federal SDWA in California, and has overall responsibility for enforcement of the California SDWA as defined in the California Health and Safety Code and Titles 17 and 22, California Code of Regulations (CCR). Regulations have been adopted under these authorities for Drinking Water Standards, Monitoring Requirements, Cross-Connections, Design and Operational Standards, and Operator Certification. The implementation of the program involves: (1) establishment of drinking water standards, (2) certification of operators and point of use treatment devices, (3) co-administration of the Safe Drinking Water Bond Law with the Department of Water Resources

(DWR); and (4) direct regulation of large water systems with oversight responsibility of small water systems. The regulation of large systems includes: (1) issuance of permits covering the approval of water system design and operation procedures, (2) inspection of water systems, (3) the enforcement of regulations to assure that all public water systems routinely monitor water quality and meet current standards, and (4) assuring notification is provided to consumers when standards are not being met.

Division of Laboratories

The Division of Laboratories supports ODW by providing laboratory services, technical support, and laboratory accreditation. Within the Division of Laboratories, the Sanitation and Radiation Laboratory and the Southern California Laboratory provide laboratory support for ODW field staff in analyzing drinking water samples collected for special studies or enforcement cases. The Environmental Laboratory Accreditation Program (ELAP) is responsible for accreditation of drinking water laboratories performing analyses pursuant to the California SDWA.

Health Hazards Assessment Division

The Health Hazards Assessment Division (HHAD) provides assistance to ODW by providing risk assessments on contaminants that drinking water standards are being proposed.

Food and Drug Branch

The Food and Drug Branch (FDB) is responsible for the regulation of bottled water and water sold through vending machines.

b. Public Utilities Commission

PUC regulates private, investor-owned companies and is concerned primarily with rates and levels of service. These companies are owned by investors expecting a return on their investments. Small companies are generally owned by a single individual, corporation, or a partnership. Owners of larger companies are generally investors holding stock shares in the company.

PUC's five commissioners are appointed by the Governor, with consent of the State Senate, for staggered terms of six years each. The PUC's primary source of funding is from a [illegible]% "user fee" that is assessed on the gross operating revenues of the regulated utilities. In carrying out its regulatory responsibilities, the PUC may take testimony, issue orders by formal decisions, cite for contempt, and subpoena witnesses and records.

In brief, the PUC ensures that customers of regulated water utilities receive the best possible service while allowing the utility a reasonable return on its investment. In this regard, its functions can be categorized as: (1) issuing Certificates of Public Convenience, (2) rate setting, and (3) regulation of service.

As a result of mutual concerns with the regulation of investor owned utilities, the PUC and ODW entered into a formal memorandum of understanding in February 1987, to ensure consistency and coordination between the agencies two programs. This memorandum of understanding defines common objectives of the two organizations, principles, agency responsibilities, and project coordination. It has been effective in improving coordination and communication between the two programs but has not fully resolved issues related to reserves for capital improvements, utility master plans to prioritize rate increases, simplification of the PUC process for small systems, and allowable operation and maintenance expenses.

c. Department of Corporations

DOC has responsibility under the Corporate Securities Law of 1968 (Corporations Code Section 25000 *et seq.*) to approve and register the security offering of mutual water companies. Subarticle 7.1 of Article 4 of Subchapter 3 of Title 10, CCR sets forth the standards governing the regulation of mutual water companies. These regulations do not deal with the quality of the drinking water served. Mutual water companies are privately-owned water companies in which each lot owner is entitled to one share per lot that they own. They are managed and operated in accordance with Articles of Incorporation and by laws approved by the DOC and filed with the Secretary of State.

DOC regulations for incorporated mutuals require compliance with DOC system design standards and financial responsibility requirements before DOC will approve the security offering. ODW has also established, in regulation, design and operation standards and is in the process of writing regulations for financial responsibility. DOC regulations require a mutual water company to contact the Director of the Department when it is being formed. The compliance of this requirement is questionable due to a past history of conflicting and duplicative requirements on the regulated water systems. There is no agreement to coordinate ODW and DOC programs and provide for no effective means for conflict resolution.

d. Secretary of State

The role of the Secretary of State with respect to water suppliers deals with the manner by which certain water utilities are incorporated. All non-profit, non-stock corporations organized under the Non-Profit Corporation Law, as embodied in the California Corporations Code, Section 5000 and following, are required to have Articles of Incorporation certified by and on file with the Secretary of State. This includes all mutually-owned water companies as well as homeowners associations, religious, charitable, social, educational, and recreational associations.

e. Department of Housing and Community Development

DHCD is responsible for the regulation of the construction of mobile home parks (MHPs) and employee housing facilities, such as labor camps, many of which have their own independent water systems. The authorizing statues for the DHCDs regulations are the Mobile Home Parks Act and Employee Housing Act with regulations adopted under these statues included in Title 25, CCR.

Regarding MHPs, an issue of concern between ODW and DHCD is in respect to construction standards that require the MHPs to comply with the state's uniform building codes that are less restrictive than ODW's waterworks standards. Because of this, ODW is unable to approve a water system operating permit for MHPs as required by the HSC because the system does not comply with the California Waterworks Standards. This is also expected to hinder regional solutions involving MHPs because of the costs to retroactively bring these systems into compliance.

Regarding its regulation of employee housing, DHCD requires an annual test of the potability of the water delivered to the facility for those with their own water systems. DHCD has not, however, defined the term 'potability' and for the most part, has relied upon certification from LEHJs to assure compliance with this requirement that generally only includes a coliform bacteria test. DHCD does not require a demonstration that the facility has a water system that has received permit approval. This would not be a problem except for the fact that LEHJs have not had the resources to seek out these facilities to ensure that they are on their inventory and have been permitted. As such, they do not inspect or regulate employee housing facilities unless they have been delegated the housing authority from DHCD. As a result, many water systems for such facilities are unregulated.

f. Department of Real Estate

The Department of Real Estate, operating under the authority of the Subdivision Law, is involved in the regulation of water systems through its approval process for the sale of subdivided lands. Subdivision laws enforced by the Department of Real Estate were first enacted in 1931 to ensure that subdividers deliver to buyers what was agreed to at the time of sale. Before real property which has been subdivided can be marketed in California, a public report from the Department of Real Estate must be obtained by the subdivider. The public report discloses pertinent information about a particular subdivision of interest to prospective buyers, including the details of the water system serving the area. Prior to the issuance of a public report, the subdivider must file an application along with supporting documents with respect to representations made in the application.

g. State Water Resources Control Board

SWRCB has two basic functions: protection of water quality and the allocation of water rights. While there would appear to be a significant overlap of authority with ODW with respect to drinking water quality, that is not the case. The SWRCB and the nine Regional Water Quality Control Boards (RWQCB) are primarily concerned with the protection of the quality of ambient surface and ground waters up to the point where the water enters a drinking water well or surface water intake. ODW, on the other hand, has primary regulatory responsibility for the quality of water after it enters the well or intake. SWRCB is the primary agency responsible for protecting the sources of drinking water, (i.e., lakes, rivers, and ground water basins).

2. Federal Agencies

a. United States Environmental Protection Agency

USEPA administers the nationwide drinking water program as originally authorized under the 1974 federal SDWA and substantially amended in 1986. The federal program consists of the establishment of drinking water standards, monitoring and reporting requirements, and public notification, which are applicable to all public water systems. USEPA can directly enforce compliance of these standards or delegate authority for enforcement of the federal SDWA to any state that has an authorizing state statute at least as stringent as the federal SDWA, and that has a state regulatory program for public water systems that meets various enforcement, planning, and record keeping requirements.

Delegation of the enforcement of the federal SDWA to a state is known as "primacy." As part of the delegation of primacy to a state, USEPA provides oversight and partial grant funding of the state program. The oversight by USEPA requires an annual workplan and specific reporting requirements.

3. Primary Local Agencies

While the principal responsibility for the regulation of small public water systems at the local level lies with the County Health Officer and LEHJs, there are a number of other organizations that indirectly impact public water systems including planning departments, building departments, Local Agency Formation Commissions (LAFCO), and Boards of Supervisors. The respective roles, responsibilities, and areas of concern for each of these units of government are described below.

a. Local Environmental Health Jurisdictions

In 1978, Senate Bill 1799, (Chapter 1150, Statutes of 1978) gave LEHJs primary enforcement responsibility for small water systems (systems with less than 200 service connection) by amending Section 4010.8, HSC. In California, small water systems represent over 89% of the public water systems, but serve only 3% of the population. Figure 2.1 illustrates the total number and types of water systems in California. The law also provided for counties without a health officer or with populations less than 40,000, the authority to contract with the state for the regulation of small water systems.

b. Local Agency Formations Commissions

LAFCO's basic authority is to approve or deny boundary changes requested by public agencies or individuals. LAFCO may also modify the boundary of any proposal. LAFCO provides input to public water systems during the formations of new communities, special districts, and "spheres of influence" for all public agencies.

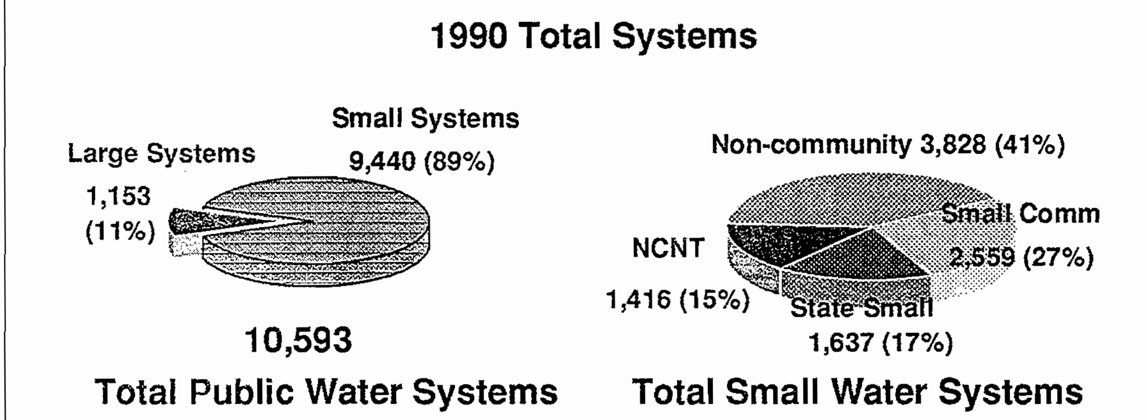

Figure 2.1. Public Water Systems in California[a]

[a] NCNT = Non-community non-transient

c. County Planning Departments

County planning departments may impact public water systems through the development of county wide plans which set the framework for specific county ordinances. However, only a few counties have adopted specific policies or ordinances relating to the establishment of new water systems and the consolidation of existing systems.

d. Local Building Departments

Local building departments have a responsibility to ensure compliance with implementation of the state's lead ban regulations including the use of low lead solders and prevention of the use of lead plumbing materials. The local building departments are not accountable to ODW, and there is no assurance that the regulation is in fact being enforced. However, an ODW statewide survey of local building officials found that the lead ban is being effectively implemented in California. Of the 57% responding (289 of 508) to the survey, 100% of the officials indicated that they were aware of the lead ban regulations (ODW 1991).

B. STATE DRINKING WATER REGULATORY PROGRAM

1. Office of Drinking Water

Changes in state law in 1986 substantially increased ODW's enforcement capability through the ability to issue citations with fines, and to issue compliance orders to water utilities in noncompliance with state laws and regulations. With the above noted changes, ODW became more of a regulatory enforcement program than it had been historically. This occurred at about the same time that more emphasis was being placed at the national level by USEPA on compliance and enforcement activities under the 1986 amendments to the federal SDWA. Also occurring about this same period of time was the development of many new state and federal standards for organic chemical contaminants. All of these events have combined during the past five years to make the drinking water program both more technically complex and more visible to the public, media, and the Legislature. The following sections describe the current activities which make up the regulatory and technical programs within ODW.

a. Regulatory Program

Included under the regulatory portion of the ODW program are: (1) issuance of permits, 2) inspection of water systems, (3) tracking of monitoring requirements of water systems to determine compliance, and (4) enforcement actions. These activities comprise the major portion of ODW field activities with training, technical assistance, plan review, and problem response being some of the other non-regulatory activities carried out by ODW.

<u>Permits</u>

All public water systems must have a permit to operate issued by the Department. During the 1989-90 fiscal year, ODW issued 155 new or amended permits including 76 that required corrective actions to be completed by the water systems. These permits and their accompanying engineering reports are very important because they set forth how a water system is to be operated, including monitoring requirements. Almost all permits include special provisions established specifically for the individual water system. These provisions thereby set forth operating requirements that, if not met, could result in a formal enforcement action taken against the water system by ODW.

Inspections

Inspections and sanitary surveys of a public water system are the activities which contribute the most to assurance of a safe water supply. While water samples tell the actual quality of water being served, they do not indicate of problems until it is too late. The primary purpose of inspections and sanitary surveys is to detect potential problems and eliminate them before the problem results in a water quality failure. State law requires that public water systems be inspected at least annually. Due to resource limitations, however, ODW is currently only able to inspect about half of the public water systems each year. During the 1989-90 fiscal year, ODW directly regulated over 1,100 large water systems, 97 small water systems, 216 governmental water systems (e.g., state park systems and military bases), and 65 state institutions' water systems (e.g., prisons and hospitals). ODW completed 596 annual inspections and 252 related follow-up field inspections. These inspections were complete reviews of the physical structures of the water systems, operation and maintenance activities of the system, and compliance with all monitoring requirements placed on the systems. It is during these annual field inspections that problems may be uncovered, requiring corrective actions by the water system and follow-up activities by ODW. In addition to these detailed inspections, ODW completed an unknown number of less detailed inspections and field reviews.

Compliance Tracking

ODW tracks the water quality monitoring performed by water systems to assure that they are doing what is required of them, and to determine if they are in compliance with all drinking water standards. This is a labor intensive effort because it presently consists almost exclusively of reviewing hard copy analytical results. ODW is currently putting into place a trial computerized data handling system for review. Hopefully, once completed, this system will lessen the burden of data review. During the 1989-90 fiscal year, 385 monitoring violations were discovered by ODW staff through their data review program.

Enforcement

Finally, the last major piece of the ODW regulatory program is enforcement. Included among the more formal enforcement actions taken by ODW are: (1) the issuance of corrective action letters, (2) specifying corrective action provisions in the water permit, (3) use of public notification, (4) issuance of citations and compliance orders, and

(5) initiation of a court action. For minor violations that the water system can be expected to properly respond to, ODW will usually just send a corrective action letter specifying the violations, the corrective actions required, and a target date to correct the problem by. During the 1989-90 fiscal year, ODW issued 1,309 corrective action letters.

Enforcement may be a major drain of resources. For example, the San Bernardino ODW staff spent upwards of 3,000 hours over a period of more than two years in carrying out enforcement actions against a single recalcitrant water system under their jurisdiction. The 3,000 hours did not include the time spent by the Attorney General and Department attorneys in processing the court actions. The effort had a successful outcome as the owner finally sold the system to a well-run and competent adjacent water system, but the impact on resources in the San Bernardino Office was very disruptive to carrying out other ODW program responsibilities. While this represents a worst-case scenario, ODW has had to deal with other recalcitrant systems that also required going to court, including a joint action with USEPA in a case taken to federal court. Such actions usually cannot be planned for and can have a devastating impact on the resources of the ODW office involved.

Domestic water supply permits will often be issued with provisions requiring the elimination of existing health hazards or the installation of special equipment; etc. A schedule for taking these actions will also be specified. During the 1989-90 fiscal year, 76 such permits were issued by ODW.

Under federal and state law, water systems are required to carry out public notification for violating drinking water standards or monitoring requirements. There are a few other circumstances, such as the issuance of an exemption or variance to a treatment requirement, which also require public notification, but these situations occur in frequently. For violations that represent a potential acute public health threat, public notifications include: (1) providing a copy of the notice to the principal radio and television stations serving the area, (2) the publishing of the notice in a newspaper serving the area, and (3) mailing of the notice to each customer, including secondary customers such as tenants and employees, with follow-up every three months until the violation has been corrected. For violations other than those representing acute health hazards, the radio, television, and newspaper notices may not be required. During the 1989-90 fiscal year, ODW required the issuance of 161 public notices.

Under authority provided by the California SDWA of 1986, ODW was given authority to directly issue citations and compliance orders. Citations are usually given to water systems to make low-cost and short-term corrective actions, such as implementing monitoring, whereas compliance orders are generally issued for long-term, expensive corrective measures, such as building a treatment plant. The citations can be issued with or without administrative fines. Both the citations and compliance orders specify in detail the particular violations, the history of the violations and any actions, or lack thereof, taken by the water system to make corrections, and a schedule of actions to be taken by the water system to bring them into compliance. During the 1989-90 fiscal year, ODW issued 92 citations and 39 compliance orders to systems in noncompliance with permit provisions, state law, or regulations. ODW also assisted LEHJs in the preparation of several citations to be issued by the Local Health Officer.

The enforcement action of last resort is to take a legal action through the court system. Such actions are reserved for the most recalcitrant and non-cooperative water systems. As discussed earlier, these actions can have a major drain on the resources of the agencies involved, and once initiated must be followed through to a decision. During the 1989-90 fiscal year, no new cases were referred to the Attorney General, but there were a few cases continuing from the previous year.

b. Technical Programs

The regulatory functions discussed above represent a very significant and important part of the drinking water program conducted by ODW, but there are a number of other activities carried out by ODW not directly associated with the regulatory overview of water systems. Among these activities are: (1) the development and processing of regulations related to drinking water, (2) development of drinking water standards, (3) the review and processing of applications from water systems for Safe Drinking Water Bond Law grant or loan funding, (4) review of systems for possible Emergency Clean Water Grant funding, (5) review of potential ground water recharge projects, (6) provision of information to other state agencies regarding activities that might impact drinking water sources, (7) certification of water treatment plant operators, (8) certification of point-of-entry and point-of-use water treatment devices, (9) provision of technical assistance to water systems and LEHJs, and (10) provision of training to both water utility and LEHJ staff. While these activities are not considered direct regulatory functions, many of them, such as the development of regulations and training of LEHJ staff, have a direct bearing on the effectiveness of the state drinking water regulatory program.

Since 1989, ODW has adopted 36 drinking water standards for organic, inorganic, and radiological contaminants. In addition, a comprehensive set of monitoring requirements were established in 1988 for organic chemical contaminants which addressed the increasing problems associated with contamination of domestic water sources for this class of chemicals.

ODW has also established regulations for water treatment devices which are generally used by individuals to treat water in their homes. These regulations, adopted in October 1990, require that all such devices be certified as effective before they can be sold in California.

Since 1976 ODW has been responsible, along with the DWR, for the implementation of four Safe Drinking Water Bond laws that provided a total of $425 million to water systems in grants and loans. During that period, ODW has established priority lists and has received project applications from more than 800 water systems. Approximately 500 of these projects have been certified by ODW as suitable for funding, with more than 300 of these projects having been completed.

ODW also provides water systems with funds to address emergency situations under the Emergency Clean Water Grant Fund. The fund was authorized in 1986 under SB 1063 (Chapter 1428, Statutes of 1985) and provided a total of $4 million for emergency funding. Since that time, water systems have been provided with emergency funds to address such problems as serious water quality contamination and water outages.

ODW carries out a program that certifies water treatment plant operators, including the testing of operators, and renewal of their certificates. During the 1989-90 fiscal year approximately 2,000 exam applications were processed and 3 separate exams were held throughout the state. In addition, more than 5,000 certificates were renewed during this period.

2. Local Environmental Health Jurisdictions

The responsibility for the regulation of public water systems is currently divided between ODW and LEHJs. LEHJs have the responsibility for enforcement of state laws and regulations for all small public water systems (those with less than 200 service connections) in California. Table 2.1 lists the 58 counties and provides information on the number of public water systems under their jurisdiction. Eleven rural counties contract or have MOU arrangements with the Department's Rural and Community Health Division for environmental health services including the regulation of 832 water systems.

The regulatory responsibility of LEHJs includes the issuance of permits, inspection, surveillance, and enforcement activities. Section 510, HSC authorized LEHJs to assess fees to pay for the reasonable expenses to carry out the provisions of the SDWA in regulating small water systems. Most, but not all, counties utilize this fee authority to pay for some or all of their drinking water program costs. Based on a 1988 survey of LEHJs by ODW, it was determined that LEHJs devoted approximately 45 person years to their small system programs.

With the passage of AB 2158, primacy responsibility for small systems (with exception of state small systems) will be transferred to ODW in July 1992. ODW will have authority to assess fees on small systems to raise up to $8.25 million per year and to contract with counties for the regulation of small systems which serve less than 200 service connections. The contracts will be approved based on a county's demonstration of its capability to meet minimum program requirements defined by ODW in regulation. This transfer of responsibility will occur in July 1992 at which time contracts with LEHJs that desire to maintain small system regulatory programs will take effect. On January 1, 1996, the Department is required to submit a report to the Legislature evaluating the effectiveness of this change in program responsibility.

CONCLUSIONS AND RECOMMENDATIONS

There are a multitude of state and local agencies involved in the regulation of public water systems and water supplies that, in the absence of legislative policy direction, are proceeding somewhat independently to implement their agency's mission and objectives. As a result, there are some conflicting and overlapping rules, policies, and procedures that lead to duplication of effort and conflicting direction to public water systems. Specifically, this is a problem with regard to the adequacy and reliability of the water supply, design of the water system, operation and maintenance of the system, and financial responsibility requirements.

Recommendation: A policy level interagency water supply and water quality coordinating committee with a representative from each agency should be established.

Recommendation: Consideration should be given to consolidation of all water regulatory programs for more efficient program coordination and policy direction. The Office of Drinking Water's role to ensure that there is an adequate and reliable drinking water supply to protect the public health should be a major factor in any consolidation of programs.

Table 2.1 1990 Inventory of Small Water Systems in California

COUNTY	SCWS	NCWS	NCNT	TOTALS
Alameda	5	7	3	15
Alpine	3	37	2	42
Amador	11	27	4	42
Butte	53	26	22	101
Calaveras	6	36	4	46
Colusa	6	36	2	44
Contra Costa	34	63	12	109
Del Norte	22	41	5	68
El Dorado	17	115	16	148
Fresno	142	103	128	373
Glenn	12	21	11	44
Humboldt	52	52	22	126
Imperial	21	15	9	45
Inyo	34	32	10	76
Kern	177	87	76	340
Kings	15	29	16	60
Lake	71	35	10	116
Lassen	16	63	11	90
Los Angeles	85	107	34	226
Madera	45	72	37	154
Marin	7	8	4	19
Mariposa	11	53	11	75
Mendocino	35	55	19	109
Merced	26	47	51	124
Modoc	6	32	9	47
Mono	23	104	14	140
Monterey	126	196	40	362
Napa	39	72	10	121
Nevada	18	52	12	82
Orange	27	15	12	54
Placer	38	35	12	85

Plumas	29	110	11	150
Riverside	114	216	33	363
Sacramento	42	65	46	153
San Benito	17	14	7	38
San Bernardino	127	219	22	368
San Diego	46	83	13	142
San Francisco				
San Joaquin	89	101	126	316
San Luis Obispo	43	51	24	118
San Mateo	16	22	6	44
Santa Barbara	60	47	32	139
Santa Clara	82	67	33	182
Santa Cruz	47	38	13	98
Shasta	55	103	29	187
Sierra	6	48	2	56
Siskiyou	38	104	24	166
Solano	9	55	15	79
Sonoma	156	165	53	374
Stanislaus	77	89	85	251
Sutter	25	26	33	84
Tehama	44	79	18	141
Trinity	25	90	12	127
Tulare	103	178	82	363
Tuolumne	36	72	11	119
Ventura	46	22	11	79
Yolo	19	61	29	109
Yuba	25	30	18	73
TOTAL:	2559	3828	1416	7803

SCWS - Small Community Water Systems
NCWS - Non-community Water Systems
NCNT - Non-community, Non-transient

REFERENCES

Assembly Bill 2158 (Chapter 1182, Statutes of 1990), Sacramento, CA, **1990**.

California Department of Health Services and California Public Utilities Commission Memorandum of Understanding on Maintaining Safe and Reliable Water Supplies for Regulated Water, San Francisco, CA, Feburary, **1987**.

California Public Utilities Commission, "Rules of Practice and Procedure," San Francisco, CA.

California Public Utilities Commission, "Regulation of Public Utilities and Transportation Companies in the State of California, A Handbook," San Francisco, CA, March **1984**.

Office of Drinking Water, Survey on Lead Solder/Lead Pipe Ban Implementation in California, Sacramento, CA, March 29, **1991**.

CHAPTER III

SOURCES OF DRINKING WATER

A. TYPES OF SOURCES

1. Surface Water

During an average year, approximately 71 million acre-feet[1] of water derived from precipitation drains from the state's land surface. An additional 1.4 million acre-feet flows into the state from streams that have all or part of their watershed in Oregon, and 4.8 million acre-feet enter the state by way of the Colorado River. California drinking water systems using surface water obtain their supplies from the resulting lakes, streams, and reservoirs. While less than 10% of the water systems in California utilize surface water as a source, these systems serve approximately 21 million people, about 70% of the state's population.

California's surface water is managed through an extensive system of local, state, and federal dams, reservoirs, and aqueducts to provide the maximum benefit for agricultural and urban usage. The State Water Project (SWP), including the California Aqueduct, dams, and reservoirs, is the most extensive water development and conveyance system in California. It has the capacity to annually transport up to 3.6 million acre-feet of surplus water[2] from northern California's Sacramento Valley over 600 miles to urban and agricultural water consumers in the Central Valley, San Francisco Bay area, and southern California. Approximately one-half of this water is runoff collected by Lake Oroville from the Feather River watershed, and the remainder from surplus flows in the Sacramento-San Joaquin Delta. During the 10 year period of 1978 to 1988, the SWP delivered almost 10 million acre-feet of water to municipal water suppliers for delivery to domestic customers. This represents an estimated average of 100 gallons-per-day for each person served from the SWP.

The major aqueducts in California are listed in Table 3.1. Figure 3.1 shows the respective locations of the major surface water development

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[1]One acre-foot of water is approximately equal to 326,000 gallons of water.

[2]Surplus water is surface water that is not subject to prior rights.

projects in the state. Many of the projects listed in Table 3.1 deliver drinking water to at least a part of their customers. Some of the projects, however, are primarily for delivery of agricultural water and any drinking water deliveries are only incidental.

Table 3.1 Major Aqueducts

Aqueduct	Capacity[a]	Length, miles
All American	15,100 / 9,800	80
California	13,100 / 8,500	444
Coachilla	2,500 / 1,620	123
Colorado River	1,600 / 1,030	242
Contra Costa	350 / 230	48
Corning	500 / 330	21
Cross Valley	740 / 480	20
Delta-Mendota	4,600 / 3,000	116
Folsom South	3,500 / 230	27
Friant-Kern	4,000 / 2,600	152
Hetch Hetchy	460 / 300	152
Los Angeles	710 / 460	244
Madera	1,000 / 650	36
Mokelumne	590 / 380	90
North Bay	46 / 30	27
Petaluma	16 / 10	26
Putah South	960 / 620	35
San Diego #1	200 / 130	71
San Diego #2	1,000 / 650	93
Santa Rosa-Sonoma	62 / 40	31
South Bay	360 / 230	43
Tehama-Colusa	2,530 / 1,600	113

Source = (DWR 1987)

[a]Cubic feet per second / million gallons per day

There are a total of 1,313 reservoirs in and adjacent to California with a combined storage capacity of 43 million acre-feet. Table 3.2 presents, by area, the number and capacity of 152 of the major reservoirs in the state. The locations of public drinking water systems using surface water sources are illustrated in Figure 3.2.

Figure 3.1 Surface Water Distribution in California (DWR 1991)

Figure 3.2
Large Water System Public Drinking
Surface Water Sources in California

TABLE 3.2 Storgag in Major Reservoirs, October 1988		
Area	Number of Reservoirs	Capacity (1000 acre-feet)
North Coast	7	3,184.0
San Francisco Bay	17	703.7
Central Coastal	6	981.3
South Coastal	28	2,112.1
Sacramento Valley	45	16,375.7
San Joaquin Valley	30	11,069.1
Tulare Lake	6	2,055.1
North Lahontan	5	1,084.8
South Lahontan	8	426.4
Totals	152	37,992.2

Souce = (DWR, 1988)

The Central Valley Project (CVP), operated by the United States Bureau of Reclamation, has three elements. The northern element includes Shasta Dam and Lake that collects water from the Sacramento River watershed for controlled delivery to agricultural users in the Sacramento River valley. This flow is augmented with flow from the American River and water imported from the Trinity River through Whiskeytown Reservoir. The second element pumps water from the Sacramento-San Joaquin Delta to the Delta-Mendota Canal for transport to users in the San Joaquin Valley. The third element of the CVP is Friant Dam and Millerton Lake on the San Joaquin River which provides water for delivery to agricultural and urban users on the east side of the San Joaquin Valley as far south as Bakersfield in Kern County via the Friant-Kern and Madera Canals. The primary purpose of the CVP is to provide water for agricultural users although some urban use takes place in the San Joaquin Valley.

Several water projects in addition to the SWP and the CVP provide water to metropolitan areas of the state. The Hetch Hetchy (152 miles) and Mokelumne Aqueducts (90 miles) transport water to San Francisco Bay area from Hetch Hetchy and Pardee Reservoirs, respectively, on the western slopes of the Sierra Nevada. In southern California the Los Angeles Aqueduct, owned and operated by the City of Los Angeles, transports water over 244 miles from the Owens Valley to the Los Angeles area. The Colorado River Aqueduct, owned and operated by the Metropolitan Water District of Southern California (MWD), transports water over 242 miles from the Colorado River to the Los Angeles/San Diego areas (DWR 1987). All of these projects were constructed for the primary purpose of delivering drinking water to urban users.

2. Ground water

Approximately 40% of California's surface area overlays identified ground water basins (DWR 1975). Figure 3.3 shows the distribution of ground water in California. DWR has defined 449 ground water basins in 9 hydrologic study areas. These ground water basins store about 850 million acre-feet of water; however, less than one-half is close enough to the earth's surface to be economically pumped from wells for use (DWR 1987).[3] Ground water basins are discrete geological-hydrological units often divided into sub-units by political boundary lines (DWR 1975).

More than 90% of the water systems in California utilize ground water to serve a population of about 9 million (about 30%). In addition, many of the systems serving surface water depend on ground water as source of reserve supply during emergencies and as augmentation of the surface water during peak demand periods. In rural areas where small water systems are prevalent, over 90% of the population relies on ground water as the only sources of their drinking water. The locations of wells supplying ground water to public water systems are illustrated in Figure 3.4.

Most of the ground water basins in California are in relatively arid valley fill areas. Precipitation (rain and snow), which occurs mostly at higher elevations in the mountains, is the source of natural recharge of the ground water resource. Although recharge takes place throughout the course of the streams across the valley floor, the most effective recharge is in the area where the streams leave the mountains where most of the course sediments are deposited (DWR 1975).

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[3]The practical depth limit for water wells is about 1,500 feet.

Ground Water Basins of California

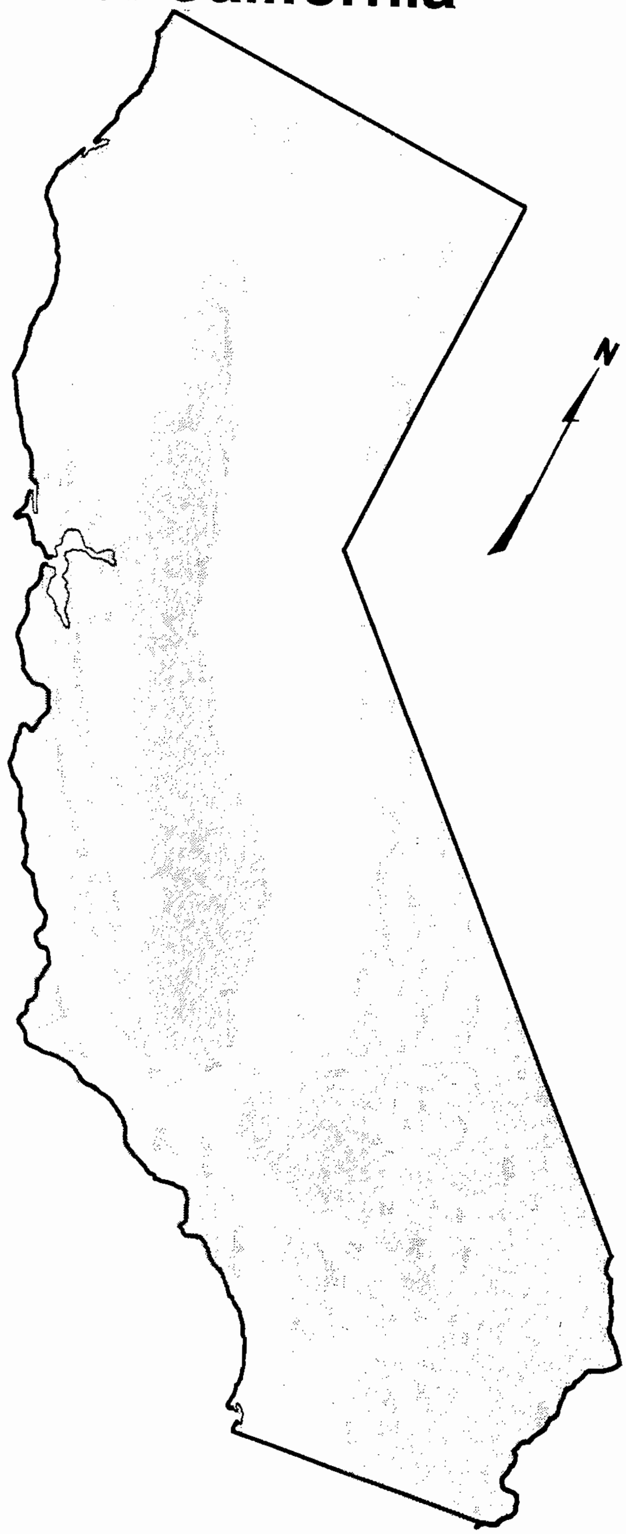

Figure 3.3 Areas of Ground Water Occurance in California

From ***Bulletin 160-87, California Water: Looking to the Future,*** California Department of Water Resources

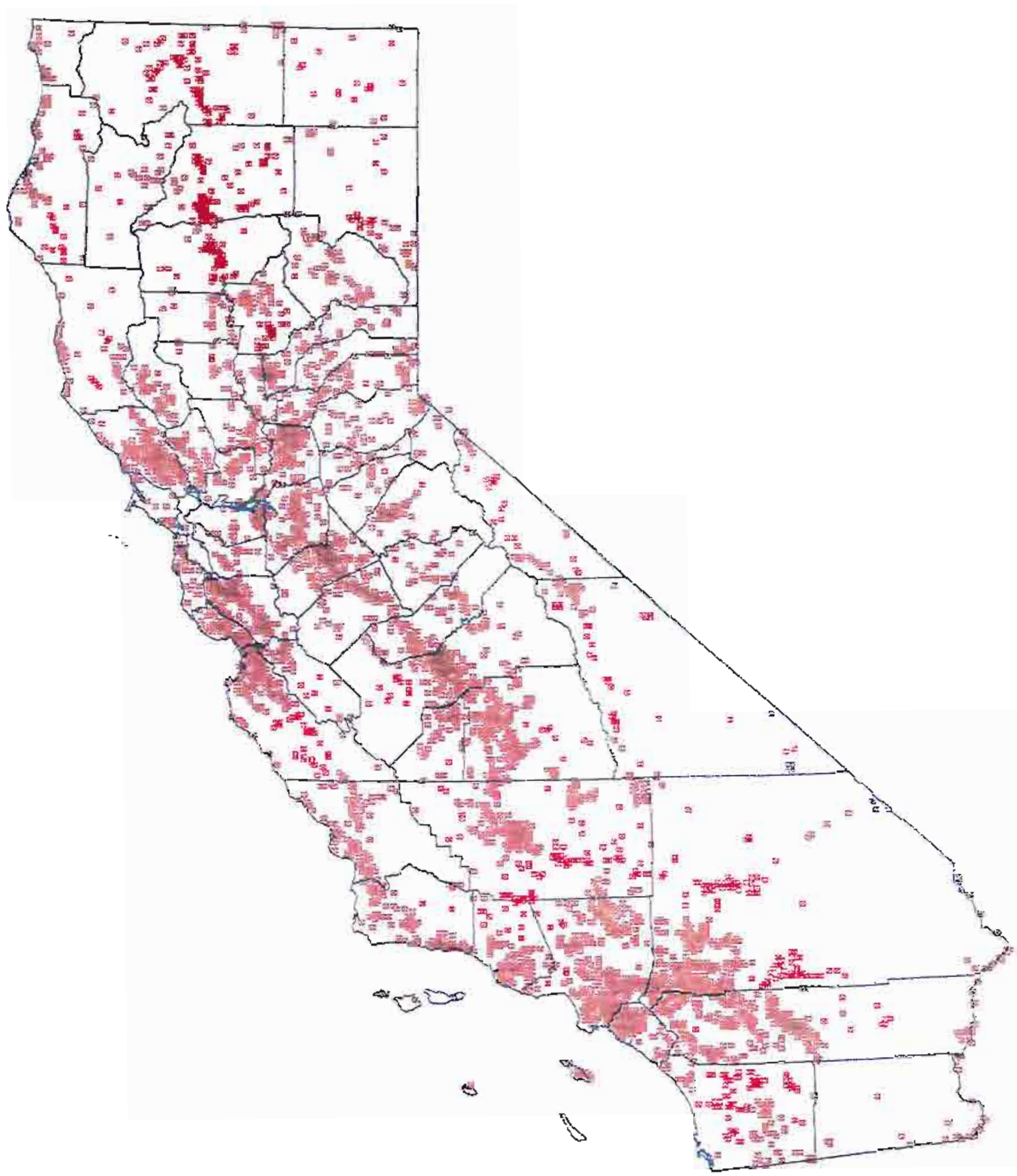

Figure 3.4
Public Drinking Water Wells in California

During normal years, precipitation falling on the valley floor area contributes little to the recharge of the ground water basin. During years of higher than normal precipitation when flooding occurs, some of the ponded water in the valley floor areas will percolate to the shallow ground water, but much of this flood flow will be lost as runoff to ocean outlets. The San Joaquin Valley is an example of effective recharge through the valley floor during years of higher than normal precipitation. When Tulare and Buena Vista Lakes fill, significant recharge of the shallow ground water aquifer takes place.

Ground water basins are also recharged artificially by water used to irrigate crops and for landscaping. In many cases, water is intentionally stored in reservoirs and ponding basins or is applied in excess to crops for the purpose of recharging the ground water basin. Some water districts in northern and southern California have imported large quantities of surface water specifically to recharge ground water basins in their areas (DWR 1975).

B. THREATS TO SOURCE QUALITY

The waters of California are exposed to a myriad of threats to their quality from both natural and man-made sources. Both ground and surface water are susceptible to contamination. The impact of various types of contamination and the possible corrective measures may differ significantly. It is usually impractical, if not impossible, to prevent contamination from natural sources. If no alternative uncontaminated source is available, the most feasible and often only solution is to treat the water before distribution in the system. Natural contaminants include general minerals, inorganic chemicals, asbestos fibers, organics leached from peat soils and other highly organic formations (such as the islands of the Sacramento-San Joaquin Delta and the trough area of the San Joaquin Valley), and radiochemicals including radon and uranium.

Man-made causes of contamination include point sources such as underground tanks, leaking pipelines, solid and hazardous waste disposal sites, waste discharges, and hazardous spills. Point sources characteristically cause localized contamination affecting a relatively small portion of a ground water basin or stream area. These can often be controlled, and in some cases, corrected at the point of contamination. Several state agencies have responsibility for regulating these sources and actively pursue cleanup of contamination when detected. The SWRCB and RWQCB are the primary state agencies involved. In addition, USEPA and the Department's Toxics Substance and Control Division (TSCD) are involved in the clean-up of hazardous contaminants.

Some important man-made causes of contamination result from non-point sources that usually affect a much larger area. In most cases an industry or major land use activity is at fault, and assignment of responsibility to a single individual is difficult. Agricultural drainage and applied agricultural chemicals, such as DBCP, throughout an area such as the San Joaquin Valley are examples (Russell et al. 1987). Nitrate contamination is common in areas of heavy agricultural activity. Excessive use of nitrate fertilizers, leachate from cattle feed lots, and extensive use of individual septic tanks are frequently sources of high nitrate concentrations. Nitrates in drinking water supplies has been investigated by the SWRCB (1988). When ground water is the affected resource, cleanup can be difficult, often requiring many years of extraction through active wells.

Seawater intrusion is a natural phenomenon that occurs in all of the coastal surface water estuaries and to some degree in all of the 262 coastal ground water basins throughout the length of the California coastline. Figure 3.5 shows the location of the major areas of known seawater intrusion. The extent of seawater intrusion into the fresh water resource is affected to a great degree by man's use and depletion of the available fresh water. Since only some of these basins are used as a water supply source the extent of intrusion is not known. In surface water estuaries, diversion and use of upstream flows determines the quantity of fresh water available to repulse the seawater. Controlled releases from storage facilities on streams tributary to estuaries is an effective means of controlling the extent of intrusion and maintaining a relatively stable seawater-fresh water interface.

The extent of seawater intrusion into a ground water basin also depends on use of the ground water resource and the quantity of recharge to the basin. In basins where overdraft[4] is persistent, the intrusion can significantly reduce the available supply of usable water. Some control of the extent and rate of intrusion is possible by development of hydraulic barriers near the seawater-fresh water interface. Several ground water basins in Southern California are protected by this method.

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[4]Overdraft occurs when the quantity of water extracted from a ground water basin exceeds the natural recharge to that basin.

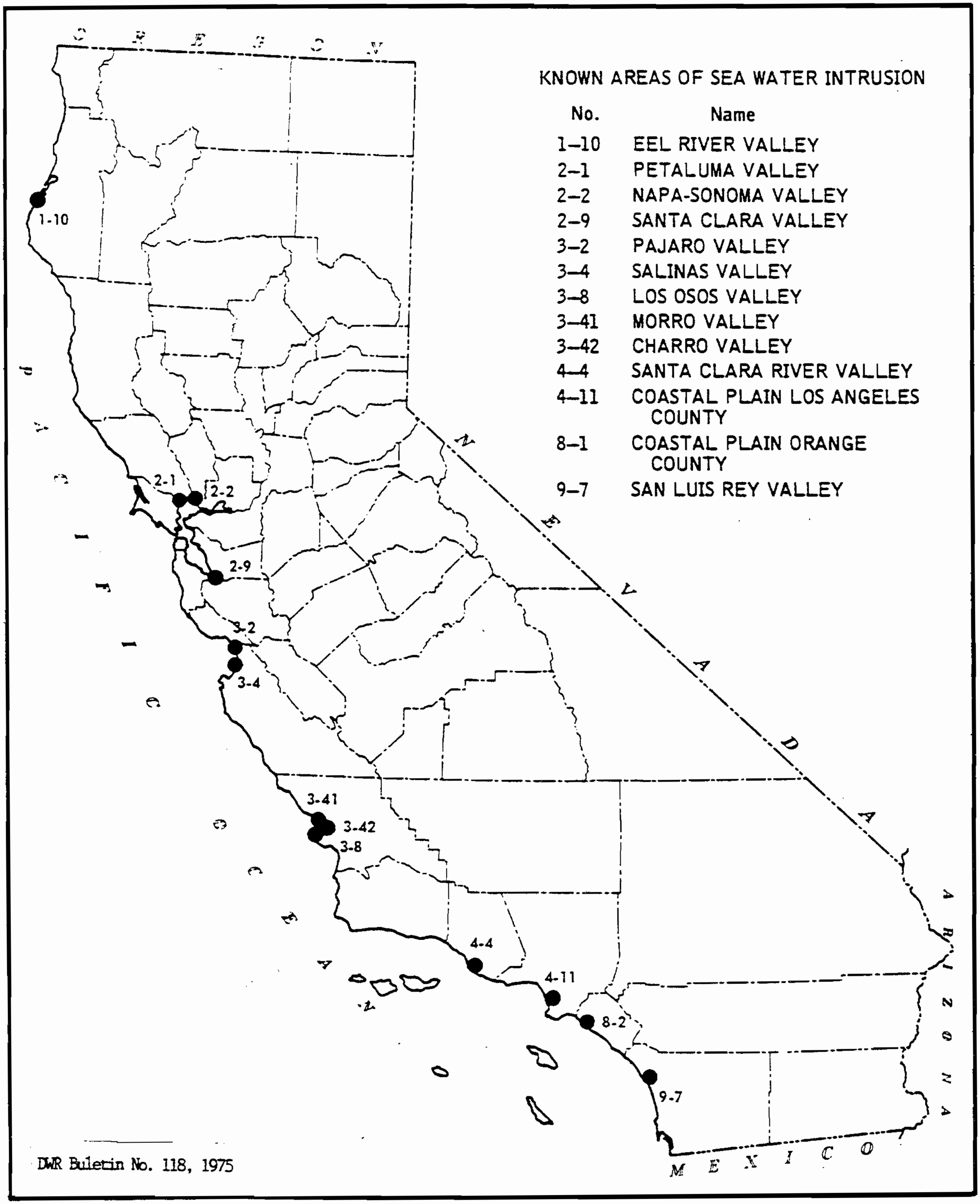

Figure 3.5. Sea Water Intrusion in Ground Water Basins

The major threat to the quality of surface water is the microbial contamination resulting from urban development of watersheds and from the intensive recreational use of the many lakes and reservoirs in California. Health officials have periodically been forced to close all or part of some reservoirs to water contact sports due to excessive fecal coliform bacteria (Stevens 1986). In addition to the hazard of transmitting disease to recreational users of the reservoirs, there is an added burden to domestic water suppliers to assure adequate treatment and disinfection.

Microbial contamination due to waste disposal to surface waters used as sources of drinking water is not a widespread problem in California due to the policies and aggressive enforcement by SWRCB to prohibit such discharges to most inland surface waters. There are, however, other microbial agents of major concern in natural water sources, especially surface water sources exposed to recreational use. *Giardia*, *Cryptosporidium*, and *Legionella* are pathogenic organisms that are all present in water. When the water is exposed to human activity, the concentration of these microbial contaminants has been found to be much higher than when the watershed is protected and use is restricted (Rose 1989). These organisms have a higher resistance to disinfection than the coliform group and significantly increase the burden on the treatment facility. Monitoring of domestic water systems has been required for the coliform group only as indicators of the sanitary quality of the water because sample collection and laboratory procedures for other agents is expensive and time consuming. There is limited information, therefore, on the impact of other microbial agents on domestic water systems.

Some waters, especially surface waters exposed to heavy use and possible waste disposal, produce occasional blooms of algae and larger biological plants that makes treatment plant operation difficult. When algae are present in a drinking water supply, there is the possibility of formation of tastes and odors that could be objectionable to water system customers. Blue-green algae is one of the most common causes of taste and odor in surface water supplies. When sufficient nutrients are available, as in lakes heavily used for recreation, substantial blooms of blue-green algae can result. These and other biological organisms in sufficient quantity can impair the filter operation of a treatment plant, thus increasing operational problems and treatment costs.

Disasters such as major accidents adjacent to waterways or on the watershed are capable of causing serious contamination of a water supply. To date there have been no major disasters affecting the water supplies at the source, although the potential exists. Most of the effect has been to the water system facilities such as reservoirs, treatment plants, and water distribution systems. There are major differences in contamination of a surface water stream and a ground water basin. When a surface water is contaminated by a waste discharge or an accident, protection of drinking water supplies can often be accomplished by shutting down the water intake until the discharge can be discontinued, and the contaminant has passed. If the contaminant enters a larger body of water, such as a lake or a large river, dilution may be adequate to minimize the immediate danger. Ground water contamination, on the other hand, can be difficult or even impossible to correct. Ground water moves through the basin at a slower rate, usually measured in feet per year, if the basin is undisturbed by pumping. When a well is in operation the direction and rate of flow can be significantly altered. When several wells are active within the basin, the combined effect can greatly increase the rate and extent of spreading of the contamination.

Table 3.3 presents a summary of common types of contamination that threaten the quality of water in California. A more detailed discussion of the contaminants found in various areas of the state is presented in Chapter V.

TABLE 3.3 THREATS TO WATER QUALITY

SOURCE OF CONTAMINATION	CONTAMINANT	TYPICAL SITES
Natural (occur state-wide)	Dissolved minerals: Asbestos: Hydrogen-sulfide: Radon.	Mineral deposits, mineralized waters, hot springs, seawater intrusion. Mine tailings, serpentine formations. Subsurface organic deposits, as Delta Islands and San Joaquin Valley trough. Present in most geologic formations
Commercial businesses	Gasoline: Solvents: Toxic metals	Service stations underground storage tanks. Dry cleaners, machine shops. Photo processors, laboratories, metal plating works.
Municipal	Microbial agents, nutrients, and miscellaneous liquid wastes	Bacteria and virus contaminants from a variety of sources such as sewage discharges and storm water runoff. Contributions from industrial dischargers, households and septic tanks.
Industrial	VOCs, industrial solvents, toxic metals, acids: Pesticides and herbicides. Wood preservatives.	Electronics manufacturing, metal fabricating and plating, transporters, storage facilities, hazardous waste disposal. Chemical formulating plants. Pressure treating power poles, wood pilings, RR ties.
Solid waste disposal	Solvents, pesticides, toxic metals, organics, petroleum wastes, and microbial agents	Disposal sites located statewide receive waste from a variety of industries, municipal solid wastes, wasted petroleum products, household waste,
Agricultural	Pesticides, herbicides, fumigants, fungicides, fertilizers, concentrated mineral salts, microbial agents	Irrigated farm runoff, ag chemical applications, fertilizer usage, chemical storage at farms and applicators air strips, agricultural produce packing sheds and processing plants, meat processing plants, dairies and feed lots.
Disasters	Solvents, petroleum products, microbial agents	Earthquake caused pipeline and storage tank failures and damage to sewage treatment and containment facilities: major spills of hazardous materials: flood water contamination of storage reservoirs and ground water sources.

C. PROTECTION OF SOURCES

I. Studies and Monitoring Programs

Several agencies maintain monitoring programs to collect water quality data and periodically report on the quality of California's water resources. DWR monitors the quality of water in the SWP, in other surface water bodies, a variety of monitoring wells, and private domestic drinking water wells. In addition, DWR conducts a variety of special water quality investigations for their own use and for other state agencies. The California Department of Food and Agriculture (CDFA) conducts special sampling studies on surface and ground water sources to investigate the occurrence of pesticides in water supplies. CDFA also collects pesticide ground water monitoring data from other agencies and reports them in annual reports (CDFA 1986; 1987; 1988; 1989; 1990). ODW contributes its public drinking water quality data to the CDFA for the annual reports. SWRCB and the nine RWQCBs conduct a variety of routine and special water quality investigations, including the monitoring of ground water in and around waste disposal sites. One such study by SWRCB, made at the direction of and reported to the Legislature, evaluated the status of nitrate contamination in drinking water (SWRCB 1988).

Between 1982 and 1984, SWRCB prepared a series of reports which addressed pesticide contamination of water resources. One report covering pesticide contamination of ground waters (SWRCB 1983) reported contamination by a variety of pesticides not seen in drinking water wells. All of these detections were in monitoring wells located at the sites of pesticide manufacturing and handling facilities. To-date, none of these pesticides have been detected in public water supplies. SWRCB recently prepared a report on the contamination of public water wells (SWRCB 1990) based primarily on water quality data in the ODW database. Since 1983, ODW has provided SWRCB with all water quality data, positives and negatives, available in its database. Some of the data cited as indicating contamination were unconfirmed results that were subsequently determined to be false positives and corrected in the ODW database.

The Office of Planning and Research collects water quality and hazardous waste data from several agencies and publishes them in an annual report, (OPR 1990). The report is prepared pursuant to the Government Code, Section 65962.5. That section requires ODW to provide the Office of Planning and Research annually with a list of all drinking water wells in which organic chemicals have been detected pursuant to AB 1803 (Chapter 881, Statutes of 1983). All public drinking water wells having any detectable level of an organic chemical are included in the annual report, even in cases where MCLs are not exceeded. As a consequence, wells considered by ODW to pose no hazard to the public health may appear on the site list.

2. Existing Protection Programs

a. Surface Water

The agency most responsible for protection of the state's surface water resource is SWRCB and the nine RWQCBs. These agencies enforce regulations that maintain the following programs:

- Basin Plans: Each RWQCB is required to prepare a basin plan for each hydrologic basin within their area. These plans form the basis for establishing waste discharge requirements for all proposed waste discharges to surface waters and to land surfaces based on the identified beneficial uses of any potentially impacted water resources.

- Inland Water Policy: SWRCB has established a policy which requires that any waste discharge to surface water must meet drinking water standards at the point of discharge if the receiving water is or has the potential for being a drinking water supply.

- Nondegradation Policy: RWQCBs maintain a policy that prevents unnecessary degradation of the state's water resources by limiting the allowable impact that any waste discharge can have on the receiving water.

- Bay-Delta Policy: SWRCB has established a water quality policy for Bay-Delta waters that balances the water quality requirements of all users, including the quality requirements for maintenance of the valuable fishery in the Delta. The policy is under continuous review and is altered as required due to changing hydrologic conditions.

- Individual waste discharge requirements: RWQCBs set waste discharge requirements for all wastes discharged to surface water courses or to land surfaces where a surface water resource could be impacted. These requirements are based on information developed in the Basin Plans as well as the other above policies. The regulations also establish monitoring and reporting requirement for all dischargers.

- Water Rights: The right to divert surface water for all uses, including for drinking water, is regulated by SWRCB. Established rights are protected from encroachment and holders of rights are prevented from wasteful misuse of the water. These regulations also include subsurface flow in identified channels and ground water under the influence of surface water.

The regulations of ODW are designed to protect the quality of surface water sources used by California water utilities to supply drinking water to meet the needs of their customers.

- Surface Water Treatment Regulations (SWTR): SWTR requires that a watershed sanitary survey must be completed every five years by all systems using surface water as a source of drinking water. The survey should include: physical and hydrogeological description of the watershed, a summary of source water quality monitoring data, a description of activities and sources of contamination, a description of any significant changes that have occurred since the last survey which could affect the quality of the source water, a description of watershed control and management practices, an evaluation of the systems ability to meet requirements of this regulation, and recommendations for corrective actions. These regulations are at least as stringent as those promulgated by USEPA in its Surface Water Treatment Rule.

- Recreation on Domestic Water Supply Reservoirs: These regulations establish a permit application and review procedure for all proposed use of reservoirs for recreation, set limits on the types of recreation that can be permitted, and determine the type of reservoir on which recreation can be permitted.

b. Ground Water

Most of the protective programs identified under Section C.2.a-Surface Water are also applicable to protection of ground water.

SWRCB and RWQCBs enforce regulations for the following programs:

- Basin Plans: The basin plans referred to under surface water are also applicable to protection of ground water.

- Underground Storage Tank Program: In conjunction with LEHJs this program monitors and regulates underground tanks used to store such materials as gasoline and cleaning solvents. When contamination is caused by leakage, the regulations also provide for clean-up.

- Discharges of Wastes to Land: These regulations establish the requirements for land disposal of wastes including location of monitoring points and wells, frequency of monitoring, and reporting requirements.

- Well Construction Standards: In conjunction with DWR, this program establishes the minimum construction standards for water wells to be enforced by the responsible local agency. If the local jurisdiction fails to establish standards within a specified time period, SWRCB may do so with the local jurisdiction still being required to enforce the regulations.

TSCD enforces regulations which maintain the following programs:

- Hazardous Waste Disposal: These regulations establish requirements for disposal of hazardous wastes to land. The requirements also establish location of monitoring sites, frequency of monitoring, and reporting requirements.

- Hazardous Wastes Site Clean-up: TCSD is responsible for regulations governing clean-up of identified hazardous substance contamination sites including investigation of the extent of the contamination and identification of responsible parties.

CDFA has jurisdiction over use of pesticides and other agricultural chemicals. These regulations provide:

- Pesticide Registration and Regulation: This program requires that all controlled agricultural chemicals be registered and usage be reported. The regulations also require license of all applicators. Under authority of these regulations CDFA also monitors potentially affected water resources to measure the effectiveness of the control program.

ODW regulations provide for protection of ground water used as a drinking water supply at the source by requiring separation of sources of contamination from well sites, and by requirement of specified surface features on all drinking water supply wells.

3. Planning for Protection

The programs described above have been effective in protecting the quality of water resources in California. The low incidence of serious contamination reflected by the ODW database is evidence of this success. The increased demands placed on the resource have, however, created the need for improved regulations. Discussed below are some programs that could be implemented, either through regulation or voluntary compliance, which would further protect the available drinking water source.

a. Surface Water

The California SWTR requires a watershed sanitary survey but it does not require that water systems conduct a sanitary survey of their distribution system and service area. If conducted periodically, as suggested in the SWTR, the survey would provide water system operators with valuable information on the physical conditions surrounding the system's sources of drinking water supply, and any hazards present and weaknesses within the system would be identified. Water system operators should be required to periodically conduct a sanitary survey of their system to identify any changes that have taken place.

The California SWTR also does not require a watershed management program for drinking water systems that use surface water sources.[5] Such a program may not be feasible for all systems, but any system can exercise significant influence over factors that impact the quality of the water available at its intake. By monitoring land use and development on the watershed and by taking advantage of the California Environmental Quality Act (CEQA) process, systems can limit the impact on their water quality. Systems should be required to maintain such a monitoring program and all responsible regulatory agencies should be required to notify all potentially impacted water systems of any and all pending changes in watershed activities.

b. Ground Water

Although the programs and regulations of state and local agencies provide protection of selected aspects of ground water supplies, there is no coordinated effort to provide overall protection for water resources generally. Because of funding and personnel limitations in all of the agencies, the current emphasis is on investigation and cleanup of existing problems. There are no provisions for establishment of land use conditions for ground water basins, including recharge areas. Building permits issued by county and city agencies recognize only the immediate area of the project. Often when the project is in opposition to the

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[5]USEPA surface water treatment rule requires a watershed management or control program for unfiltered systems. Since all surface water systems in California are required to provide complete treatment, a watershed management program is not required.

existing plan, political pressures cause amendment to the plan without adequate consideration of the effects on the resource. Waste disposal regulations provide for protection of the water quality and beneficial uses in the immediate vicinity of the discharge without consideration of the compound effect of all degrading factors in the basin. As a result, state and local agencies responsible for delivery of safe and potable water to the citizens of California must respond to local land use decisions on a case-by-case basis.

In recognition of the need to protect ground water sources of drinking water, the federal SDWA Amendments of 1986 included requirements for a state to establish a formal program for protection of the ground water resource through a "wellhead protection program." This encourages to coordinate the activities of all regulatory agencies involved in related water quality programs. For systems using ground water sources under the influence of surface water, the control measures delineated in the wellhead protection program should include the requirements of the watershed control program. A wellhead protection program should be established to improve protection of drinking water sources in California and to protect the health and welfare of the water consuming public.

D. AUGMENTATION OF SOURCES OF SUPPLY

1. Bottled and Vended Water

California consumes more bottled water than any other state, about 654 million gallons of the 1.7 billion gallons sold nationwide in 1989 (Doyle 1991). Bottled water often is utilized by consumers as an alternative water supply when a real (i.e., bacteriological contamination) or perceived (i.e., taste, odor, and color) water quality problem arises with the public water supply or where no public supplies are available. In California perceived problems are typically based on excessive media publicity or a physical problem that represents no health risk. An estimated one-third of all Californians routinely use bottled water and are paying from 700 to 1,400 times more for it than for tap water. In most cases, this $300 to $550 annual expense is not necessary, since the water provided by their water utility meets the drinking water quality requirements and is safe to drink. In the few cases where consumers have been advised to use bottled water in the interim, the problem is quickly corrected, and the customers are notified when the water can be safely consumed. A more detailed comparison of the respective cost of various bottled water supplies is shown in Table 8.7.

There are currently about 160 licensed facilities providing bottled water to California consumers (CDHS 1990a). Many facilities located in other states and countries produce water that is imported to California.

Bottled water is defined in the (CDHS 1990a), Section 26591, HSC as "any water which is placed in a sealed container at a bottling plant to be used for drinking, culinary, or other purposes involving a likelihood of the water being ingested by humans. Bottled water shall not include water packaged with the approval of the department for use in a public emergency." Vended water is water that is not placed in sealed containers and is dispensed by a water-vending machine or retail water facility. Vended water is subject to the same regulations as bottled water.

Bottled water falls into two broad categories according to use, commodity and specialty waters. Commodity waters are sold primarily as a substitute for tap water provided by utilities. It is sold in gallon jugs or three gallon and five gallon bottles that are placed on top of water dispensers. Specialty waters are sold in smaller bottles typically in the soft drink sections of retail establishments. They are often mineral waters, and are frequently naturally or artificially carbonated.

Bottled water intended for consumption that is bottled in California is usually derived from a public water supply system serving the community where the bottling facility is located. Bottled water that is labeled "spring water," "natural water," or "mineral water" may be taken from private wells, springs, or geysers.

All water to be bottled or vended for sale to the public must meet the treatment and quality requirements provided by regulations enforced by the Department's, FDB (Richardson 1990). Licensing requirements for out-of-state distributors, mineral water plants, and water vending machine operators were added to the statutes in 1978. Private operators of natural springs and wells, retail water facilities, and water haulers were added to the licensing requirements in 1984.

Bottled water is potentially subject to the same contaminants as public water systems. In addition to potential contamination from source water, bottled water is also subject to potential contamination resulting from handling, packaging, hauling, and vending. It has been reported that traces of tetrachloroethylene (PUC) and toluene have been detected in samples of some bulk water products (Consumer Reports 1987). In the mid-1980s, it was discovered that container resin solvents such as methylene chloride could be detected in some bottled water products (Richardson 1990). As a result, bottled water and bulk water sold at retail in California are subject to FDB regulations addressing its processing, packing, labeling, holding, and advertising. Additionally. California adopts by reference all federal bottled water quality standards.

A recent article in the news reported that an investigation conducted by the United States General Accounting Office for a congressional subcommittee found that microbiological contamination exceeded allowed levels in almost one-third of the bottled water tested in a 1990 nationwide survey (Hacker 1991). It was also stated that the tests for other potential contaminants were not consistently performed. The bottled water program maintained by FDB reports that water bottlers in California are in compliance with requirements, and water quality monitoring data indicates that locally bottled water is safe.

Although not necessarily a reflection of water quality, the presumed superior taste of bottled water is often the reason consumers purchase bottled water for drinking. In a 1987 test that compared 28 municipal water supplies to the taste of bottled water, twelve waters had "excellent" taste and five had "very good" taste. The "excellent" category listed two municipal supplies, Los Angeles and New York, and 10 bottled waters. The "very good" category listed two municipal water supplies, New Orleans and San Francisco, and three bottled waters. (Consumer Reports 1987).

Enforcement of bottled water regulations in California, like all other enforcement efforts, are limited by available funds and personnel. To provide the level of protection and reliability necessary to assure the bottled water customers of a safe supply would require additional funding and personnel.

2. Reclamation and Recharge

There is little likelihood that any new ground water basins of any magnitude will be found. All of the identified basins have some development, if only for local private domestic use. New ground water development will probably be of marginal quality and possibly require treatment to be acceptable as a drinking water source. However, some of these basins may be viable as a future ground water storage facilities for surplus surface water imported from other areas and stored for future use. This has proven to be an effective and economical means of storing water, and is far less costly than development of surface storage. Under ground storage also has several advantages: there is no loss due to evaporation, it is not susceptible to algae infestation, and contamination by microbial agents is minimal.

Between 1986 and 1990 California has experienced below average precipitation. The 1990-91 water year appears to be a fifth consecutive year of below normal rainfall. Water suppliers depend on adequate precipitation to replenish surface water supplies and to provide recharge of ground water basins. The below normal snow pack on the mountains throughout the state has substantially reduced the amount of runoff for surface water uses and for long term recharge. As a result there has been more than normal lowering of the ground water table.

Many municipalities are required to cleanup their wastewater to meet strict water quality requirements before it can be discharged to waste. While the wastewater may contain numerous pathogens and chemicals, it is often viewed as a potential commodity with value as an alternate source of supply for many other uses. For example, recycling this wastewater by using it for landscape irrigation or for irrigation of some crops has become an important part of community development and land-use planning. In addition, recycled wastewater can be discharged to a holding area where it can recharge the ground water supply.[6]

Ground water recharge can occur when the reclaimed wastewater is discharged and retained in large basins that allow water to percolate through the soil (unsaturated zone) and into the aquifer. Typically these operations recharge the ground water over a large surface area and are referred to as *surface spreading* operations (see Figure 3.6). A second method of ground water recharge is called *direct injection* because the reclaimed wastewater is injected into the saturated zone of an aquifer without percolation through an unsaturated zone (see Figure 3.7). Direct injection is often used to build a barrier or mound of water between a ground water basin and a seawater wedge that may be invading the aquifer. This practice is commonly referred to as a *seawater intrusion barrier.* Both surface spreading and direct injection can result in the recharge of ground water supplies that may also be domestic water supplies.

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[6]Anytime water is discharged to land or water body it has the potential for recharging ground water, however, the ground water that is affected is not always a water supply.

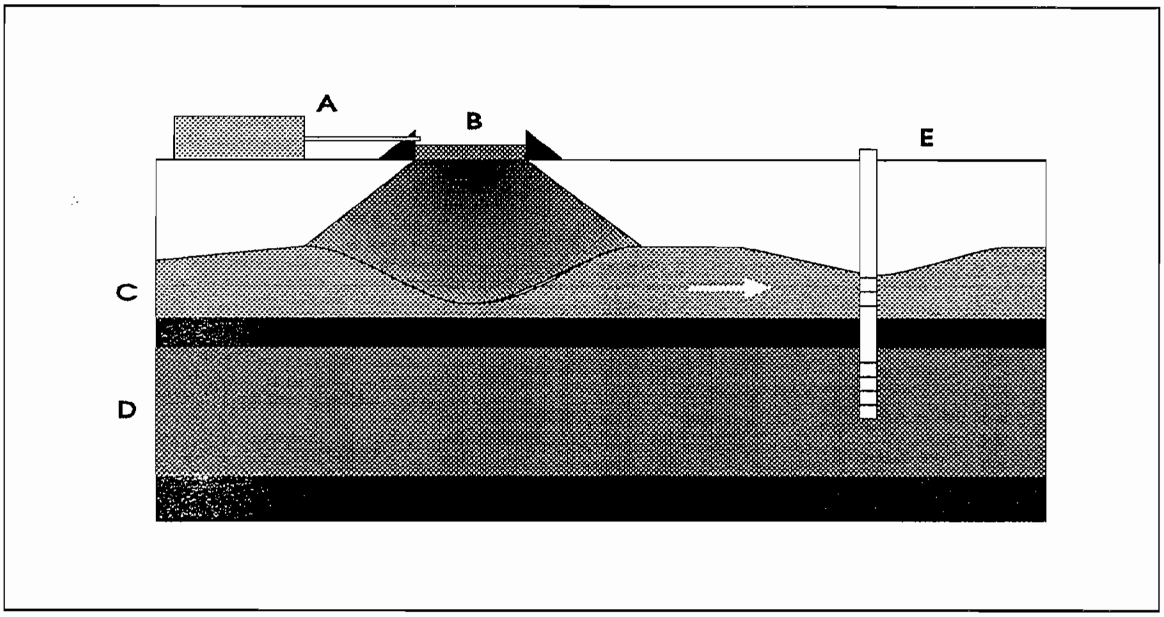

Figure 3.6. Ground Water Recharge by Surface Spreading. Wastewater is treated (A) then placed in a surface spreading basin (B) where it can percolate through an unsaturated zone before reaching the unconfined aquifer (C). The extraction well (E) partially penetrates the confined aquifer (D), but draws water from both aquifers (C and D).

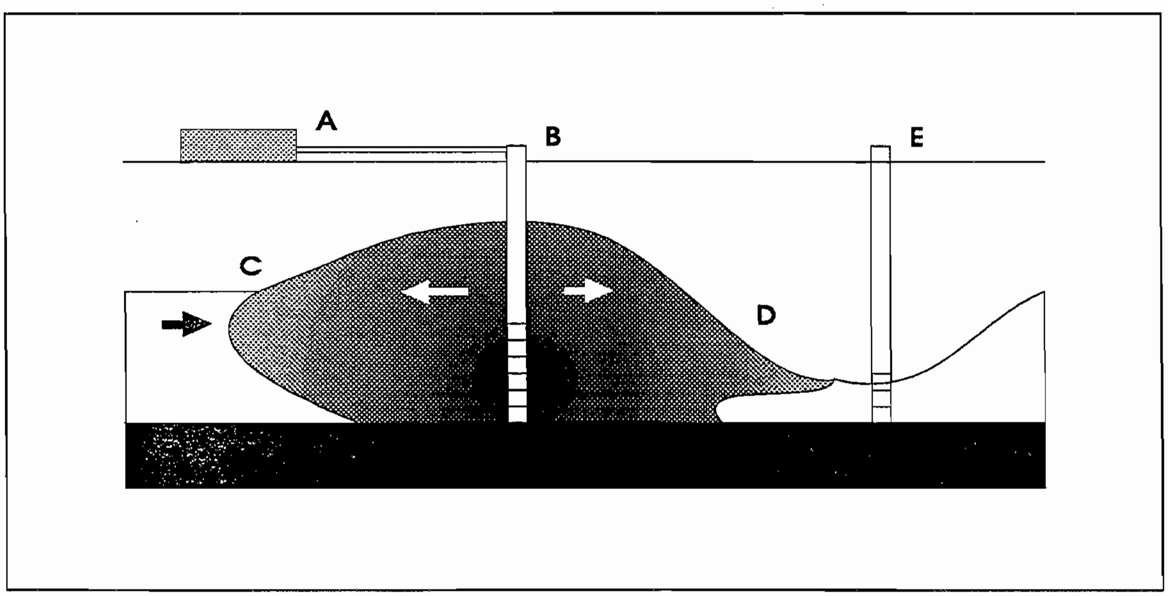

Figure 3.7. Ground Water Recharge by Direct Injection. Treated wastewater (A) is injected through a well (B) into the unconfined aquifer (D) to hold back the saltwater wedge (C). Some of the injected water moves toward the extraction well (E), mixing with some of the native ground water.

Since any ground water is potentially a source for a public water supply, it is important to protect the recharge areas to prevent wastewater discharges from causing degradation of public drinking water. It is equally important to ensure that water, either fresh water or wastewater, used for recharge does not have the potential for degrading the quality of the ground water basin and adversely impacting drinking water wells downstream (or down gradient) from the recharge area.

The ground water recharge regulations being developed by ODW are an important step in the direction of promoting wastewater reuse while protecting ground water supplies. The criteria used in the new regulations are a direct result of many years of research which has been summarized in an article by Crook, Asano, and Nellor (1990). The first "large-scale" planned ground water recharge operation was started in 1962 by the Los Angeles County Sanitation District (LACSD). LACSD discharged, by surface spreading, the secondary effluent from their Whittier Narrows Water Reclamation Plant into the Montebello Forebay of the Central Ground Water Basin. Due to a lack of health effects information and concerns over the ingestion of reclaimed water, the Department placed a temporary ban on new ground water recharge projects in 1973. In 1975 the Department convened a panel of experts whose sole responsibility was to recommend avenues of research that would allow the Department to write ground water recharge criteria. The initial ground water recharge regulations, written in 1976, were never adopted into the CCR, but were used as guidelines. Also in 1976 the Orange County Water District (OCWD) began a seawater intrusion barrier project, utilizing direct injection, to protect the ground water basin. Between the years 1978-1983, LACSD conducted a health effects study that included what was then considered to be extensive water quality characterization and health related research. Upon completion of that report (1986), the state appointed a Scientific Advisory Panel (SAP) to provide the information needed to establish statewide criteria for ground water recharge.

SAP focused most of their attention on the LACSD health effects study, and in 1987 published a report on their findings (SWRCB et al. 1987). In this report, SAP identified several areas of research that would increase the knowledge of health effects so that the limits of ground water recharge could be extended beyond the bounds of the health effects study on the Whittier Narrows project with some degree of assurance that the project was being operated and maintained in a manner that would not endanger public health.

SAP identified several areas for expanding the knowledge of the effects of ground water recharge using wastewater. Due to uncertainty about the identity and quantity of total organic carbon (TOC), research into the identification and quantitation of these compounds should be conducted. Alternatively, the Department should examine the feasibility of devising a chemical scheme to divide TOC into groups based on specific chemical characteristics. Then, using this fractionation scheme, the health effects associated with these classes of compounds could be studied. Currently, such general surrogates as TOC, BOD (biochemical oxygen demand), or COD (chemical oxygen demand) are being used to quantitate the presence of organics in wastewater. Health effects data developed on one wastewater may not be applicable to another wastewater.

Aside from the organics issue, more research in the area of wastewater disinfectants is needed so that alternative disinfectants to chlorine can be used. The goal in the development of alternative disinfectants should be to decrease the formation of disinfection by-products without compromising the microbiological quality of the reclaimed water.

SAP also recommended the development of a toxicological matrix consisting of "*in-vitro*" and whole animal bioassays in order to develop correlations between the tests so that the less expensive "*in-vitro*" bioassays could be used for water quality surveillance. These correlations should be developed across a variety of water quality types that include, but are not limited to, sources of domestic water supply. The endpoints in these health effects studies should not be limited to cancer; other health effects that may be of higher risk and more easily detected, such as impacts on reproduction, should also be included. Scientists should also examine biochemical markers as an indication of population exposure to potential contaminants from reclaimed water. In conjunction with this, SAP recommended identifying the structures of compounds that could cause responses in biological tests. Two other areas of research recommended by SAP included the need to identify the sources of unidentified compounds that may cause an adverse health effect and determine what portions of TOC could be removed by specific treatment processes.

Even with these needs for research, SAP reached some very definitive conclusions from their review of the LACSD's Health Effects Study. Their conclusions set the stage for the present Department rule making activity. SAP agrees with the Department's position that the best available water in any area should be reserved for drinking water and that wastewater should not be used as a source unless it can be demonstrated that treatment, either natural or engineered, can produce water of consistently better quality than other alternatives.

Other conclusions that would significantly impact health effects considerations were that biological and lime-treatment, chemical coagulation with filtration, or reverse osmosis would provide adequate means of controlling the inorganics. However, for controlling the discharge of organics, SAP concluded that reverse osmosis could reduce TOC levels to below 1 mg/L at which point "...all identifiable trace organic compounds of significance should be absent in detectable concentrations." SAP also stated that disinfection should still be required as part of the treatment process, but that the process should not produce harmful and stable by-products. In addition SAP went so far as to conclude that prospective health surveillances of populations should be a part of any recharge project.

Aside from their conclusion that monitoring of the biological quality at the point of extraction and disinfection is necessary, their conclusions regarding the analytical and monitoring problems contained some very interesting statements. SAP stated that analytical studies should emphasize the testing of concentrates to determine if harmful compounds are present at low concentrations. While *in vitro* testing was not likely to be responsive enough to answer the question of whether exposure to the organics contained in reclaimed water would be of risk to the human population, SAP recommended whole animal testing and retrospective surveillance as means of addressing this question. In addition, SAP concluded that monitoring to ensure the reclaimed water meets drinking water standards should continue, but should be reviewed with appropriate adjustments made, such as, including toxicological testing. All of these conclusions and recommendations are being considered and addressed by the Department in the development of the ground water recharge regulations.

The criteria developed by the Department that will be set in regulation were developed on the basis of one of the conclusions by SAP, and will be the first time in California that specific criteria will be used to regulate ground water recharge projects. Presently ground water recharge projects are regulated on a case-by-case basis. In contrast to this, the new regulations will specify, depending on the method of ground water recharge (spreading or direct injection), the minimum degree of treatment prior to discharging to a recharge area; minimum travel time and distance in the ground water basin to the first public water supply well; soil percolation requirements; and in the case of a spreading operation, the minimum vertical unsaturated zone directly beneath the ground water basin. Therefore, the regulations must provide sufficient detail to ensure the protection of potable ground water supplies.

Even realizing that artificial recharge is an important step in supplementing natural recharge of ground water basins, the research needed to address the public health issues surrounding the use of reclaimed municipal wastewater for ground water recharge has not proceeded at a rate consistent with the goals of many rechargers. As a result, progress in the development of regulations is slow. The problem of funding has most often been alleviated, in the past and present, by districts, such as OCWD or LACSD, supplying the funding for special projects, such as the LACSD Health Effects Study. However, this leaves a large number of agencies and the Department relying on their results to determine the feasibility of ground water recharge in the region of concern or to write regulations based only on a single study or experience.

The drawback to relying on the results obtained from study of one project is that there may still be a fundamental deficiency in the knowledge about what is being regulated or removed. Relying on surrogates such as TOC provides the regulators with no assurance that the TOC at one recharge site is the same as the TOC at another site.[7] This means that studies conducted by these utilities may only be applicable to those specific regions and should *not* be applied to projects in other ground water basins. The state needs to recognize this and provide more technical guidance and oversight during the development of these projects. This will ensure that the information developed has as much meaning as possible.

The Department must often develop regulations based on limited information. This is in part due to the fact that sufficient information has not been developed by the scientific community. Risk managers also face the problem that the degree of uncertainty in measured water quality parameters is not known. The Department needs the ability to assess and quantitate the adequacy of ground water recharge regulations so that logical decisions regarding proposed projects can be made and that the degree of risk to the public whose drinking water is obtained from ground water can be established. This information must be used to educate the public in the risk associated with their water supply. Without this educational step, the public's confidence in the Department's ability to protect the ground water supplies will erode.

There have also been claims made that the organics in reclaimed wastewater are degraded in the saturated zone, but a survey of the literature shows no concrete evidence of this phenomena. Even if no

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[7]TOC is simply a measure of organic carbon and any carbon source, even those of biological origin, can contribute to the measured TOC. Since the measurement of TOC is an oxidative process, it is well documented that the method of oxidation has a bearing on the types of compounds that are oxidized, thereby affecting the quantity of TOC that is measured.

organics appear in wells down gradient from the recharge zone, there is no way of determining whether they were removed by biological oxidation, transformation, or adsorption onto the soil particles. For regulators, the difference between the two processes is important. Adsorbed compounds may eventually breakthrough or be released from the soil when concentrations on the soil particles reach saturation. When the organics breakthrough they could begin to appear in the downstream wells. If biotransformed to carbon dioxide and water, the compound can then be said to have been mineralized and removed from the soil. However, if biotransformation is not complete, then the intermediates or by-products may find their way into the water supply. A good example of this is the bio-transformation of some chlorinated solvents, such as trichloroethylene TCE or PCE, to vinyl chloride without subsequent oxidation to carbon dioxide (Vogel, et al. 1985). Another concern is the release of partially oxidized organics that can migrate into the wells and react with the disinfectants to produce unwanted disinfection by-products. The state should act as a clearinghouse to centralize research topics to address these questions.

3. Dual Water Systems

Over the years many individuals and organizations have expressed the need to develop dual water systems to provide additional supplies and to help conserve a limited supply of good quality water. A dual system is developed by construction of a second system to distribute a non-potable water supply to the same service area as a potable supply. The second source can be an unacceptable irrigation well, an untreated surface water, or reclaimed wastewater.

The only commonality in dual water systems is the delivery of potable water in one system and a non-potable water in another. Frequently the secondary or non-potable source is the wastewater generated within the service area of the water system and treated at the local wastewater treatment plant. It is usually proposed to use the treated wastewater for irrigation in such areas as parks, cemeteries, highway median strips, and landscape around public buildings. Experience has shown that where the locally produced wastewater is the secondary or non-potable source, the quantity frequently is not adequate to meet the needs of the proposed use. Invariably a request is made for permission to use the potable water supply in the same areas to supplement the non-potable supply, either in a parallel or in the same distribution system.

A dual system was operated by the City of Coalinga for many years. The only available local water source was the highly mineralized ground water. The local residents that drank the water usually suffered considerable gastrointestinal distress because of the presence of magnesium sulfate (Epsom salt) in concentrations near that used as a cathartic. For several years the city hauled drinking water in railroad tank cars about 20 miles from the valley town of Huron. As a trial treatment, the city installed reverse osmosis (RO) and electrodialysis treatment in hopes of being able to discontinue hauling water. The water was distributed to each residence and office building through a separate water line with a single outlet. Although expensive, this arrangement was preferable to hauling water. As soon as SWP water was available, the dual system was abandoned.

A dual distribution system was approved by the City of St. Petersburg, Florida for installation in a "planned unit development" (Journey 1991). In St. Petersburg, the city inspects the homes but not the water systems inside planned unit developments. In addition to the potable water supply to each residence, a secondary supply, which is reclaimed wastewater, is connected to the irrigation system at each residence. Before moving in, the buyer of the first residence note that the water did not seem right and reported it to an employee of the developer. He also reported it to the plumber who maintained that nothing was wrong. After seven days, he reported it to the homeowners association and on investigation they found that the connections were reversed. The connections at a new model home and one under construction were also found to be reversed. The plumbing has all been corrected and the city is withholding all delivery of all reclaimed wastewater until they can determine how the mix-up occurred and what to do about it.

Several areas have shown an increased interest in utilizing dual system in high rise buildings. Such a system would use non-potable water for sanitary purposes such as flushing toilets and some limited landscape irrigation. A proposal for installation of this type of dual system is under consideration for a high rise building in southern California.

Any dual system poses an obvious potential threat to the potable water supply system. The intentional or inadvertent connection of the secondary system to the potable system can result in gross contamination to the risk of the health and welfare of users of the potable supply. An act so simple and common as connecting a garden hose between the two systems can result in a major contamination event.

Utilities in many areas feel that development of dual systems using treated wastewater will be essential in the future if they are to meet the needs of their service area. Because of the obvious hazards involved in dual water systems and the increasing interest in their utilization, the Department is developing specific regulations to govern the use of this concept so that the expanded use of dual water system will not endanger the health and welfare of California citizens.

4. Desalinization

Due to a series of years with low rainfall, several water systems are looking to develop alternative and perhaps more reliable sources of water. One of these alternatives is the desalination of sea or brackish waters. While it is too early to evaluate the feasibility of such endeavors, it is interesting to note that several water utilities are beginning pilot or feasibility studies to assess the practicality of using sea or brackish waters as an alternative source of potable water. In these areas of limited water resources, the need for potable water supply may outweigh the economics.

The cost of water produced by RO has been examined by several engineering companies to determine the fexibility of using seawater as an alternative resource. Montgomery Engineers (1990) estimated the cost of using reverse osmosis for the City of San Luis Obispo to be in the range of $1,900-2,000 per acre-foot/year.[8] The City of Santa Barbara and Ionics, in their draft environmental impact report, use a base cost of $1,866 per acre-foot based on a desalination production rate of 10,000 acre-foot/year (Woodward-Clyde 1990).

While the concept of using seawater for domestic use is a viable concept from a health perspective, using seawater does raise some interesting issues. The source of water for these plants is a surface water source and is regulated by the SWTR. When RO is the treatment process of choice, no more than 2 log credit should be given for virus removal (Malina 1977). Indeed some documents suggest that even less credit should be given, and that virus removal is a function of membrane composition (Taylor et al. 1989).

Unlike lakes and rivers (most fresh water sources), ocean disposal through deep water outfalls with prevailing onshore currents may be a problem not covered under the surface water treatment rules. Intake structures for desalination units should be placed a safe distance away from outfalls. This can be done by establishing safe zones that allow sufficient dilution and die-off of microbial populations prior to the intake.

Some other issues that deserve consideration are the removal of bromides by the RO process. Since removals are a function of the rejection rates there needs to be some assurance that bromide levels are

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[8]Capital costs were amortized over 20 years at 8%. Boyle Engineering (1990) estimates the cost of water produced by desalination using reverse osmosis will be $2,336 per acre-foot/year or $7.17 per thousand gallons for a plant producing 5000 acre-foot/year.

low enough not to create a problem with brominated disinfection by-products. Bromide rejection is less than that of sulfate or chloride, but greater than nitrate or iodide (Taylor et al. 1989). Chloride rejection is in the range of 92% to 95% with nitrate rejection in the 69% to 97% range. Rejection efficiency appears to be a function of membrane composition and/or construction. The data taken from the literature seems to suggest that a 90% rejection of bromide is reasonable. Such a rejection will reduce seawater concentrations to about 6 mg/L in the finished water. Adding any oxidant such as ozone or chlorine to this finished water to effect either organics removal or disinfection may result in the production of bromate and other brominated by-products.

As available water resources in the state become more scarce, technology may be forced to play an expanding role in the development of saline sources, not only seawater, but ground water, as potable water supplies. Inevitably the development of such resources will raise new questions about the safety and reliability of such sources. The state must be able to respond to those questions in a positive manner to maintain and protect the potability of the water distributed to the people of the state.

5. Surface Water Sources

DWR has proposed and is evaluating additional surface water development in conjunction with SWP. The largest and most significant of these is Los Banos Grande Reservoir near San Luis Reservoir. Other associated proposals are for extension of some of the branch canals to other service areas, construction of additional storage facilities, increased capacity of the Delta Pumping Plant, and additional South Delta and North Delta facilities. As currently constructed, SWP can deliver the designed 0.8 million acre-feet every year, but can meet the maximum capacity of 3.6 million acre-feet only about 30% of the time. With the planned additions, the maximum capacity could be delivered about 75% of the time (DWR 1989).

Other new surface water developments are proposed by local agencies. The opposition to any such developments cause long and expensive delays before any benefit is realized. Most current active proposals are for power generation facilities on the smaller mountain streams. Environmental concerns have stalled most of these projects.

If California is to meet the needs for its ever growing population, new sources of water must be developed, either by way of new surface water development or by other projects to conjunctively use all of the resources available to the maximum extent possible. The developments being evaluated and proposed by DWR would relieve the pressure for new development for the near future. These projects should be completed, but planning for additional supplies must continue beyond that.

6. Water Supply Management

As the population grows and the demands for water increase, the available opportunity for new sources of drinking water supply diminish. For Californians this fact has been accentuated by the five year drought and the resulting stress on existing supplies. The result has been serious activity on the part of numerous agencies to devise new and often innovative means for developing alternate supplies to augment and conserve existing supplies. In 1991, many Californians were for the first time faced with drastic rationing (10 gallons per person per day in one case) and finally began to fully appreciate the value of a commodity that they had always taken for granted. While regulations imposed on water utilities have assured customers of a "safe, wholesome, potable, and reliable (within the limits of nature)" water supply, there has been minimal publicity for the problems associated with providing that supply, especially during the current hydrologic conditions. The following will discuss some of the methods being considered by agencies and utilities for insuring a continued supply of water.

Water banking is a rapidly developing practice in the water industry, spurred on by the current drought. Even the state began a water banking program in 1991 by purchasing water from users (paying farmers to not grow surplus crops) for redistribution to areas of greater need. In effect, banking involves the "deposit" of a quantity of water into an "account" as a reserve for future use.

Another banking project involving the state is in operation in Kern County. One element of this project involved the purchase by DWR of approximately 19,900 acres of land from Tenneco West, Inc. The ground water reservoir underlying this land would become the depository for up to 1.2 million acre feet of surface water from SWP during periods when surplus water is available in SWP for use during years of below normal supply. Ultimate development of this project, including proposed local elements, will provide for storage of five million acre-feet of water. By comparison, San Luis Reservoir stores a little more than two million acre-feet of water (Kennedy et.al. 1988).

In yet another similar project, MWD and Arvin-Edison Water Storage District (AEWSD) (in Kern County) have proposed a joint agreement for the exchange of water from SWP. In this agreement which will extend through the year 2035, MWD would deliver to AEWSD more than one million acre-feet of water from the SWP via the Cross Valley Canal for use in irrigation in lieu of ground water. In exchange, AEWSD would deliver via SWP an average of about 100,000 acre-feet of water each year during periods when MWD allotment was not sufficient in return for MWD "exchange" credits on deposit (MWD 1989).

There are many other operations that amount to exchange or banking activities that go under a variety of names. Ground water recharge projects in several southern California basins using imported water from SWP provide the same benefits. OCWD has a comprehensive ground water management plan which includes recharge using imported water and treated wastewater for development of future supplies and for seawater intrusion control (OCWD 1990). Exchange and management projects are operating in many areas of the state, such as the Santa Clara County Water District operations in Livermore Valley and the Fremont area, and a project in the Santa Rosa area.

Storage in underground aquifers has been shown to be an effective and economical method of developing substantial storage volumes for surplus surface waters during wet years. Projects currently in operation store several million acre-feet of water, without which the current five year drought would have been far more devastating than it has been.

E. CONCLUSIONS AND RECOMMENDATIONS

> *Source water quality information collected by water utilities and by state and local agencies have enabled the Office of Drinking Water to determine that, for the most part, the sources of supply for drinking water in California are of good quality.*

Source Water Quality

The current drought notwithstanding, California has a somewhat abundant supply of water. Although 70% of the water is located in the northern part of the state, 60% of the population lives in the southern part. The problem, therefore, is primarily one of storage and distribution.

The growth in population has caused ever increasing demands on California's resources. The population of California is very mobile and heavily oriented toward recreational activities, especially those related to water and wilderness. Second homes in remote areas have caused development of part-time communities in many areas of California where private property is still available. California, especially the Central Valley area, has established its position as the leading agricultural area in the United States, supplying many of the food and fiber products used in California, the country, and to some extent the world. There is a continuing demand for more water to support this major industry that now uses about 80% of all water used in California.

Many threats to the quality of water are natural in origin and preventing contamination is difficult. As an example, where serpentine formations occur, asbestos will be found in the surface waters. Arsenic, cadmium, selenium, radon, and fluoride are other examples of naturally occurring contaminants in ground water and surface water.

Another example of a threat to water resources is seawater intrusion into coastal ground water basins and surface water estuaries. The increased demands on ground and surface water decreases the quantity available to repulse the intruding seawater and to provide for dilution of other contaminants to acceptable levels.

While these naturally occurring contaminants create problems in some specific areas, they are somewhat minor compared to the contamination caused by the human activities. Most of the drinking water contamination in California results from human activities. Industries produce, use, and waste hazardous chemicals. Agriculture uses large amounts of pesticides, herbicides, and fertilizers. Domestic activity creates sewage containing microbial agents (*Giardia lamblia, Cryptosporidium, Legionella,* viruses, and bacteria, e.g.,) nitrates, and organic compounds. When not properly managed, these waste products and activities endanger the quality of the state's water resource.

The framework for drinking water quality protection is set forth in the "basin plans" developed by the nine RWQCBs in conjunction with the recently adopted Inland Water Policy. These basin plans are the basis for identifying beneficial uses of the water, establishing water quality goals, and developing waste discharge requirements to protect the beneficial uses. The program has been successful and has provided good protection to the watersheds of surface waters used for drinking water sources. But due to the limitations of the statutes authorizing the "Basin Planning Process," the current program concentrates primarily on the quality of each waste discharge and receiving water only at the point of disposal. The cumulative impact of discharges in the watershed is not always considered. There are many activities that do not result in point waste discharges but do, in fact, impact the quality of drinking water. As a result, some watersheds may be exposed to continued increases in organic, microbial, and chemical contamination.

Recommendation: The current authority for preparation of basin plans should be strengthened and expanded to cover activities that are not currently addressed so that the plans could also be used as the basis for local wellhead protection and local land use planning decisions.

SWTR does not require that water systems conduct a sanitary survey of their distribution system and service area. Such a survey conducted periodically as suggested in SWTR would provide the system operator valuable information on the physical conditions surrounding the system's sources of drinking water supply and any hazards present and weaknesses within the system would be identified.

Recommendation: Operators should be required to periodically conduct a sanitary survey of their distribution system and service area to identify any changes that have taken place.

The California SWTR does not require a watershed management program for drinking water systems that use surface water sources. Such a program may not be feasible for all systems, but they can exercise significant influence over factors that impact the quality of the water available at their intake. By monitoring land use and development on the watershed and by taking advantage of the CEQA process, systems can limit the impact on their water quality. Systems should be required to maintain such a monitoring program and all responsible regulatory agencies should be required to notify all water systems potentially impacted of all pending changes in watershed activities.

Recommendation: Regulations should be developed to require state and local agencies responsible for land use and zoning to advise all drinking water systems, by direct notice, of all proposed changes in land use and zoning; of all proposed developments that could impact the water supply; and to solicit comments from the water systems.

Recommendation: Regulations should be developed to require all water utilities to establish procedures for monitoring proposed changes in land use and activities on the watershed of their supply.

Requirements governing waste discharges to land are also established based on the RWQCs basin plan. Quality and quantity requirements for these discharges also consider beneficial uses of the receiving ground water. As with surface water, the combined impact of discharges and impacts of other activities that are not under the jurisdiction of RWQCB has not been adequately considered and drinking water has not always been fully protected.

A wellhead protection program (i.e., land use management program to protect the areas of recharge to ground water basins and individual extraction wells) should be implemented in California. A program similar to the program proposed by USEPA could provide the same level of protection to the ground water supplies as the watershed protection program provides to surface water supplies. This program should work in conjunction with local agency land use and zoning programs and should be presented in a general plan prepared and adopted by local agencies.

Recommendation: Legislation should be considered to establish a wellhead protection program similar to the program proposed by United States Environmental Protection Agency to provide the same level of protection to the ground water supplies as the watershed protection program provides to surface water supplies.

Water Quantity

As previously indicated, California has an abundant supply of water if wisely used and conserved. The problem has mainly been one of distribution and storage. Some problems of distribution of the state's water resources have been solved by projects that provide a means of transporting large quantities of water from the areas of plenty to areas of need. The state, federal government, and local utilities have constructed major projects to develop and conserve large quantities of water to meet the needs of California's growing population. Major man-made reservoirs in California have the capacity to store almost 38 million acre-feet of water.

SWP transports drinking water more than 600 miles from the Feather River to Southern California. The Colorado River Aqueduct of MWD transports water more than 240 miles from the Colorado River to the south coastal basins. The Owens Valley Aqueduct of the Los Angeles Department of Water and Power transports water more than 240 miles from the Owens Valley to the Los Angeles basin. The City and County of San Francisco and the East Bay Municipal Utility District both transport water from the western slopes of the Sierra Nevada across the central valley to their service areas.

With the existing water development projects, the quantity of water that can be delivered will not be sufficient to reliably meet the future needs of the increasing population with a pure, wholesome, and potable drinking water supply. Plans are under study to develop new sources of water and to increase the capacity of several existing facilities to serve urban areas. Unfortunately, many smaller and more isolated systems will not benefit from these facilities. Also, very little long-range planning is being conducted to assure adequate water supplies in the future for many of these systems.

Storage in underground aquifers has been shown to be an effective and economical method of developing substantial storage volumes for surplus surface waters during wet years. Projects currently in operation store several million acre-feet of water, without which the current five year drought would have been far more devastating than it has been.

Recommendation: The state and local water districts should be encouraged to establish ground water quality and quantity management programs for the protection of ground water drinking water supplies.

As the demand on the fresh water resources in the state approaches the available capacity and as the ability to find and develop new fresh water sources diminishes, technology will be forced to play an expanding role in the development of drinking water supplies from seawater and saline ground water sources. Inevitably the development of such resources will raise new questions about the safety and reliability of the sources and the required treatment. The state must be able to respond to those questions in a positive manner to maintain and protect the potability of the water distributed to the people of the state.

Recommendation: The Department should establish reliability criteria for the processes used in desalination and should develop minimum monitoring requirements for operating plants.

Recommendation: The Department should establish a unit within the Office of Drinking Water to investigate and direct research into new water treatment technologies and to fully evaluate the consequences of their use.

Recommendation: Regulations and criteria should be established for siting of desalinization plants based on criteria for siting fresh surface water plants including, but not limited to, identification of approved and prohibited intake areas (both seawater and ground water); criteria for sanitary survey of the intake area; performance requirements for plant operation equal to, or more stringent than three specified by the SWTR; minimum monitoring requirements; and interim action levels for brominated disinfection by-products.

If California is to meet the needs for its ever growing population, new sources of water must be developed, either by way of new surface water development or by other projects to conjunctively use all of the resources available to the maximum extent possible. Projects that have been authorized as well as developments being evaluated and proposed by DWR would relieve the pressure for new development for the near future. The authorized projects should be constructed but planning for additional supplies must continue beyond that.

Recommendation: Projects that have been authorized and other projects being proposed by DWR for development of new water supplies should be funded and constructed as soon as feasible.

Use of Reclaimed Municipal Wastewater for Ground Water Recharge

Ground water recharge using treated wastewater is an important and integral part of good water resources management. It is a practice that should continue and expand commensurate with our knowledge of what constitutes safe practice. Both reclaimers and regulators need to develop a better understanding of the fate and transformation of chemicals in the ground water environment. To expand recharge practices, more research into the health effects and analytical techniques should be encouraged by the state. ODW is working to promote reclamation and reuse to help ensure California's potable water supply today and for the future by developing specific regulations and criteria to govern the development and operation of ground water recharge operations.

Recommendation: Research into the health effects associated with ground water recharge of drinking water sources with reclaimed wastewater is urgently needed and should be funded.

The Department must often develop regulations based on limited information. This is in part due to the fact that sufficient information has not been developed by the scientific community. Risk managers also face the problem that the degree of uncertainty in measured water quality parameters is not known. The Department needs the ability to assess and quantitate the adequacy of ground water recharge regulations so that the degree of risk to the public whose drinking water is obtained from ground water can be established. This information must be used to educate the public in the risk associated with their water supply. Without this educational step the public's confidence in the Department's ability to protect the ground water supplies will erode.

Recommendation: The principles of risk management should be applied to the development and establishment of regulations to govern the use of wastewater for ground water recharge.

The state should act as a clearinghouse to centralize information on research topics and to address questions regarding wastewater reclamation and ground water recharge with wastewater. The state should provide funding for reclamation projects through fees imposed on all dischargers, since wastewater reclamation benefits us all. Whether the discharge is to a stream, an evaporation pond, or body of water, reclamation of the wastewater by ground water recharge is always an option that should be considered. A state appointed advisory group should then convene to decide which projects will receive funding (projects should run from one to five years depending on the complexity, with funding for a prearranged period of time guaranteed).

Recommendation: The department should establish a technical advisory group as a subcommittee of the Drinking Water Technical Advisory Committee to deal specifically with ground water recharge problems. Membership in this committee should not be limited to professionals within the state.

Funding for research should be generated by charging fees to all wastewater facilities, since all could benefit from the greatly expanded wastewater reclamation potential. Furthermore, the state should not charge an overhead on the funds collected by this fee, except to offset the cost of administering the program. The health effects and analytical studies ongoing at LACSD and OCWD should be encouraged to continue, especially in light of a fifth year of drought. With the development of specific criteria to govern the development and operation of groundwater recharge projects, the Department is working to promote reclamation and reuse to help ensure California's potable water supply today and for the future.

The zero discharge goals established by SWRCB and RWQCBs should not promote wastewater reclamation at the expense of public health. The Department's role in protecting public drinking water supplies should be reinforced and clearly stated in statutes establishing the authority and responsibility for reviewing wastewater disposal and reclamation proposals, and establishing the requirement for SWRCB and RWQCB to incorporate Department recommendations.

Recommendation: Existing wastewater disposal and reclamation regulations should be amended to ensure recognition of the Department's responsibility for preservation of the quality of public drinking water supplies, to provide for Department review and approval of all permit applications and permits, and to require incorporation of Department recommendations in all wastewater disposal and reclamation project requirements.

Recommendation: The Department should establish a special unit to review permits and permit applications so there can be no questions of conflict of interest on the part of the discharger.

Recommendation: The objectives of ground water protection in recharge should be consistent with the goals and objectives of the state wellhead protection program.

Recommendation: The Department should establish a research program to determine the applicability of short-term genotoxicity test for monitoring reclaimed wastewater used for ground water recharge.

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CHAPTER IV

THE QUALITY OF DRINKING WATER

A. INTRODUCTION AND BACKGROUND

The following discussions of water quality contaminants are based, for the most part, on the ODW database which contains data from over 14,000 drinking water sources, collected mostly by water utility self-monitoring programs and reported to ODW as required by regulations. Due to its infancy and to restrictions of time, funds, and staff, the database is not complete, especially for the inorganic constituents. The evaluation of inorganic constituents must also include consideration of some information that is yet to be entered into the automated database but that is contained in the database maintained by the ODW District offices.

Only limited information representative of systems with less than 200 service connections has been included in the database for organic contaminants and virtually none for inorganics. Data for the unregulated organics are also limited since many utilities chose to not do a complete organic scan in the interest of reducing laboratory costs. The database does not contain any of the bacteriological monitoring information and only summary total trihalomethane (TTHM) information for systems serving populations of over 10,000 are included.

The ODW drinking water quality database contains no consistent state-wide information on the presence of unregulated microorganisms in drinking water supplies. With few exceptions, information on unregulated contaminants in drinking water have historically been collected only when funds are made available for special studies. These collection efforts have been sporadic, reactive, and usually inadequate to carry out state-wide assessments. More comprehensive and consistent information collection is required if regulations and more accurate state-wide exposure assessments are to be developed.

Figure 4.1 illustrates the distribution of drinking water sources exceeding MCLs displayed according to the number of water service connections and populations served by systems in the size ranges of 15 to 199, from 200 to 999, from 1,000 to 9,999, and more than 9,999 service connections. The greatest number of sources exceeding MCLs appears in large water systems having over 9,999 service connections.

These cases of contamination are generally systems located in areas of agricultural development or industrialized urban areas. Since agriculture and industry both attract large urban populations, it is expected that the resulting large water systems would, because of their proximity to sources of contamination, experience the highest rate of water quality failure.

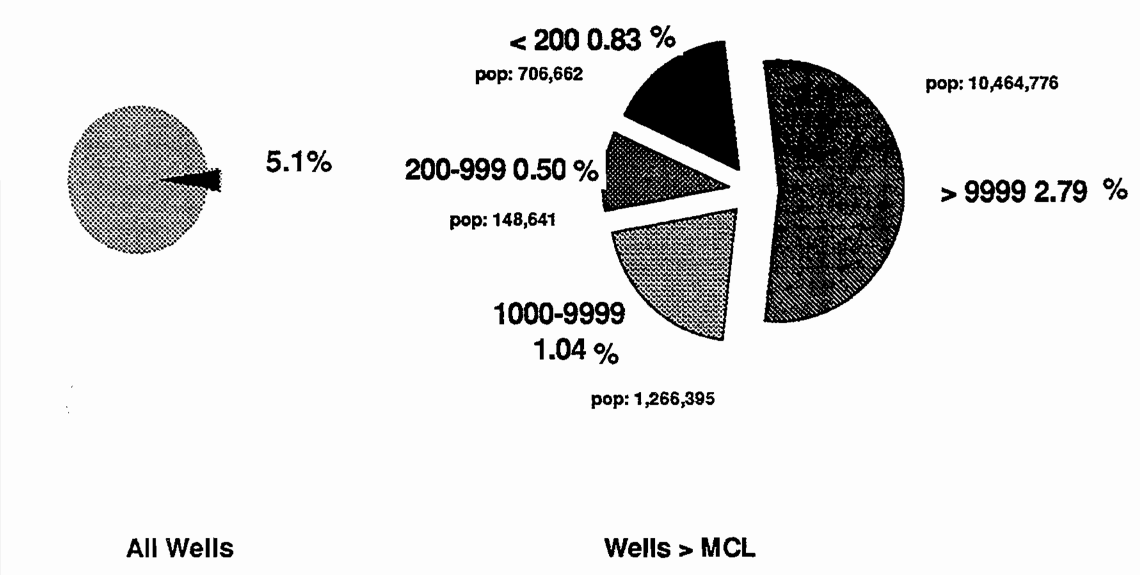

Figure 4.1. Drinking Water Sources Exceeding MCLs According to System Size

B. SURFACE WATERS

1. Microbiological

Microbial contaminants have always been the primary concern for water system operators and health officials because of the potential for waterborne illness. Routine monitoring programs for domestic water utilities require the collection of water samples from the distribution system for bacteriological examination on a schedule designed to assure the continued safety of the water. The coliform group is accepted as the indicator organism since they are the most prevalent bacteria in the environment. They are the easiest and least expensive to identify and their absence can be used as an indication that the water is safe to drink. The rarity of waterborne outbreaks in domestic water systems is testimony to the effectiveness of this monitoring.

Information on the actual presence of microbial contaminants in raw water in California is very limited and the available information has not been entered into the ODW database. Generally speaking, the only information collected to date has been collected by some of the large utilities that use surface water, largely for operational purposes. These agencies have collected some sparse information that confirms the presence of significant microorganisms that could cause a risk to the health of their customers. Contamination by microbial agents poses a greater immediate threat to the health of water consumers than most other contaminants. Most other contaminants also pose a serious threat, but risk is based on long-term exposure. Although microbial contamination is a serious health threat, of water treatment can effectively reduce the risk of exposure by physical removal of the organisms and disinfection can inactivate any organisms that escape the removal mechanism.

Recently there has been growing concern for the microbial agents associated with the presence of humans and their activities. Studies have been conducted that have shown that human proximity leads to the spread of *Giardia*, *Cryptosporidium*, *Legionella* and enteric viruses (Suk et al. 1987). Although these organisms have been present in the environment, the increased population, popularity of outdoor recreational activities, and mobility of the population has led to an increase in the numbers of organisms and their dispersion throughout the environment. Monitoring for their presence is difficult and expensive due to problems of sample collection, transportation, and laboratory analysis. Unfortunately, studies to date have not been able to establish a correlation between their presence and the presence of the coliform group or any other suitable surrogate indicator organism. Therefore, there is only limited information on their occurrence in raw water.

Two known cases of microbial contamination in the state have resulted primarily from recreational activities on reservoirs. As a result, local agencies closed the reservoirs to water contact activities. In northern California, intensive recreational activities on Whiskeytown Reservoir, near Redding, has resulted in high levels of fecal coliform bacteria that has at times has required prohibition of water contact sports (USDI 1987). In southern California, recreation on Perris Reservoir, a facility of SWP, has resulted in high levels of microbial agents in the water and in the occurrence of verified cases of shigellosis in swimmers (Stevens 1986). As a result, the local health department closed the reservoir to water contact activities for a short period.

The spread of microorganisms throughout the environment could be limited by an effective watershed protection program. However, wild animals also contribute to their dispersion and complete eradication is unlikely. The recently adopted SWTR provides for control by setting specific performance standards for treatment facilities. Physical removal is essential since all of the organisms are more resistant to chlorination than are the members of the coliform group.

Beyond the mere disinfection of the water for control of bacteria, the levels of disinfectant required to attain inactivation of these more resistant contamination microbial agents further exacerbates the formation of disinfection by-products discussed below.

2. Disinfection By-Products

Disinfection is an essential part of providing a safe, wholesome, and potable drinking water supply. Disinfection protects the public from microbial agents that escape the surface water treatment process, is used to inactivate microbiological contaminants in untreated ground water, and protects the public from organisms that may invade the distribution system by any number of opportunities.

Over the years many chemicals have been identified as being effective for disinfection of water. However, they all have some undesirable characteristic, usually the formation of a disinfection by-product (DBP), which limits their desirability (Montgomery 1989). Table 5.5 in Chapter V presents a list of the disinfectants currently accepted as effective for disinfection of drinking water in California. Many water agencies are continuously conducting research to identify new disinfectants that produce less objectionable by-products while maintaining a residual in the distribution system.

Historically, chlorine has been the disinfectant of choice for many reasons. It is available in different forms suitable for most water treatment use. It is abundant, relatively inexpensive, and controlling the dosage is easy. In the gas form it can be very hazardous and should only be used by trained operators. Likewise, the crystal form can be hazardous if mishandled or stored. In the 5% solution available at the grocery store as household bleach it is safe for use even by the untrained owners of small systems. However, in the disinfection of water, chlorine in all of its forms develops trihalomethanes (THMs), a group of carcinogenic organic chemicals. The THM concentration in the treated water is dependent on the concentration of precursors in the raw water and the contact time after chlorination.

All water systems in California that serve a population of more than 10,000 and that disinfect all or part of the water served are required to conduct quarterly monitoring for TTHM in conformance with USEPA monitoring criteria for TTHM. Briefly, this requires that a minimum of four samples be collected each calendar quarter for one year. More samples could be required depending on the number of treatment facilities, pressure zones, or other factors affecting the distribution of water.

As a rule, only four of the possible 10 THMs will occur in significant concentrations in water disinfected with chlorine: chloroform, bromodichloromethane, dibromochloromethane, and bromoform (AWWA 1980). In most cases, chloroform will be the THM present in the highest concentration. THMs form as a result of the reaction of free chlorine with the organic precursors in the water. The reaction will continue as long as there is free chlorine available, thus the time dependency of the THM concentration.

Chlorine dioxide has been used as an effective disinfectant for bacteria and virus inactivation in treated water. There are potential health effects associated with the presence in the treated water of chlorine dioxide and its byproducts, particularly for dialysis patients and those with certain enzyme deficiencies. For that reason ODW has imposed restrictions on the use of chlorine dioxide as a water disinfectant (ODW 1990).

Chloramines have been used effectively to limit the formation of THMs and other DBPs, but in most waters in this study, cyanogen chloride was found to increase in the presence of chloramines. The distribution of cyanogen chloride was demonstrated statistically to be higher for utilities that pre-chlorinated and post-ammoniated, compared to utilities that used chlorine only or ozone and chlorine.

Although chloramines have been effective in reducing the formation of TTHMs in disinfected water, a serious side effect has been noted. Soon after initiation of the use of chloramines as a disinfectant of a southern California drinking water supply, it was discovered that nitrification occurred in two covered distribution reservoirs (Wolfe et al. 1988). The adverse water quality effects included a rapid decline in the total chlorine and total ammonia-nitrogen residuals and elevated levels of nitrate and heterotrophic plate count bacteria. Temperature and detention time were contributing factors to the adverse reaction. In addition to the effects in the reservoirs, there was a high potential for distribution of bacteria throughout the distribution system.

In 1988, the Department entered into a cooperative agreement with the California Public Health Foundation to fund a study of the occurrence and control of DBPs in California drinking waters. This project was conducted in conjunction with a similar study, which involved 25 utilities around the country, being funded by a cooperative agreement between the USEPA and the Association of Metropolitan Water Agencies (Montgomery 1989).

The compounds of interest to the project included trihalomethanes; haloacetonitriles; haloketones; haloacetic acids; chloropicrin; chloral hydrate; cyanogen chloride, 2,4,6-trichlorophenol; and aldehydes. All of these compounds appear on USEPA's Drinking Water Priority Lists.

The 10 utilities participating in the California study represented a range of treatment processes and source waters. Seven utilities employed a conventional treatment process and two utilized direct filtration; the tenth used disinfection only. Two of the utilities used preozonation, followed by free chlorine for residual disinfection. Three utilities utilized only free chlorine, and four utilities had some free chlorine contact time in their treatment plants, but added ammonia to form chloramines for residual disinfection. The tenth utility used chloramines with concurrent addition of chlorine and ammonia.

The baseline quarterly sampling showed that on a weight basis, THMs were the largest class of DBPs detected in this study, comprising 50.9% of the total measured DBPs. The second largest fraction was the haloacetic acids (25.1% of the total DBPs). The information indicated that the median level of THMs was approximately twice that of haloacetic acids.

The third largest fraction found was the aldehydes. Of the ten utilities in the study, nine had a detectable level of formaldehyde or acetaldehyde in at least one sampling quarter. Chlorine, in addition to ozone, was found to produce these aldehydes at most plants. Furthermore, these aldehydes were detected in some treatment plant influent samples. Formaldehyde and acetaldehyde appear to be present in clearwell effluents because of a combination of the effects of treatment plant oxidation and/or disinfection practices, and influent water quality; the combined effects varying from one utility to another.

Analysis of all the DBP classes showed that there were no significant differences in any two sets of seasonal data. It was important to note that seasonal variations in temperature in California are not as great as those found in other parts of the country.

The SWTR establishes new levels of treatment that present challenges in the area of DBP mitigation. THMs are a major concern of the water treatment industry because of their carcinogenicity. The major constituents of the TTHM group are bromodichloromethane, bromoform, chloroform, and bromodichloromethane. THMs result from the chlorination of water containing of organic compounds. These organic compounds originate in many areas of the environment, both in nature and as a result of the activity of man. Major sources of these precursors in the waters of California are industrial wastes, agricultural wastes, and such natural sources as the peat soils in the islands of the Delta.

MWD and the City of Los Angeles Department of Water and Power (LADWP) have done much research on the control of DBPs. In their monitoring of the water quality of the Delta, MWD has determined that saltwater intrusion is a significant factor in the formation of TTHMs in treated water. Bromide, which is a natural constituent in seawater, forms brominated DBP when the water is disinfected with ozone (McGuire 1990). Ozonated water is usually post- chlorinated to produce a measurable chlorine that provides continued control of microbiological contaminants in the distribution system. This may still result in the formation of bromoform, and hence an increased TTHM concentration. Research is in progress to develop a means of mitigating this effect of water treatment.

3. Chemical

Inorganic chemicals are not usually found in high concentrations in California's surface waters at their origin. Where high concentrations are found there is usually a source of contamination involved, either natural or manmade.

Over the 1984-89 time interval, only three surface sources are on record as exceeding any primary MCLs. All three were for volatile organic chemicals. Although traces of pesticides have been reported in surface waters by other agencies, few are on record as contaminating public drinking water surface supplies. A notable exception is the detection of rice herbicides in the Sacramento River and City of Sacramento intakes.

Asbestos is the most common natural contaminant since it is related to the occurrence of serpentine, the state rock, and other geologic formations. These formations are found in many areas of the state and, therefore, asbestos fibers are commonly found in most valley streams.

All surface waters are susceptible to microbiological contamination and must, therefore, be filtered and disinfected before being served to the public as drinking water. In addition to the risk of possible microbial survival of the treatment process, consumers receiving surface water are faced with the potential health effects associated with DBPs. Since up to 70% of the population of California is served by systems using surface water as their primary source of drinking water, the microbiological and DBPs contaminants are the most significant water quality concerns facing California.

C. GROUND WATERS

The California agricultural economy has gained notoriety in part by liberal use of a wide variety of manmade chemical compounds. Some of these compounds eventually reach the underlying ground water. About 14,000 public drinking water supply wells in California were tested for over 380 different industrial, agricultural, and naturally-occurring chemicals between January 1984 and September 1989. The results of this testing are summarized below.

1. Organic Chemicals

California's public drinking water wells have been sampled for various organic pesticides. The most frequently detected chemical was DBCP that was present in 430 wells, and exceeded the MCL in 1.4% (190) of all well sources. DBCP represents the most significant of all pesticide detections that exceeded an MCL. The only other pesticides found in excess of the MCL were 1,2-dichloropropane, ethylene dibromide (EDB), and cis-1,3-dichloropropene. In total, 650 sources have demonstrated positive pesticide results but only 1.5% (209) of the source samples have been in excess of the MCL. Figure 4.2 illustrates the distribution of the drinking water wells which have exceeded drinking water standards for pesticides. Figures 4.3 and 4.4 shows the locations of wells exceeding the MCL.

Well sources were sampled for volatile organic chemicals (VOCs) during the 1984 to 1989 time period covered by this report. Of all sources, 3.2% (326) have been confirmed as exceeding one or more MCL. The results of VOC sampling in the database is in part a result of the AB 1803 program and follow-up sampling. Additionally, MCLs which have recently been adopted for many of the VOCs have resulted in a significant increase in routine and follow-up compliance monitoring.

Chlorinated solvents have been the most frequently detected group of VOCs in wells. Approximately 5% (700) of all wells tested have had detectable concentrations of PCE or TCE and about 0.9% of all wells exceeded the MCL for TCE and 0.7% exceeded the MCL for PCE. Figures 4.5, 4.6, and 4.7 illustrate the locations of the drinking water wells which have exceeded drinking water standards for TCE, PCE, and chlorinated

VOCs. Figure 4.8 illustrates the distribution of drinking water wells exceeding the MCL for chlorinated solvents.

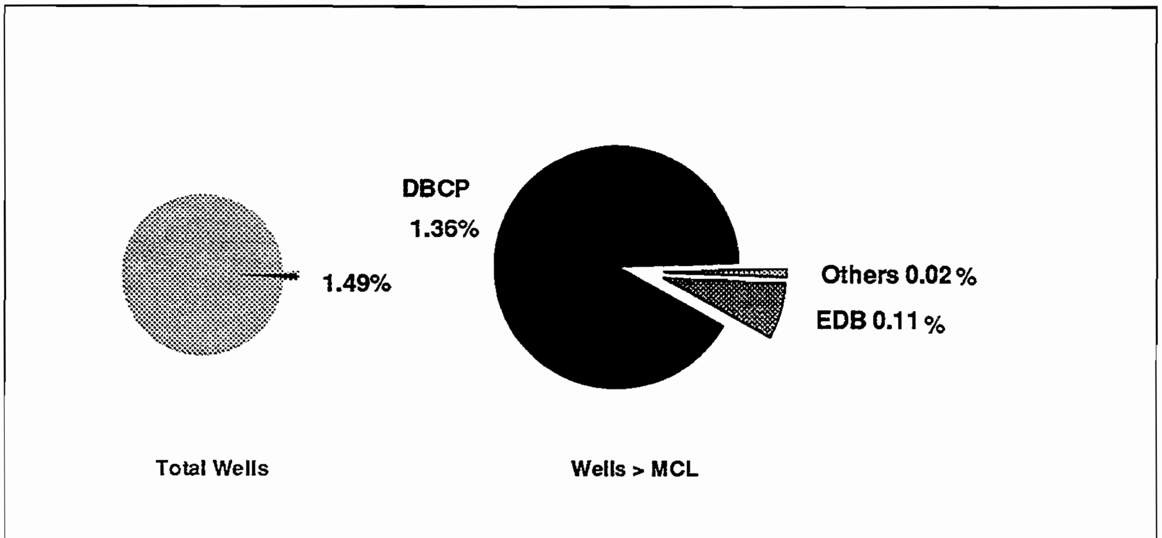

Figure 4.2. Pesticides Exceeding MCLs in Drinking Water Sources

2. Radiochemicals

As with the inorganic water quality information, not all radiological water quality information has been included in the ODW database. Based on the information in the database, there have been very few violations of radiological MCLs in public drinking water wells. Of the 1,884 wells tested for total alpha particle contamination, over 37% (700) have had detectable concentrations but only 1.1% (20) have exceeded the MCL.

In 1986, the USEPA announced its intent to establish an MCL for radon (USEPA 1986). ODW conducted a special study of radon in drinking water supplies in 1989 to provide a base for an exposure assessment of the risk associated with radon in ground water (CDHS 1990). Data collected by ODW in the 1989 study were made available to USEPA to aid in the establishment of the proposed MCL. The federal regulation for radon has been proposed in 1991. Radon may be one of the most prevalent naturally occurring radiochemical in drinking water wells but the available information is incomplete and has not been placed in the database. Initial screening of wells indicated that a majority of the drinking water wells in California might be vulnerable to contamination by radon.

Figure 4.3
Public Drinking Water Wells Exceeding
Dibromochloropropane MCL.

Figure 4.4
Public Drinking Water Wells Exceeding
Pesticides' MCLs.

Figure 4.5
Public Drinking Water Wells Exceeding
Trichloroethylene (TCE) MCL.

Figure 4.6
Public Drinking Water Wells Exceeding
Tetrachloroethylene (PCE) MCL.

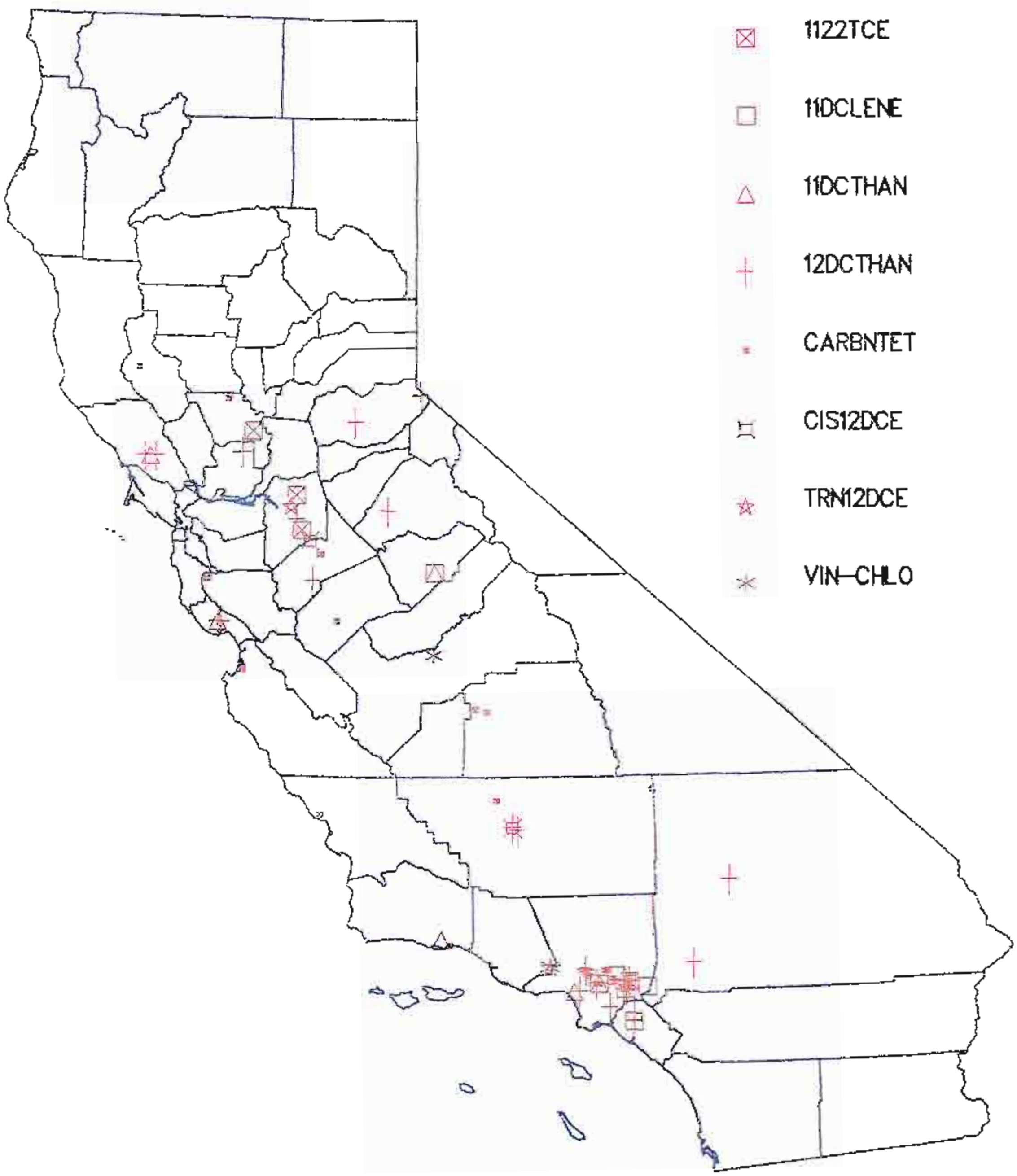

Figure 4.7
Public Drinking Water Wells Exceeding
Chlorinated Solvents' MCLs.

Others have also studied the occurrence of radon in ground water. One study reported that the mean concentration of radon was 589 picocuries per liter (pCi/L) in 44 wells sampled in California (Dixon and Lee 1988). Nationwide, California was among the seven states with the highest concentrations. In southern California 203 wells in service areas of member agencies were sampled by MWD to determine the levels of radon (Black and Veatch 1990). The results ranged from 93 pCi/L to 1,538 pCi/L with a median of 312 pCi/L.

A Geographic Information System (GIS)[9] analysis of the results of the 1989 ODW study indicated that if an MCL of 200 pCi/L is established for radon, all of public drinking water wells would be vulnerable to radon. This conclusion is supported by the findings of the other investigations cited above.

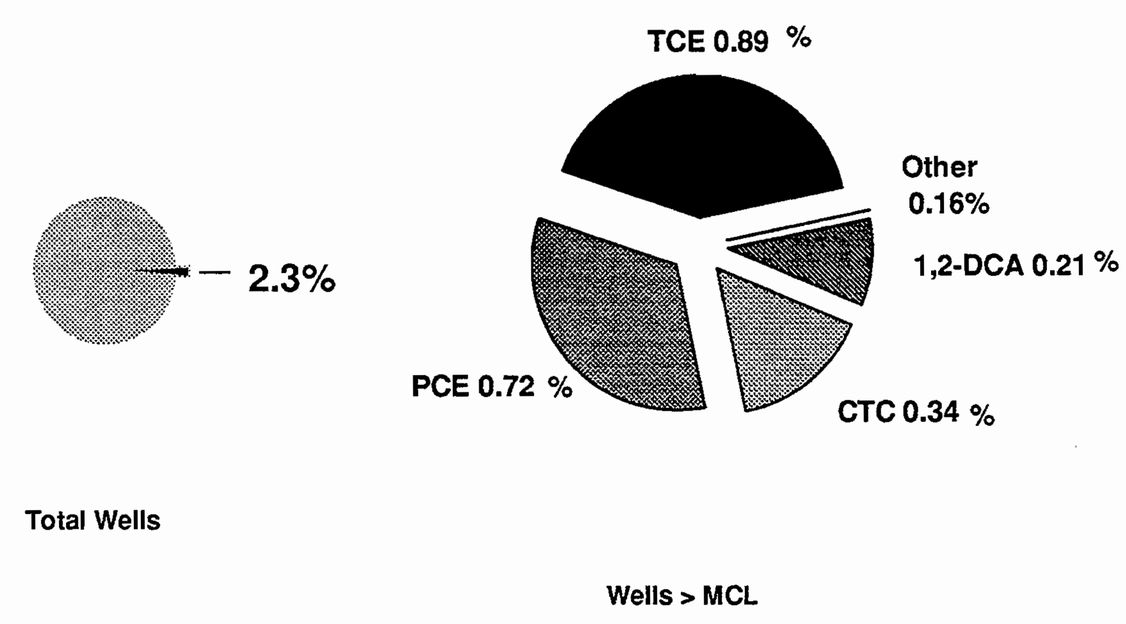

Figure 4.8. Public Drinking Water Wells Exceeding Chlorinated Solvents MCLs

[9]A computer software program capable of evaluation of geographically related data and preperation of maps.

3. Inorganic Chemicals

The database indicates that nitrate is the most frequently recurring inorganic contaminant for which a primary drinking water standard has been set. The database contains listings for 294 sources in violation of the nitrate MCL. This represents a violation rate of only 2.1%. The distribution of ground water sources that exceed the MCL for nitrate is shown on Figure 4.9. Sources that exceed the MCL must be treated to reduce the concentration of the nitrate, taken out of service and placed in standby status for potential use with treatment at a later date, or abandoned. SWRCB has reported widespread contamination of ground water aquifers with nitrate exceeding the MCL in 9% of the 121,000 analyses from over 38,000 wells (SWRCB 1988). This study included information from private drinking water wells in addition to water quality information obtained from the ODW monitoring programs. It is possible that private wells are not in compliance with the drinking water standards as there is no regulatory requirement that they comply.

Less than 1% of the wells in the ODW database that were tested for have exceeded the MCLs for these substances. Statewide, selenium was found in excess of the MCL in 39 wells. The wells were generally located in localized areas indicating that selenium is not a constituent of widespread concern in drinking water wells. It is a serious contaminant in agricultural wastewaters that are ponded, where evaporation can concentrate it and all other chemicals resulting in a hazard primarily to wildlife. Arsenic has also been detected to a lesser extent. There are a few locations in California where sources are exceeding the MCL.

In spite of the much-publicized contamination of ground water by man-made organic chemicals, there is little evidence of widespread contamination of drinking water supplies. A relatively few water systems have been forced to abandon sources of supply or install treatment when contamination was detected. When required, corrective action has been quickly implemented and the risk to the public has been minimal, especially given the long-term nature of the associated risk.

If a regulatory program is to be successful in effectively monitoring and regulating the quality of water served to the public, an effective and efficient information management program is essential to collect, organize, and make accessible the information necessary to carry out the program. The increased volume of water quality and compliance information generated by the new drinking water quality monitoring regulations has required the ODW to develop an expanded and improved information management system. If the system is to accomplish its purpose, it must contain current information and be updated regularily.

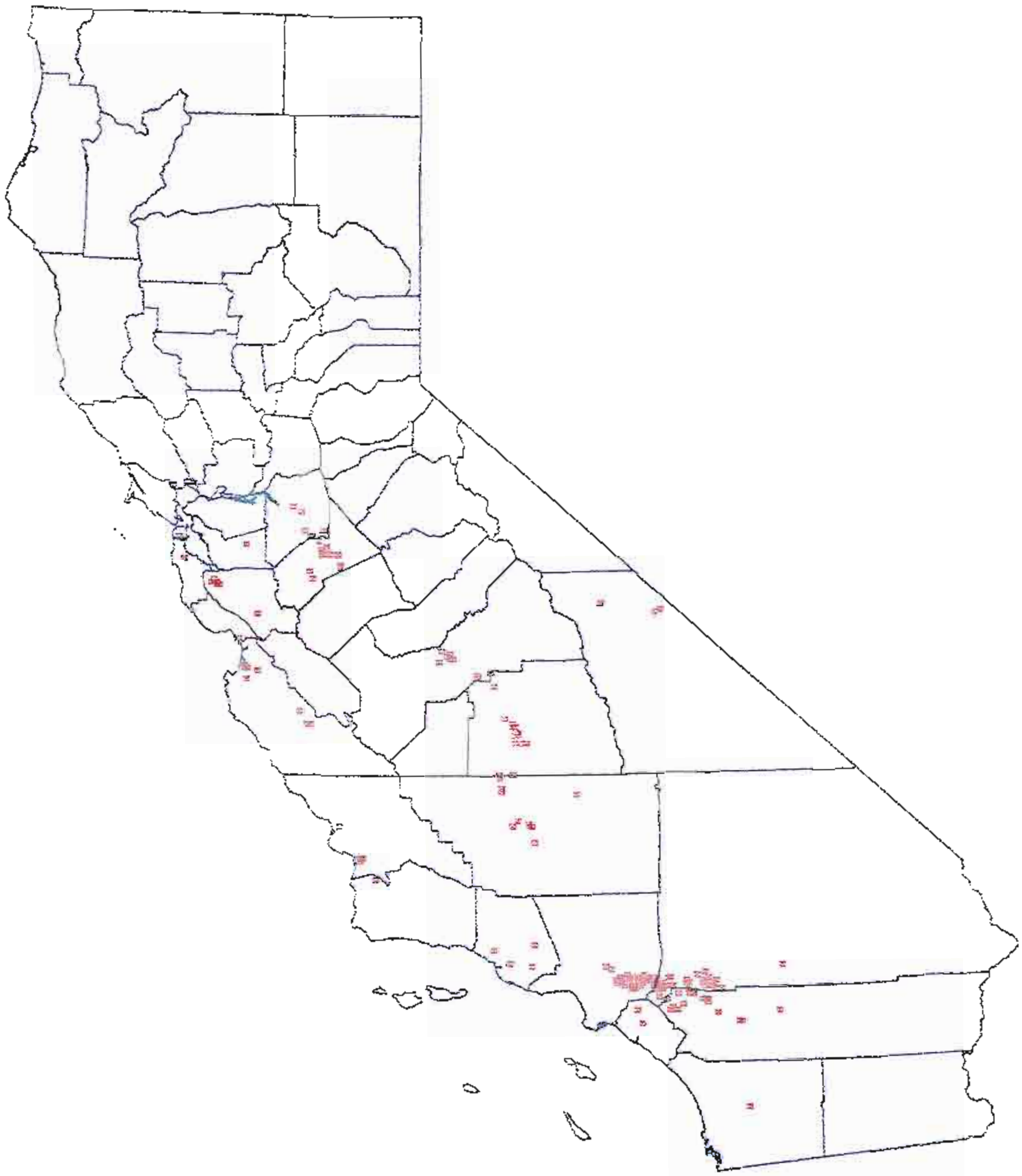

Figure 4.9
Public Drinking Water Wells Exceeding
Nitrate MCL.

D. REGIONAL WATER QUALITY ISSUES

It has previously been stated that the waters of California are exposed to many sources of contamination. That is not to say that there is widespread contamination, but only that the potential exists and that diligence must be exercised to prevent unnecessary degradation of the water.

There are some areas in the state where contamination has caused serious deterioration of the quality of the water. For the most part, the cases have been relatively localized and some control has been possible. In some cases, clean-up of contamination has been ordered by regulatory agencies with some measure of success. In other cases, clean-up is impractical and the only alternatives for water users are to find alternate supplies or institute treatment of the contaminated water.

Presented below is a brief discussion of some of the more significant areas of contamination that have occurred. This is not intended to be an exhaustive report on contamination but rather a summary to identify the character of contamination in each region where domestic water supplies have been adversely impacted. Table 4.1, presents a summary of typical events of contamination by region.

1. San Francisco Bay

The San Francisco Bay Area is a densely populated region with a wide variety of industrial and commercial activity. Some areas of localized contamination have occurred, the most serious being contamination in the South San Francisco Bay area in Santa Clara County where industrial solvents have impacted the local ground water basin. Only one supply source of a large water system has been affected and removed from service. This one contaminated well source, however, brought state and nationwide attention in 1981 to ground water contamination problems. The contamination of the Great Oaks Well No. 13 by a leaking underground storage tank owned by the Fairchild Semiconductor Corporation, brought to light that underground tanks leak and the chemicals stored in these tanks can contaminate the ground water.

The contamination of this well led to intensive health effects studies of pregnancy outcomes by the Department. The results of the studies found no correlation between contaminated drinking water and adverse health effects in the area studied (CDHS 1985b, 1988a, and 1988b).

This incident also significantly impacted the drinking water as well as other water quality and environmental programs. Several laws, regulations, and programs resulted from this incident. Some of the most significant are: (1) AB 1803 and the survey of large and small water system wells for organic chemicals, (2) new USEPA and California MCLs for organic chemicals, (3) underground tank requirements, (4) Proposition 65, and (5) AB 21.

Some supplies for small systems and several individual water sources have also been contaminated. As in the case of the Great Oaks well contamination, where the responsible industry was identified, the regulatory agency has ordered cleanup of the contamination.

In the South San Francisco Bay area in Alameda County, on the east side of the Bay, there is some evidence that domestic wastes have affected the local ground water. However, the most serious contamination is from seawater intrusion. Alameda County Water District is operating a basin management project to recharge the basin and to control the intrusion of seawater. The program relies to a great extent on the availability of imported water from SWP to augment local storm runoff. Due to drought conditions, both of these sources may not be adequate to effect control this year.

2. Central Coast

The Central Coastal Region is not seriously affected by contamination. The most significant is the nitrate contamination of the ground water basins by domestic waste discharges, agricultural activities, and cattle feed lots in the Gilroy-Hollister Valley area and the lower Salinas Valley. Seawater intrusion into the ground water basin in Monterey Bay has forced some systems, including Fort Ord and Marina, to locate new sources of water further inland. The Fort Ord and Marina area is also affected by localized ground water contamination from VOCs due to past military operations at Fort Ord. Some systems in the Morro Bay area have also had their sources impacted by increased seawater intrusion. The current drought conditions have seriously exacerbated seawater intrusion in many areas. This area had the second highest incidence of positive selenium results with nine wells exceeding the MCL in San Luis Obispo, Santa Barbara, and Ventura counties.

3. Sacramento Valley

The Sacramento Valley Region is very important to most people in the state. It is the origin of the two largest water transfer projects in the state, SWP and CVP. There is an abundance of streams and lakes that support all sorts of outdoor recreation. The valley floor is a major agricultural area, ranked second in the nation in the production of rice. Because of the discharge of agricultural wastes from rice fields each year, the City of Sacramento is required to alter their treatment plant operation for water pumped from the Sacramento River because of the presence of herbicides (molinate and thiobencarb) used on rice. Although these contaminants are below the MCLs, thiobencarb produces taste and odor problems at low concentrations.

The most significant occurrence of selenium found in drinking water supply wells was in the Sacramento Valley county of Yolo where 14 wells exceeded the MCL. Since the wells were taken out of service the risk to the customer was minimized.

4. Sacramento-San Joaquin Delta

The Sacramento-San Joaquin Delta (Delta) (Figure 4.10) has been described as the most important body of water in California (SWRCB 1990). It is the hub of the "California water wheel", receiving input from all directions and distributing the result to areas of need in the west and in the south.

Drainage from the irrigated Delta islands is also a major contributor of organics. These islands have been recovered from the Delta Marsh by construction of over 1,000 miles of levees and by pumping the water into the Delta channels to lower the water level in the soil to below the root zone of the planted crops (DWR 1990). Since the ground surface elevation is usually lower than the elevation of the water surface in the adjacent channel, near continuous pumping is required to maintain the islands. The soils are mostly peat with a high organic content which is leached to the waste drain waters together with the agricultural chemicals used on the crops.

The quality of the water in the Delta determines the quality of water available for delivery to users in the North and South Bay areas, in the San Joaquin Valley, and in southern California. The wastes from the Sacramento Valley and the San Joaquin Valley contribute a significant portion of the microbial agents and organic compounds found in the Delta waters.

Seawater entering the Delta from the San Francisco Bay further deteriorates the quality of water available for export. The upstream extent of this intrusion depends on the quantity of inflow contributed by the areas tributary to the Delta. Although the salinity of the Delta water is important to domestic users, there is more concern for the concentration of bromides which are common to seawater (McGuire 1990). When water is subjected to disinfection to make it microbiologically safe, DBPs are formed, as previously described in B.2 - Disinfection By-Products. Bromides in the water from seawater intrusion, when combined with the organics present, greatly increase the formation of TTHMs. The primary sources of TTHM precursors in the Delta waters are the organic compounds in wastes in the influent tributary waters, the drainage from Delta islands, and the bromides in the intruding seawater.

The levees, which have been constructed to prevent the Delta waters from flooding the lowland islands, are fragile structures subject to damage by floods and by earthquake. Flooding of the Delta islands when a levee breaks has impact far beyond the loss to the agricultural industry involved. When the flooding recedes the increased wet area further increases the effective depth of seawater intrusion and thus the concentration of THM precursors.

5. San Joaquin Valley

The San Joaquin Valley is the leading agricultural area of the country. It attracts a large population and a broad array of supporting industries. As a result there is a great potential for contamination of the water resource. The locations of wells in the San Joaquin Valley that exceed one or more MCL are shown on Figure 4.11. DBCP has been found in many areas of the valley. DBCP is a fumigant used by agriculture to control root nematodes in a wide variety of crops. As a result of DBCP contamination, many systems in the valley have been required to replace ground water sources or install treatment to remove the contaminant. This has caused significant financial hardship on several systems and their customers.

Ground water in the San Joaquin Valley has been subjected to contamination by nitrates, both from agricultural activities and domestic waste discharges. As with other industries, agriculture tends to attract urbanization. The eastern side of the Valley has developed into several urban areas associated with agriculture and its support industries. The resulting domestic and industrial wastes have contributed to the occurrence of nitrate contamination. About 25% of the drinking water wells in the state with nitrates above the MCL are located in this area. Several systems have been required to replace drinking water wells because of nitrates above the MCL. One system installed treatment to reduce the level to below the MCL.

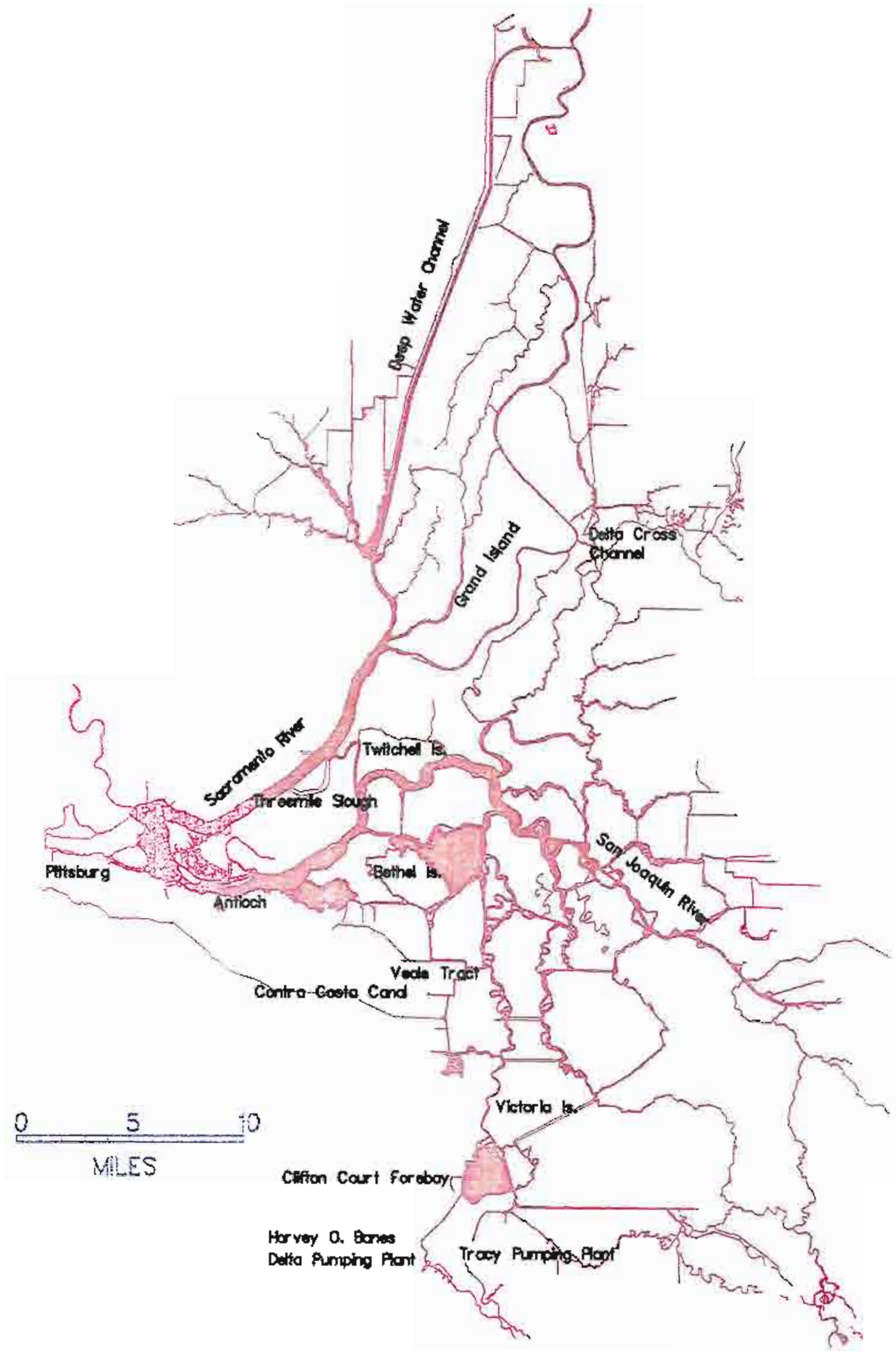

Figure 4.10
Sacramento – San Joaquin Delta

TABLE 4.1 SIGNIFICANT REGIONAL WATER QUALITY CONTMINANTS

REGION	CONTAMINANT[a]	SOURCE	IMPACTED AREA
North Coast	Microbial agents	Recreation on reservoirs and domestic waste disposal	Whiskytown and other reservoirs, downstream domestic systems, Russian River Valley
San Francisco Bay area	VOCs, industrial solvents, microbial agents, salinity	Industrial wastes and domestic waste treatment and disposal systems, military installations, seawater intrusion	Santa Clara and Alameda Counties Bay side ground water basins, Bay saltwater marshes
Central Coast	Nitrates, salinity	Agriculture, cattle feed lots, domestic waste, seawater intrusion	Lower Salinas Valley and coastal areas of Monterey Bay
Sacramento Valley	VOCs, pesticides, herbicides, microbial agents, dissolved minerals and metals	Rice field and other agriculture, domestic waste discharges, recreational activities, military installations, abandoned mines	Sacramento Valley ground water basins, Sacrament River and the Sacrament-San Joaquin Delta
Sacramento -San Joaquin Delta	Pesticides, herbicides, microbial agents, industrial solvents, TTHM precursors, asbestos, salinity	Agricultural drainage form Sacramento and San Joaquin Vallies and Delta Low Lands, domestic waste discharges, and seawater intrusion	All domestic users of water exported from the Delta (SWP, CVP, Contra Costa Co. WD and local utilities that divert directly from the Delta): treatment is affected by increased organics from island drainage, organics in wastes and bromides in seawater intrusion
San Joaquin Valley	Pesticides, herbicides, VOCs, nitrates, selenium, TDS	Agricultural drainage, chemical formulators, chemical applicators, metal fabricators and platers, pole pressure treaters, commercial enterprises, military installations	Localized areas of the San Joaquin Valley have been contaminated by local industries, large part of the ground water basin contaminated by ag use of DBCP and other chemicals and nitrate. SWP upstream of Kettleman City, entire valley ground water basin,
San Fernando Valley	Solvents TCE & PCE, other VOCs, toxic metals	Local industry and commercial establishments, military installations	San Fernando Valley ground water basin
San Gabriel Valley	TDS, nitrate, microbial agents, TCE, PCE, CTC , other VOCs	Industry, commercial and sewage wastes, ag wastes, solid waste landfills	Ground waters throughout the valley and into the coastal plain of LA County
Santa Ana Valley	VOCs, metals, nitrates, microbial agents, salinity, pesticides	Industry, mining, agricultural and sewage wastes, solid waste landfills, seawater intrusion, military installations	Ground waters in the upper and lower Santa Ana Valley in LA and Orange Counties and in San Bernardino County

[a]TDS: total dissolved solids; PCE: perchloroethylene or tetrachloroethylene; TCE: trichloroethylene; CTC: carbon tetrachloride; Ag: Agricultural

In the reach from the Delta to Kettlemen City (Kings County), SWP is subject to contamination by agricultural wastes entering through drain inlets at many locations. The sanitary survey of SWP (Brown and Caldwell 1990) identifies numerous inlets in this reach. Some of these inlets also allow entry of large amounts of asbestos fibers from hillside storm drainage. Although a concern, asbestos is successfully removed by conventional treatment processes and poses no danger to consumers.

The San Joaquin Valley is recognized for the occurrence of high concentrations of selenium in agricultural wastes collected from west side farm lands and stored in (Kesterson) Reservoir for eventual export to a safe disposal area. For various reasons, disposal was not accomplished and the chemicals in the waste concentrated to unsafe levels. Clean-up of the Kesterson site has been accomplished and the agricultural wastes are now collected and ponded on the individual farms. Only two drinking water supply wells have been reported to have selenium in excess of the MCL and these are not in the area impacted by the agricultural wastes.

Other industries have also contributed to the presence of organic compounds in the ground water. Throughout the valley there are localized areas of contamination caused by industries such as metal fabricators, dry cleaners, and chemical formulators to list but a few examples. Even the food packers and processors supporting the agricultural industry have contributed to the contamination by disposal of wastes containing salts, fumigants, and fungicides.

6. South Coastal

The South Coastal Region is one of the most densely populated areas of the state. Over half of the population of California now lives south of the Tehachapi Mountains and the numbers continue to grow. While the weather may play a part in the desire of people to locate in Southern California, opportunity for employment is more of a consideration. Employment means industry which means potential contamination of the water supply. As a result of the population and industry, much of the ground water is contaminated to where its use as a domestic supply is restricted. The locations of wells in a part of the South Coastal areas that exceed one or more MCL are shown on Figure 4.12.

The San Fernando Valley ground water basin has been contaminated with the industrial solvents TCE and PCE. LADWP, in cooperation with USEPA, is currently operating a clean-up project to correct the contamination and make the water usable (LADWP 1986).

Ground water in many areas of the coastal basins has been contaminated by toxic chemicals and industrial solvents deposited in landfills. A prominent example is the Stringfellow Landfill in Riverside County. Remedial efforts have been in progress in this area for over 20 years. The contamination has caused the abandonment of some of the basin for domestic use and threatens the loss of the entire basin (Kotiaho 1990).

Disposal of dairy and domestic wastes in the upper drainage area of the Santa Ana River in the Upland and Riverside areas has caused serious contamination of the ground water downstream in Riverside and Orange Counties. To aid in disposal of the large amount of domestic waste generated in the area, some local projects have been established for recharge the ground water basin with the treated wastewater. These projects are of particular concern to domestic users of the ground water because of the potential of contamination by inadequately treated sewage.

Ground water in several areas of the south coastal basin have been contaminated by nitrates from agriculturally related activities and from domestic waste discharges. Of the 294 sources reported in the ODW database as exceeding the nitrate MCL, over half are located in the San Gabriel-Santa Ana river basins.

Ground water supplies from basins adjacent to the coast in this region have been the most impacted by seawater intrusion. Currently there are three active seawater barrier projects operated by local agencies in this area. The projects use either injection of water to form a mound, pumping to develop a trough, or a combination of the two to prevent the inland migration of the seawater. One of the barriers use treated domestic wastewater as a source for injection. As with the use of wastewater for ground water recharge, there is also concern for the use of the waste for injection for seawater intrusion control. Currently some of the extraction wells used in this barrier have been pumping almost totally injected wastewater indicating that wastewater is now at or inland from the pumping trough. A fourth experimental barrier project in Ventura County is now inactive. Some control of intrusion is maintained by recharge of the basin with imported water.

A significant portion of the water served in Southern California is imported. LADWP imports water from the Owens Valley on the east side of the Sierra Nevada through 244 miles of a combination of open canals and pipelines for delivery to and treatment at its plant at the upper end of the San Fernando Valley. Until it arrives at the treatment plant, there is only limited opportunity for contamination because of the isolated area and the enclosed pipeline. Following treatment, however, the water is stored in several open reservoirs. These facilities are subject to a variety of potential contamination. In spite of the efforts of LADWP and the urging of ODW, resistance by local residents has prevented covering or enclosing these reservoirs.

MWD imports water from the Colorado River through a 242 mile aqueduct for delivery to Lake Mathews in the coastal basin. In addition they buy a significant amount of their water from SWP with delivery at several points south of the Tehachapi Mountains and as far south as Perris Reservoir in Riverside County. Water from the Colorado River is generally protected from contamination because it is contained in a pipe line. SWP, on the other hand, is transported in open canals and is stored in several reservoirs after it crosses the Tehachapi Mountains.

SWP provides many benefits, all of which served to justify the construction of the 600 mile transfer project. Among those benefits are recreation and fishery. As a result, reservoirs of the project are generally open to a full range of recreational activity.

In addition to the potential for microbial contamination, recreational activities often lead to eutrophication[10] of the reservoirs which in turn can cause blooms of taste and odor-causing algae. Also there is usually an increase in the benthic[11] population. This is particularly troublesome in reservoirs that are subject to thermal stratification and seasonal overturn. When this happens, the benthos is disturbed and the resulting water quality causes serious operational problems at treatment plants, and jeopardizes their ability to continue to serve a quality product and to meet the MCL for TTHMs.

Since one of the primary objectives of SWP is to provide a viable fishery, there is a prohibition against the use of algaecides such as copper sulfate which would be detrimental to the fish. This has caused serious problems to the domestic uses of the project waters since they are not permitted to utilize many of the most successful algae control methods.

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[10]The addition of nutrients to the water.

[11]Plants and animals that live at or on the bottom of a water body.

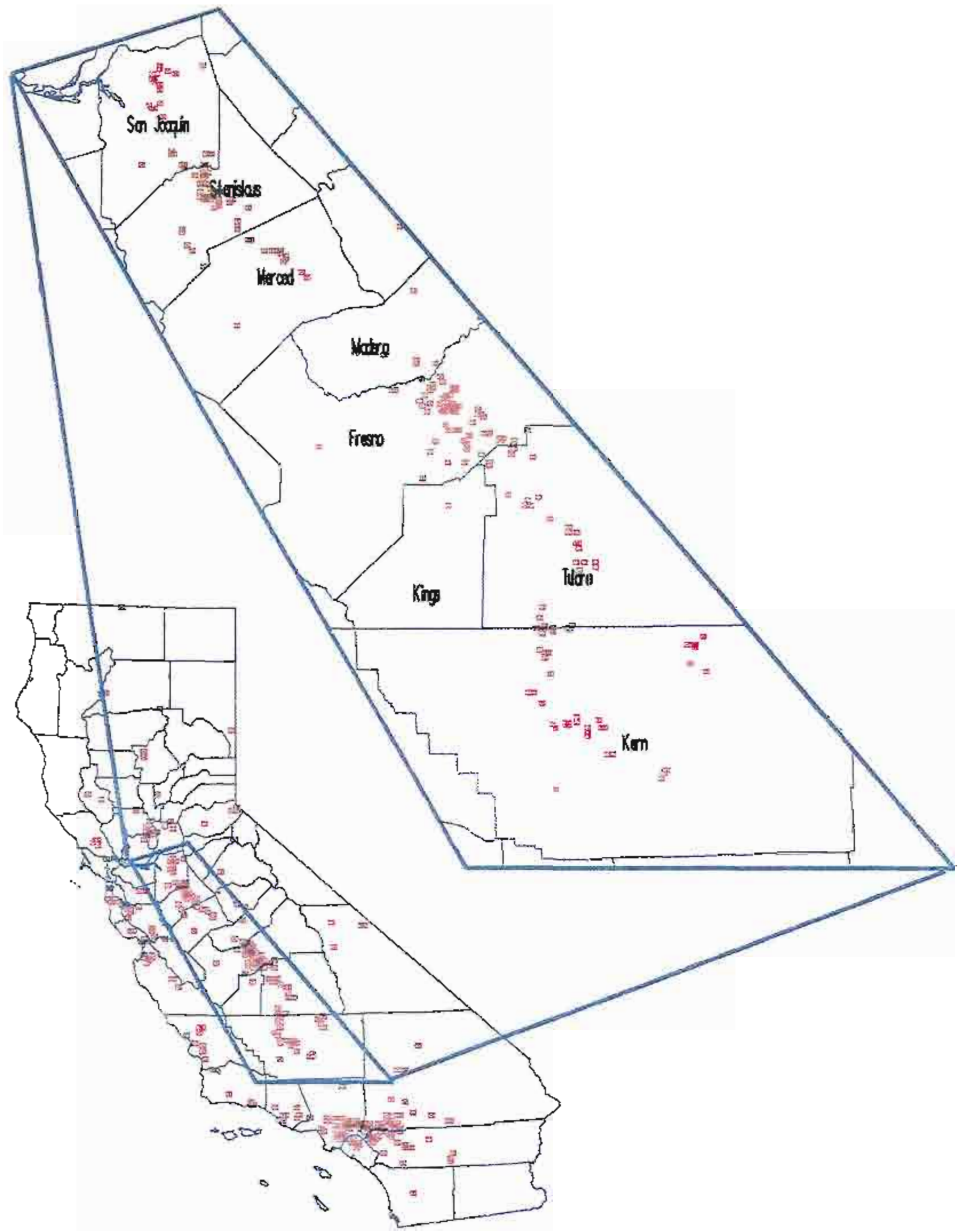

Figure 4.11
Public Drinking Water Wells in San Joaquin Valley
Having Contaminants Exceeding MCLs.

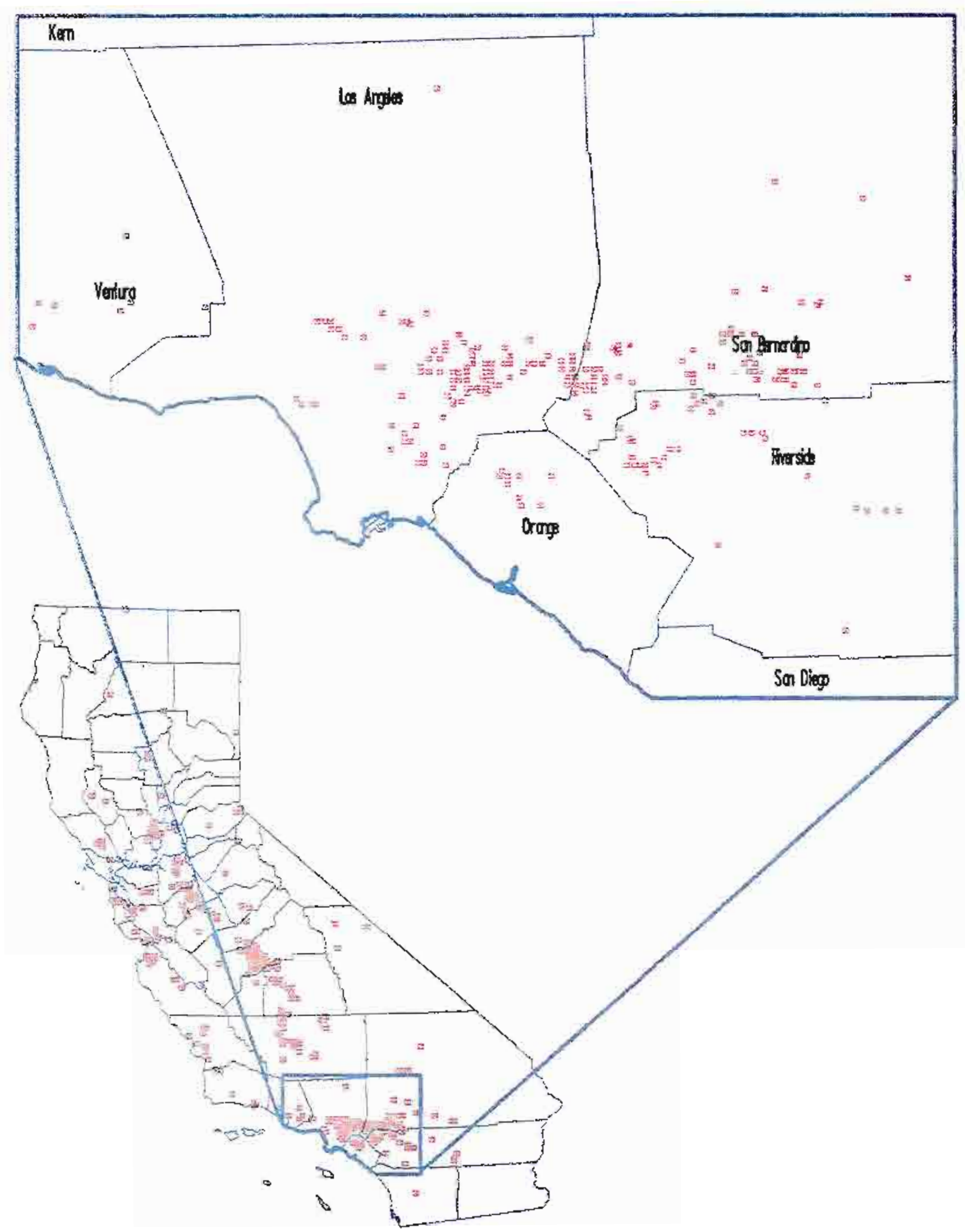

Figure 4.12
Public Drinking Water Wells in Southern California
Having Contaminants Exceeding MCLs.

E. DISTRIBUTION SYSTEM WATER QUALITY

1. Background

New systems constructed today are required to meet minimum standards imposed by the responsible regulatory agency. The applicable rules and regulations imposed by the various regulatory agencies having authority over domestic water systems are described in Chapter II of this report. The agencies that impose standards of construction on new water system facilities are ODW, PUC, DHCD, and DOC.

Although each agency has its own set of standards, differences between the requirements are minor. Systems regulated by ODW are required to provide a minimum quantity of water as determined by the number of customers. Storage capacity can be provided to off-set a portion of the source capacity required to meet peak demands. A minimum pressure of 20 pounds per square inch (psi) is required at all levels of demand. The minimum pipe size permitted is 4-inch except that 2-inch pipe can be used for looping a section of the system. ODW has no requirement for fire flow capacity. Dead-end lines are permitted only if looping is impossible or if the main is to be extended in the near future and the extension will eliminate the dead end.[12] ODW also imposes minimum requirements for separation of water and sewer lines.

Systems regulated by PUC are required to provide a minimum quantity of water depending on the number of customers. The source capacity may be reduced if storage is provided to meet peak and emergency demands. A minimum pressure of 40 psi must be maintained under all conditions. For PUC systems, the minimum pipe size is 6 inch where a fire hydrant is to be installed. Four inch pipe can be used if it is only to provide looping of a section of the system. All fire hydrants must produce a specified minimum fire flow volume (PUC General Order 103).

DHCD regulates systems serving MHPs and employee housing. Because of the substantially different conditions in these types of systems, the regulations differ. The most significant difference between DHCD and ODW requirements is in the separation of water and sewer lines. DHCD permits installation of water lines and sewer lines in a common trench (Uniform Plumbing Code). When MHP are customers of a larger water system, they are usually treated as a single customer with one or more

[12]California Code of Regulations (formerly the California Administrative Code), Title 22, California Waterworks Standards.

connections. Because of the different water-sewer separation standards, backflow protection is frequently required.

Most of the water systems in California have been in existence for many years and many were formed before any state agency had regulations in place or the authority to impose regulations. With the exception of some of the larger municipal utilities, most were started as individual services and grew one or two connections at a time largely for convenience and economy. There was seldom any fund established for future operation and maintenance or equipment replacement.

2. Types of Problems

The most serious threats to distribution systems result from inappropriate action by customers (e.g., cross-connections) and from inadequate maintenance and replacement of deteriorated facilities. Some of the more frequently observed hazards are discussed below.

a. Inadequate Facilities

The physical condition of the water distribution system is as much a factor in maintaining the quality of water served as is the quality of the source. Major utilities such as the larger municipal systems, water districts, and large privately owned systems long-ago learned the value of constructing a quality distribution system and maintaining it in good condition.

The worst distribution systems usually occur in the smaller water systems. Most of these systems operate on a financial shoe-string, barely making monthly payments for electrical power. There is seldom a fund for replacement of distribution mains or storage reservoirs and the hat is often passed when it is necessary to replace pumping equipment. The facilities are often allowed to deteriorate until repair is impractical. Pipe lines in these systems are often thin wall steel tubing or galvanized pipe which are susceptible to corrosion and failure. Because of the condition of the pipe, pressures are often near the minimum allowed to prevent excessive leaking. Holes in the pipe that are the result of corrosion offer a perfect opportunity for back-siphonage of contaminated water into the distribution. The heavy tuberculation or pitting in these pipes also makes disinfection difficult by offering a safe haven for proliferation of any bacteria that may enter the system. Frequently the systems will have long dead-end lines that have no blow-off facilities other than customers garden faucets. Circulation in these lines is minimal and disinfection is near impossible when contamination is detected.

The rapid expansion of recreational areas where individuals have constructed part-time housing is creating a new type of inadequate system. It has been common practice for these areas to develop an unofficial water system by interconnecting the various houses with minimum sized pipe without regard to any standard and often without building permit or approval. When the systems become official, a complete new distribution system may be required for them to meet minimum standards required by the regulations.

b. Operation and Maintenance

Because of the financial condition of the smaller water systems, they are usually unable to pay a wage that would attract qualified operators. Maintenance is usually performed by a part-time person, usually a person with little or no experience with water systems. Often the owner attempts to maintain the system in his spare time while also holding a full-time job. Because of limited time and the cost of pumping the water, the owner may maintain an adequate main flushing program. Major repairs are usually done under contract by a local tradesman. Because of these arrangements, the system usually receives little attention between the annual inspections by LEHJs and ODW. Performance of the necessary repairs identified during the inspection is reluctant, especially if substantial cost is involved. This problem is most prevalent in small water systems and is discussed in more detail in Chapter X.

c. Direct and Indirect Additives

It is often necessary to add chemicals directly to a water supply to make it suitable for distribution to customers as a drinking water supply. All surface water used as a drinking water source must be disinfected to protect public health. Ground water many have taste and odors, and some minerals produce unacceptable qualities that must be treated to produce a palatable water. Ground water can also become contaminated with microbial organisms that require disinfection before it is safe to consume. Disinfection of public water supplies has long been practiced throughout the world as a means of reducing the risk of waterborne disease. Disinfection is not, however, without its drawbacks. A more complete discussion of DBPs is presented in B.2 Disinfection By-Products of this chapter and Chapter V.

Other chemicals, such as coagulant filter aids, are added directly to the water to increase the rate and effectiveness of turbidity removal prior to filtration. Some water treatment chemicals, such as aluminum sulfate (alum) have health implications and require strict control in the treatment process. Taste and odors caused by natural contaminants such as hydrogen sulfide are often treated with chlorine or some other oxidant or by filtering through activated carbon. This is often necessary to make the water palatable to the customer. Customers often perceive a greater risk in consuming water with an offensive taste or odor than water that may contain health endangering contaminants.

Many ground water supplies in California contain significant concentrations of iron and manganese. These constituents have no health implications but they are often the center of customer complaints of stained plumbing fixtures and laundry. Correction is accomplished by addition of chemicals to precipitate the iron and manganese so that filtration is possible. Table 4.2 presents a list of the most commonly used chemicals for water treatment.

During distribution, chemicals may enter the water indirectly as a result of leaching of soluble solvents from the linings of storage tanks and transmission pipe. Some waters are corrosive and will cause erosion of pipe materials in the distribution system and in the plumbing of customers houses. As a result such constituents as copper from copper pipe which is frequently used for household, plumbing and lead from solder used to fabricate copper plumbing may enter into the household water supply. Legislation adopted in 1985 prohibits the use of solders containing more than 0.2% lead in making joints and fittings in any private or public potable water system. Corrosion can also cause asbestos to be released from asbestos-cement pipe used in drinking water distribution systems.

d. Distribution Reservoirs

Reservoirs are an important part of many water systems. They provide for storage of water to meet the extreme peaking needs of a system and thereby reduce the quantity of continuous supply required. Without storage, operational cost and efficiency would suffer. Storage is also an important source of water to meet emergency needs such as periods when the pumping equipment is out of service for repair, in the event of power failure, and in the case of disasters such as a major fire.

As a general rule, uncovered reservoirs should only be used to store untreated water. Because of concern for the health risk involved, state policy has prohibited new open reservoirs for storage of treated drinking water since 1976. Uncovered reservoirs are exposed to most of the same hazards that endanger all surface water sources. Some systems still have uncovered reservoirs in use for storage of treated water for further distribution to their customers. As a rule these reservoirs are protected from significant hillside runoff and from water contact sports activity. They are not, however, protected from access by wild life or water fowl, and by vandals unless they are fenced and locked.

Table 4.2 Commonly Used Water Treatment Chemicals

Treatment	Chemicals
Disinfection	Calcium Hypochlorite (HTH); Chloramine (NH2Cl); Chlorine (Cl_2); Chlorine dioxide (ClO_2); Hypochlorous acid (HOCl); Ozone (O_3); Peroxone (O_3/H_2O_2)[a]; Sodium hypochlorite (NaClO)
Taste and Odor Control	Activated carbon (C), Chlorine (Cl_2); Chlorine dioxide (ClO2).
Dechlorination	Sodium thiosulfate ($Na_2S_2O_3$); Sulfur dioxide (SO_2).
Coagulation	Aluminum sulfate (Alum, $Al_2(SO_4)_3$.14H2O); Ammonium sulfate ($(NH_4)_2SO_4$); Ferric chloride ($FeCL_3$); Ferric sulfate ($Fe_2(SO_4)_3$); Ferrous sulfate ($FeSO_4.7H_2O$); Sodium aluminate ($NaAlO_2$); Sodium silicate (Na_4SiO_4).
Softening	Calcium hydroxide ($Ca(OH)_2$); Calcium oxide (CaO); Sodium carbonate (Na_2CO_3).
Algae Control	Copper sulfate (Blue stone, $CuSO_4$).
Fluoridation	Hydrofluosilic acid (H_2SiF_6); Sodium fluoride (NaF); Sodium fluosilicate (Na_2SiF_6).
Defluoridation	Magnesium hydroxide ($Mg(OH)_2$).
pH Adjustment	Sodium bicarbonate ($NaHCO_3$); Sodium hydroxide (NaOH); Sulfuric acid (H2SO_4).
Corrosion Control	Sodium hexametaphosphate ($NaPO_3$)n).
Ion-exchange Resin Regeneration	Sodium chloride (NaCl).

[a]The joint use of ozone and hydrogen peroxide

Most systems that still have uncovered treated water storage reservoirs in use are attempting to cover them or install replace cover reservoirs. LADWP proposed to cover 10 open reservoirs in their system in 1990. During a series of public meetings held in compliance with CEQA requirements, LADWP met significant public opposition because of the aesthetic value of the water body. Most of the opposition came from property owners that did not receive their water from the reservoir in question.

Covered reservoirs may also be subject to significant problems. Most covered reservoirs are lined with some material which may contains soluble solvents. If the lining is not properly cured before the reservoir is placed into service, the water can become contaminated with organic solvents. This problem has resulted in reservoirs being taken out of service to have the lining stripped and replaced. Aged lining can become pitted and provide a protected place for bacteria to attach and grow, subsequently causing the system to fail the bacteriological standards.

e. Microbial Agents

Contamination of a water system by microbial agents represents a serious threat to the health of water consumers. Earlier in this chapter contamination of the raw water sources by microbial agents was discussed. This discussion will deal with apparent contamination in the distribution system. It has been accepted practice in the drinking water supply industry to monitor for microbial contaminants by monitoring for surrogates in the coliform group. System operators along with state and county health departments have historically accepted the absence of coliform as indicative of the absence of other bacteria and viruses. *Giardia*, *Cryptosporidium*, and *Legionella* have only recently become organisms of concern. When attendees at a convention of the American Legion experienced pneumonia symptoms with no identifiable cause, all possible avenues of infection, including the water supply, were investigated. Since then many investigators have identified legionella organisms in drinking water distribution systems.

The presence of bacteria in raw surface water supplies is expected, and the California SWTR is designed to protect the users of water by providing a required treatment train of barriers to physically remove the organisms from the water, followed by disinfection prior to distribution. The presence of microbial contaminants in the discharge from the treatment plant indicates a failure of the treatment system. Since a measurable residual of disinfectant must be maintained throughout the distribution system, any microbial organisms found may represent a defect in that system.

Microbial agents generally are not found in ground water unless contamination has occurred in the vicinity of the source well. For this reason, systems obtaining their drinking water supplies from ground water are not required to disinfect unless there is continued positive bacteriological results. These systems are also not required to monitor the raw water prior to its entry into the distribution system.

When monitoring detects microbiological contaminants in a distribution system, there are many possibilities that must be explored to find and remove the origin. In the interest of the public, the system is required to take numerous samples to confirm the contamination. If the positive results are confirmed by follow-up samples, the system is required to collect additional samples to determine the source of contamination.

Bacteria can be present in a distribution system because of failure of a treatment process, a cross connection between the system and an unsanitary source, a defect in the distribution system, inadequate flushing of the system after repair or addition to the distribution, or regrowth of bacteria due to the presence of a biofilm. Any of these causes are possible even in systems that are disinfected. Failure of the treatment process can result when the raw source is excessively contaminated and physical barriers or disinfection fails to produce total and/or deactivation of organisms. The surviving organisms may be detected in subsequent samples anywhere in the system. If the residual concentration of disinfectant in inadequate, even injured organisms can recover. Surviving organisms will grow and reproduce if conditions are favorable. Most distribution systems will age and develop some scale or tuberculation which provides sites where bacteria can attach and be protected from the full impact of disinfection. Most distribution pipe will develop some level of biofilm which is an organic or inorganic deposit on the pipe surface consisting of microorganisms, microbial products, and detritus (LeChevallier 1990). Biofilm formation occurs with the transport and accumulation of microorganisms and nutrients at the surface of the pipe. The rate of biofilm formation depends on the physiochemical properties of the pipe surface, the physical roughness of the surface, and the physiological characteristics of the microorganisms.

Growth and/or regrowth[13] of bacteria or other microbiological organisms, such as *Giardia, Cryptosporidium,* and *Legionella,* is enhanced in systems that fail to provide an adequate disinfectant residual or that do not disinfect. Experience has shown that maintenance of a residual may not prevent the growth/regrowth of microbial agents in the presence of a biofilm. Removal of the biofilm from a distribution system may require super disinfection or possible physical removal by scraping the inner surface of the pipe.

Some organisms are more resistant to disinfection, particularly with disinfectants now in common use. For instance, Witherell et al. (1988)

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[13] Regrowth occurs when microbial organisms survive the treatment process and grow in the distribution system.

determined that *Legionella* is more resistant to chlorine than are coliform bacteria. Also, while *Legionella* is commonly found in aquatic habitats, their numbers in the cold water of distribution systems may be so low as to escape detection by routine sampling practices. Warm temperatures in the range of 86°F to 104°F, stimulates growth of this bacteria to significant populations. Organisms will often find protection by attaching to or residing within the carcass of other organisms that have not survived the treatment process or disinfection.

The most successful deterrent to the presence of bacteria in a distribution system is prevention of entry to the system. This is best accomplished by using the best quality water available and, if necessary, inactivating the organisms before distribution. Entry to the system by way of cross connections can be corrected by removal of the cross connection or by providing adequate protection of the system. Hydraulic flushing is often successful in removing much of the biofilm habitat and reducing the potential for bacterial presence. A more complete list of the microbial agents commonly found in drinking water distribution systems is presented in the sub-committee report on Health Risk Associated With California's Drinking Water in Table 11.

f. Cross Connections

Cross connections are perhaps the greatest source of potential contamination within a distribution system. A cross connection occurs when a non-potable source is connected to a potable domestic water system. It may be an unsanitary water well connected through a residential service or an auxiliary unit, for example, an air conditioner, working on a service to an industrial plant. Not all cross connections result in contamination of a water system but every cross connection has the potential for causing significant contamination in the event of loss of pressure in the public water system.

There have been several cases of cross connection in California that resulted in contamination of a domestic water system. The most frequent type of event involves interconnecting the fresh water piping in an industrial plant with the piping supplying some industrial process. Water is an essential ingredient in many processes such as chemical mixing and formulating, metal fabricating and plating, and food processing. Some of these connections are made during plant construction as an unplanned modification to the plumbing. More often, however, they are the result of a temporary repair made during plant maintenance.

Often when rural residents are connected to community systems they object to paying for water to irrigate the large garden that they have enjoyed for years. They don't see any objection to using the old farm well for irrigation even though it is contaminated and no longer usable for drinking water. They make the connection through the irrigation system they have always used which is still connected to the house. In this case, there are any number of combinations of events that can result in contamination of the domestic system; examples include low pressure due to a broken water main or a major fire.

These are only two examples of cross connections that have the potential of causing major system contamination. Table 4.3 presents a list of some of the occurrences that are known. There are undoubtedly many more unknown events than there are known. Events are often only discovered because of a serious contamination of the water supply system.

g. Disasters

Disasters impacting distribution systems usually result from events that are beyond the control of the system operators. Some disasters are of small magnitude and have little or no lasting effect on the operation of the system. Major electrical storms have damaged system equipment so severely that customers have been without water service for several hours and in extreme cases for days. While these storms are not a major concern to most of California, they are an annual event in the mountain and desert areas where the most vulnerable system are located.

Flooding poses a particular hazard to distribution system elements that are near or on the surface of the ground. Wellhead structures that are not adequately protected are subject to contamination by surface flooding. Distribution mains, particularly in mountain areas where cover is often limited and where pipe lines cross stream channels, are subject to being washed out. Two water systems in the Lake Isabella area were almost totally destroyed in 1984 when unprecedented flooding occurred. Flows estimated to be equal to the 100 year volume occurring in steep mountain channels uncovered and severed long segments of pipe andinundated wells with sand deposits. In one of the systems, a storage tank was even moved off its foundation.

Table 4.3 Typical Cross Connection Events

Event	Result
Malathion used to treat grain being loaded on ship. Conveyor stopped but chemical pump was not.	Malathion was widely distributed through water system. No injuries or illness reported.
Telemetery system failure allowed storage tank to drain causing low pressure, a pressurized heating/cooling system with anti-freeze partially drained to water system.	Customers reported foul-tasting dirty and discolored water, no injuries were reported.
Chemically treated water in a school heating-cooling system back flow to water system when pressure nearby dropped.	Teacher in classroom noted the pink water and reported the event, teachers did not allow students to drink water, no injuries reported.
Pesticide applicator connected mixing tank to house water faucet, pressure in tank caused back-flow of mixture to water system.	Contamination of about 3 block area of water system. Customer complaints of milky water and foul taste. No known illness.
Sewage irrigation water flowed into community supply well through open hole in casing.	Large area of community system contaminated. Many customers suffered gastrointestinal illness.
Pest control operator allowed back siphonage of chlordane to water system.	Contaminated small area of water system, no illness reported.
Meat processing plant waste system cross connected to process water system.	Waste water backsiphoned to process water, contaminated 2.9 million pounds of meat which was destroyed.
Chemically treated water in fire control system backflow to domestic water supply at steam generating plant.	Several employees suffered gastroenteritis, no one was hospitalized.
Anti-freeze treated fire control water back flow to water system at military base.	Several people on base suffered illness, no reported hospitalization.
Back siphonage of treated boiler water to school water system.	Two students hospitalized, several treated.
Developer fluid at a photo processing plant back siphoned to water system.	Contamination stopped in plant, water system not contaminated, no illness.
Water from mineral bath pool at a state park pack siphoned to water system.	System was contaminated with bacteria, no illness reported.
Caustic soda syphoned to clear well at water treatment plant after inflow stopped.	Large area of system contaminated with caustic, many people treated for mouth burns, many people reported skin rash, burn and irritation.

Earthquakes have resulted in severe damage to water systems facilities. During the Loma Prieta earthquake in 1989, water mains were separated by earth movement when the earthquake struck the San Francisco and Santa Cruz areas. Several water treatment facilities were damaged and power failures caused pumping equipment to be inoperable. In 1971 the San Fernando Valley was struck by earthquake that resulted in damage to several systems (Sturm 1972). Disruption of communications affected operational control of the systems, and power outages made some pumping and distribution equipment inoperable. Pipe lines were separated and dam structures were damaged. As a result, downstream residences were endangered, residents were forced to evacuate, and valuable stored water was lost when reservoirs were drained for safety reasons. LADWP's Van Norman Dam and Reservoir were damaged to the extent that it was taken out of service and rebuilt. During both of these events water utilities quickly took actions necessary to limit the risk to their customers and to prevent contamination of their system.

During the winter of 1990 many areas of California experienced low temperatures of long duration that resulted in serious damage to many water systems, especially in the northern part of the state. Although the temperatures were not significantly lower than what had been experienced in previous years, they stayed lower for much longer periods of times and did not allow the water and facilities to warm up during the day time. In addition to loosing large quantities of water, many systems were faced with large bills for repair and replacement of damaged equipment, especially valves located above ground.

Terrorism and vandalism are often cited as potential disasters, but there is little record of these events having endangered large populations. Attention to reasonable security measures, such as fencing with locked gates and housing of more sensitive equipment, is adequate to prevent all but the most intent individuals from access.

Man-made disasters also represent a serious hazard to water systems. These, however, usually result from a careless act on the part of a human. The events are seldom intentional but can be devastating nonetheless.

The distribution system is often the weakest link in the chain of water supply facilities that deliver water to the costumer. As the infrastructure ages and deteriorates, the distribution systems become increasingly vulnerable to contamination through leaks and other failures. Unsafe interconnection of unapproved sources to the system by customers is a constant concern. The importance of a well planned operation program, a funded program for facilities replacement as needed, and a knowledgeable, well-trained operator cannot be over emphasized.

F. COMPLIANCE WITH DRINKING WATER REGULATIONS

Compliance with the drinking water standards is not determined solely from the water quality at the source. The water quality at the source does not fully represent what is being delivered to the consumer and is only one of the various factors that must be evaluated before a water systems is determined to be in compliance. When a source has been found to exceed a MCL a water system can take various actions to assure customers that the water being delivered is in compliance with the drinking water standards. These include removing the source from service, treatment, and blending. Regulatory jurisdiction can determine if the system is in compliance only following a full review of the system.

1. Primary Standards

Table 4.4 gives a summary of the percent of small water systems failing several different categories of regulatory requirements, and shows that the noncompliance rate of small water systems is much greater than previously estimated with an overall rate that exceeds 50%. It is also significant to note that the California rate exceeds the national average of 40% reported by USEPA (Personal Communication 1990). In comparison, Table 4.5 gives a summary of large water systems in California that are regulated by ODW. This shows large water systems have an overall noncompliance rate of less than 5% for bacteriological quality.

Figure 4.13 illustrates that over 90% of the failures observed in small water systems were due to noncompliance with monitoring requirements. This is particularly significant because the entire drinking water quality protection program is based on a concept of routine self sampling and analysis by the water utility to detect the presence of contaminants. If the quality of the water being delivered is not monitored, there can be no assurance that water delivered to consumers is safe.

The large water systems are doing a very good job in performing the required monitoring. The monitoring failures are well below a 10% noncompliance rate. This also has significance from the standpoint that monitoring failures can generally be resolved quickly through increased surveillance and compliance pressure without significant economic impacts on the utility.

a. Bacteriological

Up until the late 1800s, many of the leading causes of death and serious illness were caused by pathogenic microorganisms found in drinking water. Although this problem is far less severe today, pathogenic microorganisms are still the leading cause of waterborne disease. The monitoring of water supplies for bacteriological quality is the key to early detection and correction of contaminations, and is vital to the provision of safe drinking water.

Figure 4.14 compares the noncompliance rate for bacteriological failures between small water systems and large water systems during, fiscal year 1988-89. As indicated, nearly 50% of the small water systems are in noncompliance with the monitoring requirement as compared to less than 1% of the large water systems. Additionally, the MCL noncompliance rate of 16% for small water systems was significantly greater than the less than 0.5% for large systems.

The average noncompliance rate of a typical community water systems and a typical non-community water systems are shown in Figure 4.15. The figures represent the percentage of a year that the average system failed an MCL or failed to take or report a sample. In both cases the monitoring and reporting failure level is about five times the MCL failure level. The average community water system is in compliance a total of 19.1% of the time and the average non-community water system about 31.7% of the time. In a year's time, the small water systems of the state accumulated an estimated 11,000 monitoring and reporting failures and about 2,000 MCL failures annually.

b. Turbidity

The monitoring of surface water sources is required to assure the quality of water delivered. Surface waters are subject to contamination from many sources, and turbidity measurement is a gauge of the amount of particulates in the water. This is necessary because it serves to evaluate the effectiveness of filtration, and detect failures in the filtration process. High turbidity water is also of concern because it can interfere with the reliability of bacteriological water quality monitoring.

Table 4.4 Small Water System Noncompliance Status with Drinking Water Standards[a]

Test/ Requirement	Monitoring Failure	Quality Failure	Fail Quality & Monitoring	Fail Requirement
Bacteriological	48%	15%	57%	NA
Inorganic Chemical	42%	6%	44%	NA
Organic Chemical	45%	unknown	unknown	NA
Turbidity	83%	43%	85%	NA
Radiochemical	62%	0.4%	62%	NA
Cross Connection	NA	NA	NA	79%
Operator Certification	NA	NA	NA	56%

Table 4.5. Large Water System Noncompliance Status with Drinking Water Standards[b]

Test/ Requirement	Monitoring Failure	Quality Failure	Fail Quality & Monitoring	Fail Requirement
Bacteriological	6.2%	3.6%	10%	NA
Inorganic Chemical	1.4%	1.1%	2.5%	NA
Organic Chemical	1.0%	0.1%	1.0%	NA
Turbidity	2.0%	2.2%	4.2%	NA
Radiochemical	0%	0%	0%	NA
Cross Connection	NA	NA	NA	10%
Operator Certification	NA	NA	NA	5%

NA - Not applicable

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[a]ODW Compliance Survey of LEHJs for Fiscal Year 1988-89.

[b]ODW Compiled Information, Fiscal Year 1989-90.

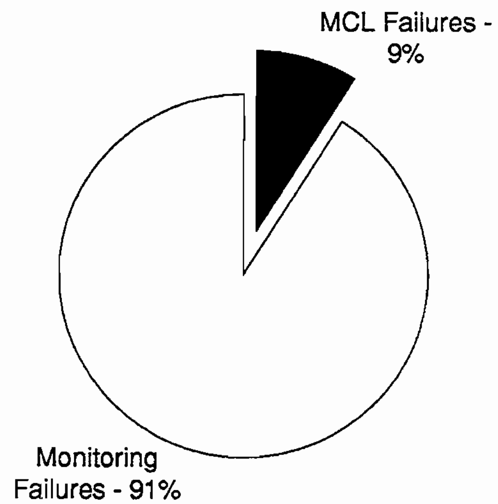

Figure 4.13. Monitoring vs MCL Failures for Small Water Systems

Data represented in Table 4.4 indicates that about 17% (43 systems) of the small water systems complied with the monitoring requirements for turbidity, and about 7% (18 systems) failed the MCL during the survey period. If it is assumed that those that failed the MCL were also the systems that complied with monitoring requirements (not an unreasonable assumption given the complexity and cost for monitoring for turbidity), then nearly 43% of the systems using surface waters would be in noncompliance with the MCL and may require substantial system improvements. Table 4.5 shows the large water systems noncompliance rate to be about 4% for the quality and monitoring standards combined.

c. Organic Chemicals

All community and non-community, non-transient water systems, whether using surface or ground water sources, are required to comply with the organic sampling requirements in the SDWA including VOCs, pesticides, and herbicides. Prior to the federal 1986 SDWA only surface waters were routinely required to monitor for organic chemicals. In California, there was a special one-time ground water study of organic contaminants that was required under AB 1803 in 1984 and 1985.

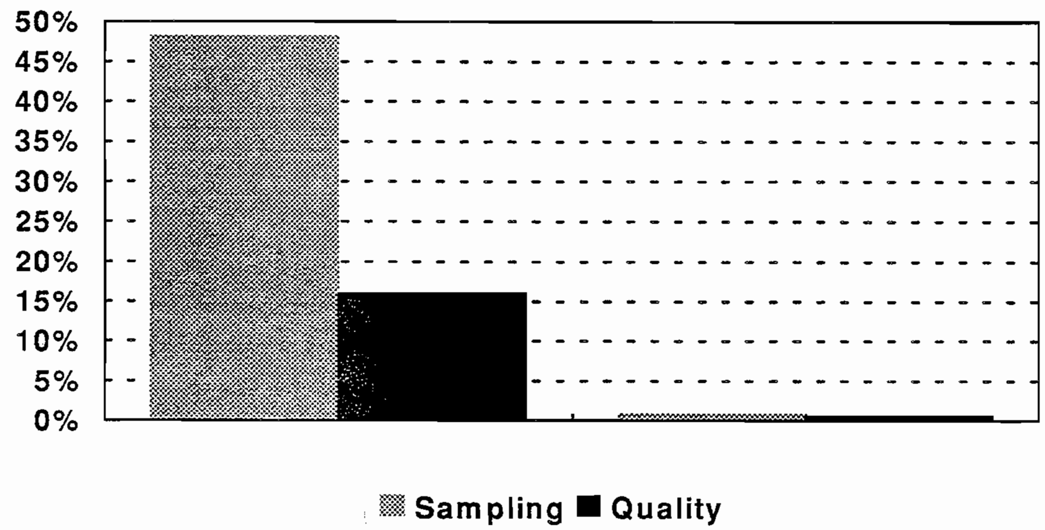

Figure 4.14. Noncompliance Rates By Size of System and Regulatory Jurisdiction

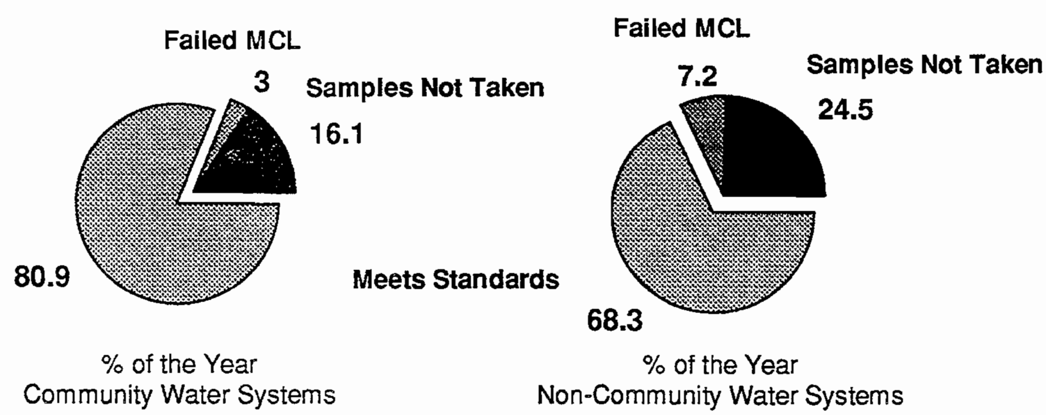

Figure 4.15 Bacteriological Sampling for a Typical Small Water Systems

The results of the AB 1803 small water system ground water sampling program were reported to ODW on June 5, 1990 (CDHS 1990). The results of this survey indicate that of the 45% of systems sampled, approximately 8% were contaminated with organic chemicals. However, only 5.6% of the systems had levels exceeding established MCLs or Action Levels. For comparison purposes, it was significantly lower than the 18% of the wells contaminated with organic chemicals with 6% exceeding established MCLs for large water systems. While no specific reason could be given for this, it can be postulated that the majority of small system sources are located in rural areas where sources of organic contaminants are limited.

As noted in previous chapters, the requirements for monitoring of and synthetic organic chemicals (SOCs) has only been implemented in 1989 and small water systems have not yet complied with these requirements. The information on compliance is not yet available, but it can be expected that the small water system noncompliance rate for the new organics monitoring will be very high. The large water system compliance rate for the new organic monitoring is expected to be comparable to the rates in Table 4.5.

d. Inorganic Chemical

Community water systems must monitor surface water sources annually and ground water sources every three years for inorganic chemicals. The inorganic chemicals group includes arsenic, selenium, nitrate, fluoride, and several heavy metals including lead. Exposure to these substances may pose a threat to health if concentration in drinking water exceed MCLs. While most inorganic chemicals are of concern for long-term exposure, some, such as nitrate, may have short-term impacts as well. Because of the potential for health impacts, the level of inorganic chemicals must be assessed periodically to protect against excessive exposure.

The small water system noncompliance rates for inorganic chemical monitoring are shown in Figure 4.16. Of particular note is that in community water systems the monitoring and reporting failure rate is 40% and that the MCL failure rate is over 11%. For non-community water systems, even with their reduced monitoring requirements, the monitoring failure was nearly 25% with MCL failure rates at over 6%. Table 4.5 shows the large water system noncompliance rates for the inorganic chemicals to be about 2.5% for both the monitoring and quality standards.

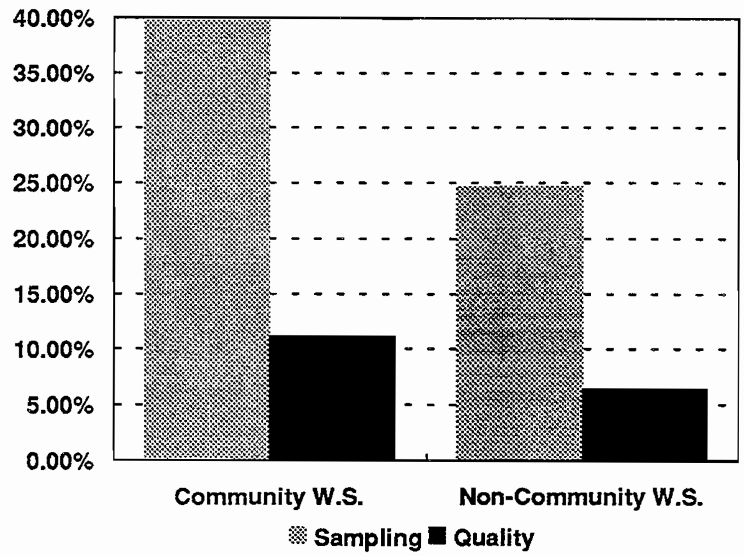

Figure 4.16. Inorganic Chemical Noncompliance Rates for Small Water Systems

e. Radiochemicals

Community water systems are required to monitor for naturally occurring sources of radioactivity. Long-term exposure to sources of ionizing radiation such as radium, uranium, and radon have been associated with an increased risk for certain kinds of cancer. Monitoring for and meeting the MCL for natural radioactivity is important to maintaining a safe source of water.

Results of the compliance survey show that 62% of the system surveyed have failed to comply with the radiological monitoring requirements for gross alpha radiation. However, of the 1,025 systems that did sample, only 4 systems violated the MCL. In comparison there were no reported large water systems failures.

2. Additional Requirements

Two additional regulatory requirements of considerable significance in assuring the reliable provision of safe drinking water include cross-connection control programs and compliance with operator certification requirements. Compliance of water systems with each of these requirements is discussed below:

a. Cross Connection Control Programs

A cross connection is a connection between a potable water system and any source or system containing unapproved water or other non-potable liquids that during a period of low pressure may cause contaminants to enter the potable water system by means of backflow from these sources. Title 17, CCR, requires that every public water system be protected against potential backflow from cross connections, and have an ongoing program to identify, prevent and correct cross connections. Cross connections are of concern because they can potentially permit sudden exposure of many consumers to severely contaminated water that may pose a significant health risk due to the presence of the contaminant.

Figure 4.17 shows the number of small water systems with cross connection control programs. Noncompliance rates for this requirement are the highest of any of the categories reviewed. The rates found are 78.5% and 82.7% respectively in the community water systems and non-community water systems respectively. In comparison, the noncompliance rates for all large water systems was less than 10%.

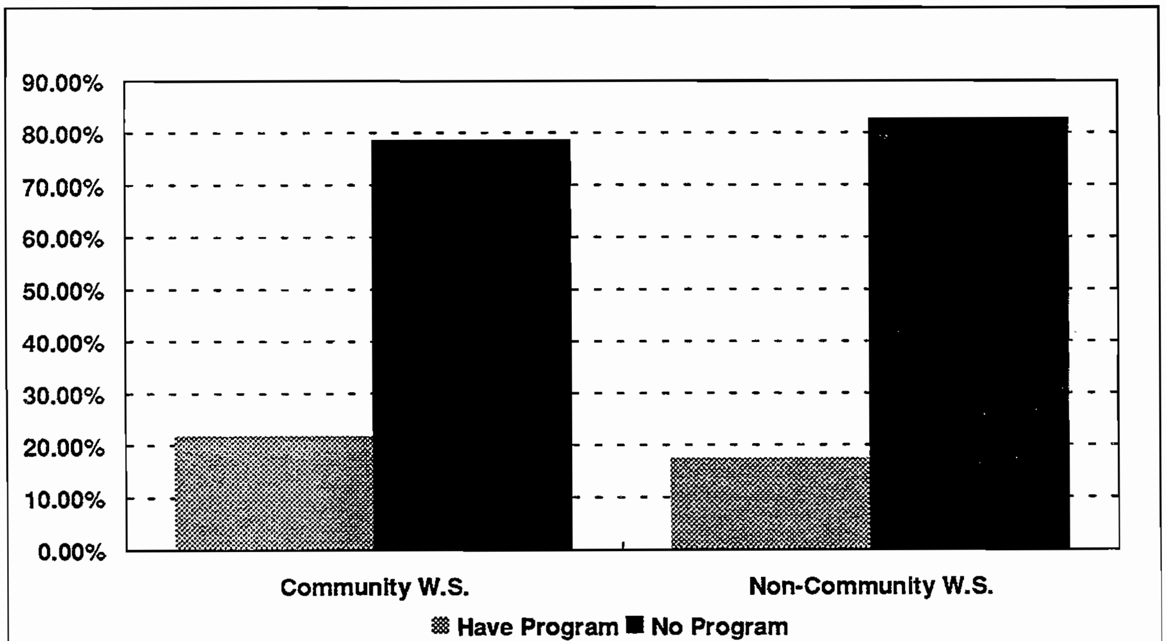

Figure 4.17. Cross Connection Control Program Noncompliance Rates for Small Water Systems

b. Certified Operators for Water Treatment Plants

Title 17, Chapter 7, CCR, requires that water systems that treat the water (add chemicals or otherwise alter the water before delivery to consumers) must have certified operators to ensure that the treatment facility operates as designed. Operational malfunctions of water treatment plants can immediately expose consumers to water that contains disease causing microorganisms or harmful chemicals. Properly trained and certified operators ensure that optimal treatment is provided to produce a reliable and safe water supply, and assures a higher degree of compliance with monitoring and repeating requirements.

Figure 4.18 illustrates the degree of noncompliance with the operator certification requirement in community and non-community systems. For community water systems, approximately 76% do not require a certified operator. However, of those that do require operators, over 50% are in noncompliance. For non-community water systems, approximately 61% of the system that require a certified operator are in noncompliance. In comparison the large water systems have a noncompliance rate of less than 5%.

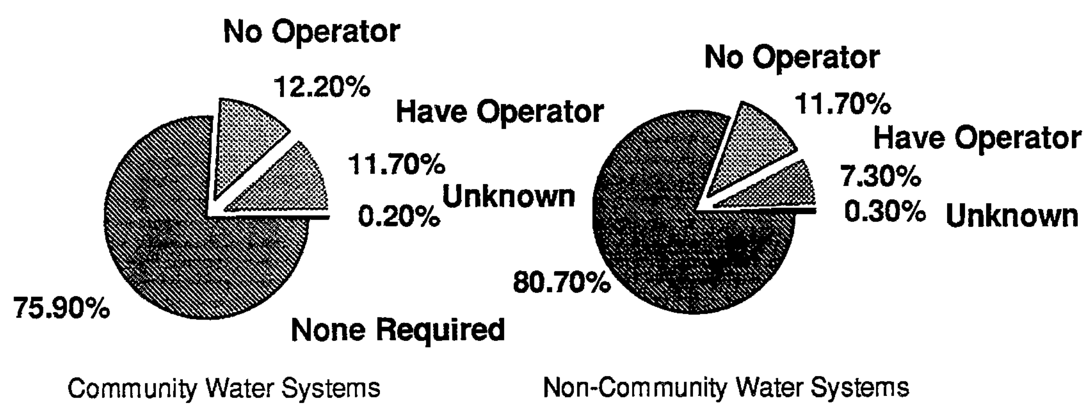

Figure 4.18. Operator Certification Noncompliance Rates for Small Water Systems[a]

[a] Certified operators are required in those systems that treat their water.

3. Corrective/Enforcement Actions

One of the main reasons for the good compliance by many of the large water systems is due to an aggressive ODW surveillance and enforcement program. As noted in Chapter II, the ODW program is a comprehensive program directed towards assuring that the large water systems are providing a pure, safe, wholesome, and potable water to consumers. The ODW program has dedicated professional and technical staff that is well respected by the water supply industry.

ODW staff has worked cooperatively with the large water systems to achieve a high rate of compliance. However, when needed ODW has taken appropriate enforcement actions to get the necessary compliance. As noted in Chapter II, ODW issued 1,309 corrective action letters, 92 citations, 39 compliance orders, and required the issuance of 161 public notices, during fiscal year 1989-1990.

ODW compliance and enforcement actions are very significant in comparison of all state programs nationwide. USEPA reports that 16 states have taken no enforcement actions and 12 states have taken less than a total of 5 actions.

The compliance and enforcement situation for small water systems clearly has not been as effective as with the large water systems. The information regarding enforcement actions taken by LEHJs on small water systems is very limited and not readily available. While some LEHJs have used various methods, some quite successful, to get compliance by the small water systems, LEHJs have not implemented a formal enforcement program similar to ODW. Through the California Conference of Directors of Environmental Health, LEHJs have adopted a formal enforcement policy: however, lack of resources have prevented counties from having an effective enforcement program. This issue is discussed in Chapter X.

CONCLUSION AND RECOMMENDATIONS

The information in the ODW database indicates that the source waters, both surface and ground water, available to the utilities providing drinking water to the citizens of California are of good quality. In cases where utilities are required to use sources that do not meet the drinking water standards or MCLs, other sources are available for blending or treatment so the drinking water served to the customers meets MCLs and is at all times pure, wholesome, and potable. General cooperation by water utilities and aggressive enforcement of the state regulations and drinking water standards by ODW effectively reduces any significant exposure to consumers from concentrations of contaminants above MCLs.

All surface waters are susceptible to microbiological contamination and must be filtered and disinfected before served to the public as drinking water. In addition to the risk of possible microbial survival of the treatment process, consumers receiving treated surface water are faced with the potential health effects associated with DBPs. Since up to 70% of the population of California is served by systems using surface water as their primary source of drinking water, the microbiological and DBPs contaminants are the most significant water quality concerns facing California.

The most frequently found contaminant in ground water used for drinking water supply in California, in excess of the drinking water standard, is nitrate. The ODW database indicates only 2.1% of the well sources are in noncompliance of the nitrate MCL. The most recurring synthetic organic chemical contaminant in ground water is the soil fumigant, DBCP, which has exceeded the MCL in only 1.4% of the wells sampled. Second and third in frequency of occurrence exceeding the MCL were TCE that was found in excess of MCLs in 0.9% of the wells sampled and PCE found in 0.7% of the wells sampled. TCE and PCE are industrial solvents and their occurrence is generally related to heavy to moderate industry.

With few exceptions, data on unregulated contaminants in drinking water have historically been collected only when funds are made available for special studies. These collection efforts have been sporadic, reactive, and usually inadequate to carry out state-wide assessments.

Recommendation: A comprehensive and consistent program for collection of data on unregulated contaminants is required for development of regulations and state-wide exposure assessments for these contaminants.

If a regulatory program is to successfully monitor and regulate the quality of water served to the public, an effective and efficient data management program is essential to collect, organize, and make accessible the information necessary to carry out the program. The increased water quality and compliance data generated by the new monitoring regulations has required ODW to develop an expanded and improved data management system. If the system is to accomplish its purpose, it must use current, regularily updated information. .

Recommendation: Funding should be provided to complete the ODW database for all constituents and sources in order that the quality of water served to the public can be adequately monitored.

Regional Water Quality Issues

Water transported by the SWP and delivered to domestic water systems for use as drinking water are exposed to many sources of contamination as described by the sanitary survey conducted by the water contractors at the request of the ODW. The Delta, through which water of the SWP flows, provides the most significant threat to the quality of drinking water supplies. Agricultural wastes from farmed Delta lowlands discharged to the Delta channels and to the California Aqueduct, exacerbated by bromides in seawater intruding into the Delta channels, increases the potential for development of TTHM and other by-products of disinfection in water supplies exported from the Delta. It is difficult for some systems to meet the existing MCL for TTHM on a routine basis. A lowered TTHM standard, as proposed in USEPA "strawman" draft of the Disinfectants and Disinfection By-Products Rule, will cause greater noncompliance.

Recommendation: To the extent feasible, measures should be taken to prevent degradation of the domestic water transported through the Delta by minimizing the introduction of DBP precursors from agricultural operations and by controlling seawater intrusion into the Delta. The domestic water supply should be further protected from agricultural drainage and other sources of potential degradation during transport through SWP and other aqueducts.

The previously noted 2.1% of the wells exceeding the nitrate MCL are distributed statewide in the San Bernardino-Los Angeles-Riverside area, San Joaquin Valley, San Francisco Bay area, Central California Coast area, and in San Diego County. The organic chemicals DBCP, TCE, and PCE in excess of their MCLs are found in two areas of the state, the San Joaquin Valley from the Delta south to the Tehachapi Mountains in Kern County, and the area comprising the counties of Los Angeles, southwestern San Bernardino, Orange, and western Riverside.

The distribution system is often the weakest link in the chain of water supply facilities that deliver water to the costumer. As they age and deteriorate, the distribution systems become increasingly vulnerable to contamination through leaks and other failures. Unsafe interconnection of unapproved sources to the system by customers is a constant concern. The importance of a well planned operation program, a funded program for facilities replacement as needed, and a knowledgeable, well-trained operator cannot be over emphasized.

Compliance With California Drinking Water Regulations

Compliance with the drinking water standards is not determined solely from the water quality at the source. The water quality at the source does not fully represent what is being delivered to the consumer and is only one of the various factors that must be evaluated before a water system is determined to be in noncompliance. When a source has been found to exceed a MCL there are various options, such as removing the source from service, treatment, and blending, that a water system can take to assure customers that the water being delivered is in compliance with the drinking water standards. Only after review of a water system, which has a source or sources exceeding an MCL, by the regulatory jurisdictions can the determination be made if the system is in compliance.

The combination of a low percentage of sources exceeding a MCL with a high rate of compliance by water systems meeting the drinking water standards indicates that consumers are being assured that water being delivered is pure, wholesome, and potable. The high rate of compliance is attributed to the good cooperation by the water utilities and an aggressive surveillance and enforcement program conducted by the Office of Drinking Water.

The large water systems, systems with 200 or more service connections, have a compliance rate of over 95%. However, small water systems, particularly the non-community transient systems, have unacceptably high rates of noncompliance with the primary drinking water standards, with more than 63% of these systems in noncompliance with one or more requirements, largely the monitoring and reporting requirements. This problem is attributed principally to the lack of an adequate regulatory program focusing on small water systems.

AB 2158 addressed some of these problems. The compliance with drinking water standards by small water systems, however, remains a significant drinking water issue that must be addressed by the legislature and the Office of Drinking Water.

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CHAPTER V

HEALTH RISK ASSESSMENT

A. RISK ASSESSMENT

As a requirement for maintaining primacy, the Department must adopt the same or more stringent drinking water standards as those promulgated by USEPA. Drinking water quality standards are promulgated under the California SDWA. Because of public concerns and legislative mandates, California has the most stringent and comprehensive drinking water standards of any state in the country. The number of standards continues to expand, and in some cases are more stringent than the federal standards. The Department conducts risk assessments as part of the process of proposing and promulgating drinking water standards, which occasionally includes conducting risk assessments for contaminants for which USEPA has no proposed standards. To date, risk assessments have been performed by the Department for approximately 100 contaminants.

Risk assessment is the characterization of the potential adverse health effects of human exposures to environmental hazards. Risk assessments should contain all of the following four steps (NAS 1983):

- Hazard Identification - The process of determining whether exposure to an agent can cause an increase in the incidence of an adverse health condition e.g., (cancer and birth defect).

- Dose-Response Assessment - The process of characterizing the relation between the dose of an agent administered or received and the incidence of an adverse health effect in exposed populations, and estimating the incidence of effect as a function of human exposure to the agent. This typically requires extrapolation from high to low dose and from animal bioassay data to humans.

- Exposure Assessment - The process of measuring or estimating the intensity, frequency, and duration of human exposures to an agent currently in the environment or of estimating hypothetical exposures that might arise from the release of a new agent into the environment.

- Risk Characterization - The process of estimating the incidence of a health effect under the various conditions of human exposure described in exposure assessment.

Estimates of risk are often expressed either in terms of the chance of an individual getting a disease or the number of additional cases of the disease that would be caused in a population exposed to a given level of a chemical for a lifetime. For example, the theoretical additional cancer risk from a lifetime of exposure to drinking water containing TCE at 5 µg/L is approximately one in one million. If a population of one million were so exposed, it would theoretically mean that instead of 250,000 cases of cancer in the population over a lifetime[14], there would theoretically be 250,001 cases of cancer. The risk of cancer to the individual is increased from 0.250000 to 0.250001.

It must be emphasized that estimates of the risk that would result from very low exposures, such as may be found in drinking waters, are subject to a wide range of uncertainty. For example, it is assumed that the extremely high doses administered to experimental animals and high occupational exposures affect humans in the same way, but to a greater degree, than do low doses encountered in the environment. In addition, there is recent evidence that some of the methods used in the animal cancer studies may not be valid, such as the vehicle used to administer the chemical, and the concern that certain strains of mice have a predisposition to cancer. Due to the many uncertainties, the calculated risk should not be treated as a precise estimate of the actual risk. Rather, quantitative risk assessment provides information on the relative risk of a substance; that is, contaminant A may be "x" times more hazardous than contaminant B. Although limited, risk assessment can provide a yardstick for setting priorities, standards, and action levels, and for developing control strategies.

The risk assessment process may involve the use of toxicological (animal) and/or epidemiological (human) studies to estimate the effects of chemicals and other substances in humans. From the data obtained in toxicological studies, an extrapolation from the doses used in animal bioassays to humans is made. Assumptions must be made regarding similarities between the test animal and human responses to the chemical under consideration when the doses are extrapolated to the estimated human exposure at many orders of magnitude lower than those given to test animals (high doses are used in animal experiments

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[14]The background incidence of cancer in the United States shows that one out of every four individuals will contract cancer during their lifetime.

to clearly test the chemical's effects). Humans differ from animals in a number of ways, including rate and types of metabolism, length of lifetime, and diet, all of which can influence the toxic response to chemicals. Among the various animal species, large differences also occur. For example, different types of animals vary by 1,000 times in the amount of dioxin that causes death.

Since most epidemiological studies are of incidents where an individual or group was exposed to high doses of a substance, this data must also be extrapolated to estimate the effect of the substance in humans at the low doses potentially found in the environment. However, there are inherent limitations with the use of human epidemiological data in that, the effect of the pollutant of interest cannot be isolated from the effects of other exposures an individual may experience. The latency period of the effects of many chemical exposures often precludes the direct association between cause and effect. It is also extremely difficult to adjust epidemiological studies to account for the myriad of other exposures humans experience on a daily basis. Because of these limitations and the time required to conduct a proper epidemiological study, the majority of chemicals used have not been studied using epidemiological methods.

Risk assessments are conducted by the Department's HHAD. Specific risk assessment guidelines have been developed by HHAD to identify and assess the risks of carcinogenic contaminants. These guidelines are documented in the Department's *Guidelines for Chemical Carcinogen Risk Assessment and Their Scientific Rationale* (CDHS 1985a). Use of the guidelines helps to ensure that scientifically valid and uniform methodologies are employed in risk assessments. The Department's guidelines are similar to those adopted by the USEPA in 1986 (USEPA 1986).

The epidemiological investigation of reported excesses of disease is carried out by the Department's Environmental Epidemiology and Toxicology Section (EETS). Non-infectious illness clusters are studied to determine whether the illness resulted from a potential environmental exposure. To date, studies conducted by EETS and other agencies in California have not identified an association between illness clusters and drinking water quality in any case.

1. Non-Carcinogen Risk Assessment

For contaminants which have been determined through the risk assessment process to be non-carcinogens, the dose of the contaminant which produces the no- or lowest-observed-adverse-effect-level (NOAEL or LOAEL) is determined from the most sensitive species studied. NOAEL is the dosage of a chemical to which experimental animals are chronically exposed that produces no harmful effect detectable by toxicological techniques. Uncertainty or safety factors are applied to account for the uncertainties in the animal study and species differences. The uncertainty factors that are applied either individual or in combination to NOAEL is determined using the guidelines provided in Table 5.1.

Table 5.1 Uncertainty Factors Applied to NOAELs in Non-Carcinogen Risk Assessments

Uncertainty Factor	Condition
10	Valid experimental results from studies on prolonged human ingestion, with no indication of carcinogenicity.
100	Few or no toxicological data on ingestion by humans, but there are valid results from long-term studies in animals and no indication of carcinogenicity.
1000	No long-term or acute data on humans and only scanty data on animals, and no indication of carcinogenicity.

The term "threshold" is used in toxicology to describe the border line between no-effect and effect levels of exposure. Stated in other terms, the threshold is that dosage of a contaminant below which there will be no adverse effects, whereas above that dosage the effect appears and increases with increasing dose. The threshold for a given effect can vary between species and between individuals within the species. Therefore, the concept of an absolute threshold for a given toxicant is very elusive, but of great importance to the understanding of the toxic actions of chemicals. The use of uncertainty factors is not applicable to carcinogens because it is assumed that carcinogens do not have thresholds. Mathematical models for high-dose to low-dose and animal-to-human dose extrapolation are used in carcinogen dose-response assessments.

2. Carcinogen Identification

The Department and other federal and state agencies treat an agent as a potential cancer hazard to humans if it exhibits sufficient evidence of carcinogenicity in animals. The Department guidelines recommend as evidence of carcinogenicity positive results in two species of animals. In general, the Department uses the same criteria used by the International Agency for Research on Cancer (IARC) in weighing the evidence for carcinogenicity. These criteria are provided in Table 5.2. Although the criteria required as evidence for carcinogenicity by the Department is similar to that of USEPA, there are some differences. USEPA generally accepts weaker evidence for carcinogenicity in more or less equivalent classifications. An example is that USEPA requires only evidence of carcinogenicity from two studies in a single species, whereas the Department requires positive evidence in at least two different species (for IARC classifications 2A and 2B). The major practical implication is USEPA will regulate a chemical as a carcinogen even if the chemical produces tumors in a single species, even in the face of clearly negative data in other species.

Table 5.2 IARC Definitions for Weight of Evidence for Carcinogenicity

Classification	Definition	Practical Interpretation
1	Carcinogen for humans	Sufficient evidence as a carcinogen in humans.
2A	Probably carcinogenic for humans	Limited evidence of carcinogenicity in humans and sufficient in experimental animals (positive in at least two species).
2B	Possibly carcinogenic for humans	Inadequate to limited evidence of carcinogenicity in humans, but sufficient evidence in experimental animals (minimum of two species).
3	Agent is not classified as to its carcinogenicity in humans	Limited evidence in experimental animals (e.g., carcinogenic in a single species) or no adequate data in humans or animals.
4	Agent is probably not carcinogenic to humans	Evidence suggesting lack of carcinogenicity in humans together with evidence suggesting lack of carcinogenicity in experimental animals (a minimum data set would be negative results in at least two species in well designed and conducted studies).

Source: (IARC 1990)

3. Carcinogen Risk Assessment

In the absence of scientific data indicating that alternative procedures should be used, the Department guidelines recommend the use of default assumptions for extrapolating cancer risk from the "high" dose-response data from animal studies to "low" doses anticipated for human exposure. Upper bound estimates of cancer potency are obtained by fitting a mathematical model to animal cancer bioassay data. To extrapolate potency derived from animal data to humans, "surface area scaling factors" are generally used; that is, if the amount of chemical contaminant per unit surface area (expressed as mg/m^2 of animal surface area) is given every day for the animal's life, the same risk is assumed to occur in different species. Additional factors are applied to correct for studies of short duration or with poor survival of the test animals. The Department uses the linearized multi-stage model in most cases to fit the available data into a dose-response curve when extrapolating from high to low doses.

The Department risk assessment guidelines do not approve the concept of thresholds for carcinogenesis unless clear and convincing evidence is presented to demonstrate that a threshold exists below which no carcinogenic effect will result from exposure. The guidelines for establishing carcinogenicity may not apply to every circumstance, and each compound must ultimately be evaluated based on the available evidence. The risk assessment process cannot be considered as establishing a certain risk for any contaminants. Rather, these are only theoretical values or estimates, and the results should be used so that the relative risk of different chemicals can be compared, allowing for judgements in the management of the risk. Although the current state of risk assessment is limited by many uncertainties, the procedures used are the only available means to obtain a comparable perspective on the potential for illness and cancer development from chronic exposure to selected compounds. There are many assumptions made by HHAD in performing risk assessments as a result of technological data gaps. Research is necessary to fill these data gaps to improve the overall certainty of risk estimates.

B. RISK MANAGEMENT

Risk management is the process of evaluating alternative regulatory actions based on the risk assessment, and selecting among them. This is a decision-making process which includes the consideration of social and economic factors, technological limitations, and laboratory capabilities. The end result, of course, is the recommendation or proposal, of a maximum acceptable concentration of a contaminant in drinking water. A risk/benefit analysis is conducted in this process to establish a balance between costs (to remove the contaminant to the proposed level) and benefits to human risk reduction.

There are many limitations identified in the risk assessment process, including physiological differences between animals and humans, the debate over the predisposition of certain laboratory animals to cancer and/or organ damage, and the need to extrapolate from the high doses given to experimental animals to the low doses to which humans may be exposed to in the environment. Despite these limitations, it is inherent to the risk management process to assume that humans are usually as sensitive as the most sensitive animal species tested in any given experiment.

In establishing Recommended Public Health Levels[15] (RPHLs), the risk is not managed, per se. An RPHL is, by statute, a health-based level which does not take costs and technology into consideration.

1. Establishing Drinking Water Standards

In accomplishing the requirements of the California SDWA, the Department has established a program for promulgating primary drinking water standards or MCLs. MCLs are legally enforceable and are based on health effects of contaminants balanced with technical feasibility and the cost of treatment. The Department has established MCLs for 89 primary and secondary drinking water contaminants. Action levels (ALs), which are health-based interim guidance levels, have been recommended for 29 contaminants discovered in California water supplies that do not have a MCL established yet. ALs are not legally enforceable but are often adhered to by water providers because they are concerned with the quality of their product. In cases where monitoring for a contaminant is not feasible, such as for the microbial agents *Giardia*, viruses and *Legionella*, a treatment technique will be adopted in lieu of a MCL.

For protecting health, California's MCLs for non-carcinogens are generally based on the NOAEL or LOAEL from the best study with an uncertainty factor applied to protect members of the population who may be particularly sensitive (e.g., pregnant or nursing women, children, the elderly, and those with impaired immune systems). If the chemical is a carcinogen, then the MCL is established at an "acceptable" lifetime cancer risk which balances the risk with costs and technology. The risk assessments prepared by HHAD present the *de minimus* risk level, which is the negligible calculated individual lifetime risk level. Typically, the risk values of 1-in-1-million to 1-in-10,000 per lifetime are assumed to be the *de minimus* risk levels for establishing MCLs, with the 1-in-1 million risk level most frequently assumed for environmental exposures to the general population (CDHS 1987a) where technically and

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[15]The Recommended Public Health Level is the maximum concentration of a contaminant in drinking water established pursuant to the criteria set forth in the Section 4023, HSC.

economically feasible. This means that if one million people were to drink two liters of water per day for a lifetime (70 years) which was contaminated at the MCL level, there would theoretically be one more case of cancer per one million people than there would have been ordinarily. Existing California MCLs and ALs are shown in Appendix 1.

MCLs are calculated for a single chemical only with a few exceptions (ie., TTHMs). They do not specifically address the toxicological interactions of chemical mixtures. However, possible synergistic effects are accounted for by using many conservative assumptions in the risk assessment process. Further, MCLs are derived for drinking water only and are not meant to be utilized as target levels for the clean-up of contamination of environmental waters.

The current MCLs for all constituents except for microbiological contaminants, turbidity, and nitrate are based on adverse health effects associated with chronic effects resulting from long-term exposure. MCL for nitrate was established to prevent acute infant methemoglobinemia ("blue baby" syndrome). MCL for total coliform and the treatment techniques specified in the California SWTR were established to prevent acute infectious disease outbreaks. The health effects for both lead and fluoride are considered to result from chronic short-term exposure.

The 1989 revision to the California SDWA also required the establishment of RPHLs for contaminants in drinking water, which are recommended drinking water standards that apply to systems with greater than 10,000 service connections. The major differences between MCLs and RPHLs is that RPHLs are strictly health-based numbers, with no considerations given to technical feasibility, implementation costs, analytical methodology, or other factors. RPHLs have been drafted for internal discussion for 34 organic and inorganic contaminants. Only in nine cases is the draft RPHL lower than the established MCL. For these nine contaminants, the existing MCL is set at a level that results in a risk greater than one in one million.

2. Risk Management Issues

a. Cost-Effective Risk Reduction

There are finite resources available within the state to pay for risk reduction from all environmental sources. In prioritizing the use of those resources to reduce the overall risk to the population, the risk from each source of contamination must be weighed against the cost to reduce the risk from that source.

For example, lead is present in the environment in ambient air, dust, soil, food, and water. It is also still present in many housing areas as a result of the past use of lead-based paints. The exposure of children to lead may result in impaired intellectual development. According to the USEPA, lead exposure in children is approximately 30% to 40% from food, 10% to 20% from drinking water, and 5% to 20% from ambient air. No information was given on the amount of exposure from lead-based paints, but it is known that in certain areas, this exposure may be significant.

Implementation of the federal Lead and Copper Rule for drinking water has been a high priority item for USEPA as a result of the concern of lead exposure in children. Although USEPA is turning toward a balanced decision making process that weighs the risk with cost considerations, the Lead and Copper Rule is a single-issue approach for reducing lead exposure, and potentially costly to some consumers. In comparing the exposure from lead in drinking water as opposed to other sources, the cost of reducing lead in drinking water may not provide the greatest potential reduction in risk. For example, spending the same dollars on removing lead-based paint in the inner-cities and lead in foods may provide a greater direct reduction in risks or the greatest cost/benefit. However, the control of some drinking water contaminants that are not ubiquitous in the environment is the most effective way to reduce the consumers exposure to that contaminant (such as DBCP). The costs to reduce this long-term risk, though, is not weighed against the possible use of those funds to reduce other risks of greater significance elsewhere.

The state and federal governments must begin looking towards a coordination of risk management in order to provide the population with the greatest benefit for their dollars spent. As budget financial constraints become more common in government, the state must look for ways to use the dollars to the greatest benefit. The communication to the public of the risks from various environmental exposures is critical to obtaining and directing resources to where risks in California can best be managed.

b. Mandatory Compliance With Secondary Standards

Secondary drinking water standards are set to control water color, odor, appearance, and other characteristics affecting consumer acceptance. Waters exceeding the secondary standards may be aesthetically objectionable to consumers, but pose no risk to health at concentrations which may be found in drinking water. These constituents, when found at high enough concentrations to be noticeable, present the greatest adverse public perception problem of almost any other contaminants.

This is because most constituents with primary drinking water standards are not seen or smelled when present in drinking water at levels above the MCL. Constituents with secondary standards, such as iron and manganese, however, can be seen in the form of discolored water when the secondary MCLs are exceeded. Many customers perceive that a health hazard (or risk) exists for secondary standard violations from the perception that nothing should be in drinking water, and if something is visible or smells, then it must be harmful.

Since no health risk exists when a water system exceeds a secondary standard, the issue has arisen as to the need for water utilities to monitor for and provide treatment for secondary standards to the same level as is provided for primary drinking water standards. Section 4017, HSC states that:

> "Any person who operates a public water system shall....comply with primary and secondary drinking water standards."

ODW has developed guidelines for granting waivers for secondary standards for public water systems. CCR, Title 22, Sections 64401(c), 64403(b)(1), and 64473(d) provide for waivers of MCLs for secondary standards when certain conditions exist. The basis for granting waivers is the degree of consumer acceptance of the water and their willingness to pay for the costs of meeting the secondary standards. New community systems that have come into existence since the date of a Department policy (January 1989) have not been eligible for waivers. This is especially significant in light of the cost for a water utility (and consumers) to pay for the increasing mandatory monitoring and treatment requirements. Public education regarding the lack of risk associated with secondary standard violations and the potential cost impacts for treatment will aid consumers in making this decision. This type of information is presented to consumers as part of the Department's policy in determining customer acceptance.

The Department, with the aid of the Drinking Water Technical Advisory Committee, is evaluating this subject further and a recommendation will be made to the Legislature in the near future.

C. PUBLIC PERCEPTION OF RISKS

1. Risk Perceptions

When reviewing the health risks associated with drinking water contaminants provided later in Chapter V, D, this information must be placed in perspective to obtain a clear understanding of how these risks relate to the individual. All human activities carry some degree of risk. In an individual's daily life exposure to a multitude of potentially toxic substances and pathogenic microorganisms occurs as well. In general, the risks from these activities and exposures can be placed into two categories: voluntary and involuntary risks. Smoking, alcohol consumption, driving, eating a high fat diet, and even crossing the street all have a risk associated with them, and yet the individual knowingly accepts these risks either because the activity is necessary or desirable. Many people choose to remove or reduce these risks by choosing not to smoke or drink or by reducing their fat intake. These are personal choices.

Exposure to involuntary risks present a different ethical problem. Breathing air, eating food, and drinking water are essential for life. Therefore, contamination of any of these essential elements constitutes exposing someone to an involuntary risk, even though the risk may be substantially lower than risks a person may take voluntarily every day.

Many factors affect the public perception of a risk besides whether it is a voluntary or involuntary risk. These factors include whether risk is of a natural or manmade origin; whether the effect is immediate or delayed; how familiar the person is with the concept of the risk they are taking; whether there is a benefit associated with taking the risk; whether it is a necessity or a luxury; the concept of fairness; and the degree of trust in the decision-making institution. Many people are willing to take an occasional or a controlled risk. On the other hand, there may be no awareness of the risk associated with an activity, food. For example, many natural carcinogens occur in foods such as apples, bananas, broccoli, mustard, mushrooms, radishes, and turnips, just to name a few.

It would be desirable from a public health standpoint to decrease both voluntary and involuntary exposure. However, socially esteemed values of personal freedom and privacy effectively restrict governmental intervention on such voluntarily assumed risks, such as smoking, to vigorous education campaigns, package warnings, and the creation of no smoking areas. Society allows government to take more stringent actions to control involuntary exposures to carcinogens in water, air, and food.

There are two polarized viewpoints on how environmental risks should be managed. One viewpoint is that, when taking into account real-life risks, such as alcohol, cigarette smoke, poor diet, and traffic accidents, spending money to reduce the already minute theoretical risk of cancer from contaminants in drinking water is not cost-effective. The position is that the larger daily risks problems should be tackled first before splitting hairs over one in one million risks in drinking water. On the other extreme is the viewpoint that the only acceptable environmental health risk level is zero.

The public perception of the concept of contamination and risks are a major concern to the water industry and to the regulatory agencies. As an example of how the public can misconstrue issues regarding their drinking water, customers often perceive that a health hazard exists for secondary standard violations such as iron and manganese. This is because they can see the contaminant in the form of discolored water.

2. Interpretation of Public Attitudes

In a state as large and diverse as California, it is often difficult to determine the public attitude on issues. In fact, there will never be a consensus of opinion, but a broad range of opinions and attitudes. To get a feel on how the public perceives the quality of their drinking water, several public opinion surveys were reviewed and are discussed below.

A study of California residents conducted by The Field Institute (1990) asked general questions regarding environmental issues facing the state, including water supply development, water quality, and water policy. In ranking 11 critical issues facing the state in the next 5 to 10 years, ensuring an adequate water supply ranked second next to drugs, while water quality ranked near the bottom (eighth) just above automobile liability insurance. Only 4 in 10 individuals said improving the quality of drinking water is a critical issue.

There were regional variations in responses to this question which showed that Northern Californians are significantly more pleased with the overall quality, taste, and appearance of their tap water than are Southern Californians. Dissatisfaction with the overall quality ran from a high of 35% to 40% in the Southern California area, dropped to 26% in the San Francisco Bay Area, and further to 22% in Northern California. In Southern California, the rate of dissatisfaction of overall quality closely matched the percent of dissatisfaction with the taste of tap water, leading to the conclusion that concern was mainly about the aesthetic quality rather than the chemical quality of drinking water.

Southern California however, is generally served by surface water, which is augmented by ground water in some communities. The source of surface water primarily used in Southern California is from the California Aqueduct, which is known to have a high potential for forming DBPs such as THMs that may pose a significant carcinogenic risk even at the current drinking water standard for TTHMs. The ground water aquifers in the southern part of the state have been significantly impacted by industrial contaminants. Providing ground water as a source of drinking water requires utilities to build costly treatment facilities, search for uncontaminated aquifers, and to actively protect the remaining high quality ground water sources from degradation. Therefore, there should be a much higher concern for the existing quality, and preservation of that quality, than was shown by the responses.

Because of federal and state concern over water quality contaminants, additional drinking water regulations are continuously being proposed and adopted. As is detailed in Chapter VIII, the cost of meeting these regulations will cause a substantial increase in the cost of water, perhaps even exceeding what the public is paying for other environmental issues such as air quality, which evoked more concern from the public in the Field Institute's survey than did water quality issues over the next 5 to 10 years.

Another study, conducted in 1988 in Santa Clara County (Rund 1988), found that a majority of residents (55%) believed there was a problem with the quality of their water; and among those citizens who believed their water has a quality problem, two-thirds said the problem was a big one. The Santa Clara County area, especially the Santa Clara Valley, has had problems with ground water contamination. However, as discussed in Chapter IV, the drinking water quality has not been affected by these incidents, with few drinking water wells impacted by the contaminants. There have also been several investigation conducted by the Department to determine the cause of an increased incidence of adverse pregnancy outcomes in a specific tract in Santa Clara County (CDHS 1985b, 1988a, and 1988b). None of the studies conducted have been able to show a correlation between adverse effects and water quality. This shows a basic misinterpretation of the information regarding water issues by the media and public.

3. Risk Perspectives

The purpose of risk assessment is to allow decisions to be made regarding the hazards causing risks in order to reduce those risks. The assigned "risk" level obtained from either toxicological or epidemiological carcinogenicity data has little meaning without comparing this to other risks to place it in perspective. Tables 5.6 to 5.10 presented at the end of this chapter provide the theoretical risk for potential carcinogens which are regulated in drinking water. By comparing these risks, one can obtain an understanding of which contaminants provides the greatest risk for the concentration specified (the MCL). Since these risks have almost all been estimated from animal bioassay data, the results are similarly comparable because they are calculated from similar data. For example, using the data in Table 5.6, it has been estimated that, at the same concentrations, PCE produces cancer in laboratory animals 2.5 times more readily than will TCE. Although neither is known to cause cancer in people, it might be expected that PCE would do so 2.5 times more readily.

Table 5.3 shows a variety of risks to which people are commonly exposed, calculated in various ways (Wilson and Crouch 1987). These can provide a general means to compare the risk associated with any drinking water contaminant with other commonplace risks. This table includes both voluntary and involuntary risks.

Table 5.3 Some Commonplace Risks[a]

Action	Annual Risk
Cigarette smoking, one pack per day	3.6×10^{-3} or 1/280
All cancers	2.8×10^{-3} or 1/360
Mountaineering (mountaineers)	6×10^{-4} or 1/1700
Motor vehicle accident (total)	2.4×10^{-4} or 1/4200
Police killed in line of duty (total)	2.2×10^{-4} or 1/4500
Air pollution, eastern United States	2×10^{-4} or 1/5000
Police killed in line of duty (by felons)	1.3×10^{-4} or 1/7700
Home accidents	1.1×10^{-4} or 1/9100
Frequent flying professional	5×10^{-5} or 1/20,000
Motor vehicle accident (pedestrian only)	4.2×10^{-5} or 1/23,000
Sea-level background radiation (except radon)	2×10^{-5} or 1/50,000
Alcohol, light drinker	2×10^{-5} or 1/50,000
Four tablespoons peanut butter per day	8×10^{-6} or 1/125,000
Drinking water with USEPA limit of chloroform (100 μg/L)[b]	6×10^{-7} or 1/1,700,000
Drinking water with USEPA limit of TCE (5 μg/L)[b]	2×10^{-9} or 1/500,000,000
Electrocution	5.3×10^{-6} or 1/189,000

[a]Adapted from Wilson and Crouch, 1987; ranked from highest risk to lowest risk.
[b]Risks calculated by Wilson and Crouch are not necessarily calculated in the same way the Department does for drinking water contaminants, resulting in a difference of the annual risks shown in Table 5.6 for TCE and Table 5.10 for chloroform. These risks, however, may be compared strictly within the bounds of this table for the purposes of gaging the comparative risk of each incident, whether voluntary or involuntary.

In attempting to rank and place into perspective the possible carcinogenic hazards resulting from known environmental exposures, which are typically involuntary exposures, Dr. Bruce Ames, University of California, Berkeley, has developed a scale of the possible hazards for the amounts of various common carcinogens. The HERP (Human Exposure/Rodent Potency dose) index, developed by Dr. Ames, expresses the ratio of human exposure (daily lifetime dose in milligrams per kilogram) as a percentage of the dose required to cause tumor development in half of the rodents tested (in milligrams per kilogram). Table 5.4 presents the HERP calculations of possible cancer hazards in order to compare them within several categories of environmental exposure. Dr. Ames has pointed out that this ranking suggests that carcinogenic hazards from current levels of pesticide residues in foods or contaminated water are likely to be of minimal concern relative to the background levels of natural carcinogens in the diet (Ames, Magaw, and Swirsky-Gold 1987).

Table 5.4 Ranking Possible Carcinogenic Environmental Hazards[a]

HERP[b]	**Daily Human Exposure**	**Carcinogen dose per 70-kg adult**
	Environmental Pollution	
2.1	Mobile home air (14 hr/day)	Formaldehyde, 2200 υg
0.6	Conventional home air (14 hr/day)	Formaldehyde, 598 υg
0.008	Swimming pool, 1 hour (for child)	Chloroform, 250 υg (average pool)
0.001	Tap water, 1 liter chlorinated	Chloroform, 83 υg (US average)
0.0004	Well water, 1 liter contaminated (Woburn, Massachusetts)	Trichloroethylene, 267 υg
0.0003	" "	Tetrachloroethylene, 21 υg
0.0002	" "	Chloroform, 12 υg
	Pesticide and Other Residues	
0.0003	DDE/DDT: daily dietary intake	DDE, 2.2 υg (US average)
0.0002	PCBs: daily dietary intake	PCBs, 0.2 υg (US average)
	Natural Pesticides and Dietary Toxins	
6.2	Comfrey-pepsin tablets (nine daily)	Comfrey root, 2700 mg
4.7	Wine (250 mL)	Ethyl alcohol, 30 mL
2.8	Beer (12 ounces; 354 mL)	Ethyl alcohol, 18 mL
0.1	Basil (1 g of dried leaf)	Estragole, 3800 υg
0.1	Mushroom, one raw (15 g) (*Agaricus bisporus*)	Mixture of hydrazines, and so forth
0.07	Brown mustard (5 g)	Allyl isothiocyanate, 4600 υg
0.06	Dried squid, broiled in gas oven (54 g)	Dimethylnitrosamine, 7.9 υg
0.03	Comfrey herb tea, 1 cup	Symphytine, 38 ug (750 υg of pyrrolizidine alkaloids)
0.03	Peanut butter (32 g; one sandwich)	Aflatoxin, 0.064 υg (US average, 2μg/L)
0.006	Bacon, cooked (100 g)	Diethylnitrosamine, 0.1 υg
0.003	" "	Dimethylnitrosamine, 0.3 υg
0.003	Sake (250 mL)	Urethane, 43 υg
	Food Additives	
0.06	Diet Cola (12 ounces; 354 mL)	Saccharin, 95,000 υg

[a]Adapted from Ames, Magaw, and Swirsky-Gold, 1987. Explanatory footnotes have been excluded in this adaptation and should be referred to for a better understanding of the source of each exposure and the development of HERP for that exposure.

[b]Human Exposure/Rodent Potency dose index, developed by Dr. Bruce Ames, UC Berkeley expresses the ratio of human exposure (daily lifetime dose in milligrams per kilogram) as a percentage of the dose required to cause tumor development in half of the rodents tested (in milligrams per kilogram). Ranking is from the highest to the lowest HERP index in each category.

HERP indices of less than 1.0 show that the average daily exposure in humans is less than the dose that caused tumor development in 50% of the rodents exposed. HERP indices greater than 1.0 show that the average human exposure is greater than the dose to cause tumor formation half of the rodents. The lower the HERP, the lower the average dose in humans compared to the dose which may cause tumor formation in half the animals exposed.

4. Risk Communication

Risk communication involves the exchange of information and opinion about risk among individuals, groups, and institutions. With regard to drinking water, risk communication would include the consumers, the water utilities, and local, state, and federal agencies. Within the Department there are several mechanisms by which information regarding risks are communicated to the public. These include the public notification process when a water system exceeds a primary drinking water standard; the mandatory annual water quality report provided by the water system to their customers; and opportunities for ODW, HHAD, and EETS staff to respond to public inquiry. However, the only process whereby the public is encouraged to discuss and exchange information regarding risks are during public hearings that are required prior to the adoption of an MCL, RPHL, or other regulations proposed by the Department. At the hearing, the Department accepts input on the public opinion and attitude regarding the proposed standard, associated risk, and costs to the utility and customer to meet the proposed standard. These comments are taken into consideration prior to promulgating the final standard or regulation. Where factual data is found to differ greatly from the proposed position taken by the Department, the standard or regulation may be modified.

Both studies discussed above showed that consumers do not receive most of their information about water quality from the water company, but from the television and newspaper. Not surprisingly, information from these sources may sometimes be misstated or misinterpreted by the media or public. The Santa Clara study stated that the residents were thirsty for information about water quality. Public perception of risks is closely related to risk communication. Where the lines of communication are not open, the public perception may not be consistent with the actual risk to which they may be exposed.

D. HEALTH EFFECTS AND RISKS IN DRINKING WATER

The health effects information and risk assessments for individual contaminants for which the Department has established MCLs are summarized in Tables 5.6 through 5.10, presented following this chapter. Table 5.6 presents health risk information for organic chemicals; Table 5.7 for inorganic chemical; Table 5.8 for radiochemicals; Table 5.9 for microbiological agents; and Table 5.10 for DBPs. The draft RPHLs have been provided in these tables for contaminants for which such levels have been developed for internal discussion as of February 14, 1991.

The risk levels presented in Tables 5.6 through 5.10 for those contaminants that are carcinogens represent the theoretical risk of contracting cancer if a person were to consume 2 liters of water per day for 70 years which contained a carcinogenic contaminant at the MCL. As already discussed, these risk levels are highly wrought with uncertainties and MCLs are calculated using various assumptions. They should be used only as a means of comparing and managing other environmental risks that the population are exposed to from all means and sources. It should be noted that for contaminants which are not known, probable, or possible human carcinogens, there has been no risk level presented. When calculating MCLs for non-carcinogenic contaminants (other than microbial agents), there are uncertainty, or safety, factors applied to the NOAEL to determine MCLs. As such, there is no known risk associated with consumption of these contaminants below MCLs.

The health effects presented in these tables are a summary of the most common effects observed in toxicological and/or epidemiological studies. For the organic chemicals, the health effect used for the determination of MCLs is underlined in the table.

A brief discussion of the health effects and risks associated with those contaminants of concern in California drinking water is provided below. These are presented under the general classification of surface water, ground water, and distribution system water contaminants. The health effects and risks for several contaminants for which California currently has no MCL, such as radon and *Cryptosporidium*, are provided. The regulatory status of these are discussed individually.

1. Surface Water Contaminants of Concern

The quality of surface waters can vary over time. Typically, surface water contains microorganisms, such as bacteria, *Giardia* and *Cryptosporidium*, as well as organic and inorganic particulate matter and dissolved solids. The presence of organic matter and the intrusion of seawater which contains bromide is also of great concern due to the reaction of these constituents with disinfectants, resulting in the formation of by-products of significant health concern. Surface waters are subject to contamination by municipal wastewater discharges, animal and human activities in the watershed, industrial wastes, and agricultural runoff, which contain microbial agents and DBP precursors. Watershed protection to minimize or eliminate these sources of pollution is essential to public health protection. All surface waters are required to undergo treatment as specified in the California SWTR. This may include predisinfection, coagulation, flocculation, sedimentation, filtration, pH adjustment, and post-disinfection. The formation of DBPs may be reduced through the use of alternative disinfectants. Control of the precursors in the source waters will be essential in order for utilities to meet potentially more stringent standards for DBP which are under discussion by USEPA.

a. Microbiological Contaminants

Microbial agents are found in all surface waters of the state and pose a continuing threat to human health. It has been clearly shown that without adequate treatment of surface water for drinking water purposes there is a definite potential for a disease outbreak to occur. A historical perspective on the incidence of waterborne diseases over the last two centuries demonstrates the part played by filtration and disinfection in reducing diseases. In the latter half of the nineteenth century, the bacterial diseases of typhoid and cholera became epidemic in the western world. Filtration and chlorination brought about dramatic declines of these diseases in the early part of this century (Amirtharajah 1986). The California drinking water program was established in 1915 to prevent outbreaks of typhoid fever and cholera, which were continuing to occur sporadically. Implementation and enforcement of microbiological water quality standards has led to widely improved drinking water quality. Compliance with the Department's regulations for bacteriological quality and turbidity is being achieved by most public water systems. No longer do widespread epidemics of typhoid fever and other waterborne diseases occur. There have been no documented incidents of waterborne outbreaks in community water systems for over two decades.

The trends in reported outbreaks in the United States (CDC 1990) are shown in Figure 5.1 for the years 1971 to 1988. The trend in the reported number of outbreaks nation-wide increased between 1971 and 1980, as seen by a total of 53 waterborne outbreaks reported for 1980. That number has subsequently decreased to a low of 13 reported waterborne outbreaks in 1988. There has been an overall decline in the number of reported outbreaks in the 1980s. There has been a better reporting of diseases, advances in analytical methods, better treatment technologies, and the better understanding of the microbial agents that cause diseases.

The majority of waterborne disease outbreaks and illness cases are not reported. One study funded by USEPA in Colorado found that only about one-quarter of the waterborne disease outbreaks were being recognized and reported (USEPA 1985). USEPA believes that a major factor in the failure to recognize waterborne disease outbreaks is that most people experiencing gastroenteritis, some of which may be waterborne in origin, do not seek medical attention, and physicians generally cannot attribute gastroenteritis to any specific source. It is estimated that the actual number of outbreaks is 20% to 80% more than the number reported because microbiologically contaminated drinking water is often not suspected as the cause of the illness. However, no waterborne disease outbreaks have been identified in properly designed, well-operated water systems that have met USEPA surface water treatment requirements (USEPA 1989).

The protozoa *Giardia lamblia* is one of the most common etiological agents contributing to outbreaks of waterborne gastroenteritis (Craun 1988). From 1986 to 1988, Center for Disease Control (CDC) reported nine outbreaks of waterborne giardiasis nation-wide, eight of which were in community water systems[16]. Six of the reported outbreaks were associated with unfiltered surface water systems in which the only treatment was chlorination. Some of the outbreaks were caused by fecal bacteria such as *Salmonella* and *Shigella* whose presence should be detected by monitoring for total coliform bacteria. Viral agents implicated in recent waterborne illnesses include Norwalk and Norwalk-like agents, rotaviruses, and the hepatitis A agent. In about half the waterborne outbreaks the causative agent has not been found. There is increasing suspicion that many of these may be due to unidentified viruses or the protozoa *Cryptosporidium*. Unfortunately, the unavailability of suitable analytical techniques has impaired efforts to resolve this issue.

Gastroenteritis has been listed as the most common waterborne disease. Gastroenteritis is not a reportable disease, probably because it is the most common human illness after the common cold. Symptoms include nausea, vomiting, and diarrhea. Comparable illnesses may be caused by

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[16]CDC definition of an outbreak is two or more cases of illness.

several strains of bacteria, including *Shigella sonnei*, *Salmonella typhosa* and *Escherichia coli*, as well as by the protozoan parasites *Giardia lamblia* and *Cryptosporidium*, and many viruses. These illnesses have been known to cause death or disability in sensitive individuals, such as those with suppressed immune systems, or due to excessive dehydration. Several diseases involving the central nervous system, and more rarely the skin and heart, are caused by the better-characterized enteroviruses: polioviruses, coxsackieviruses, and echoviruses.

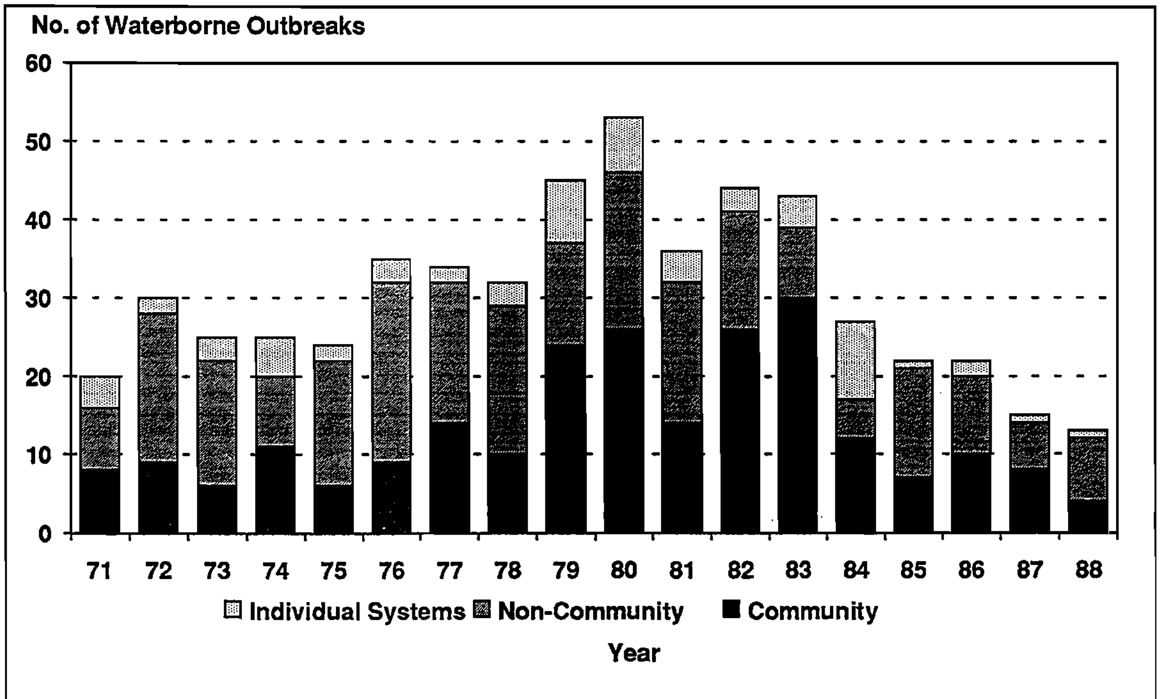

Figure 5.1. Trend in Waterborne Disease Outbreaks[a]

[a]Data obtained from CDC 1990.

Giardia lamblia

The overall risk of transmission of *Giardia* through drinking water is influenced by the concentration or number of cysts found in the source water and the level of treatment or reduction in the number of cysts achieved through treatment. The Department has required that surface water treatment achieve a 99.9% reduction of *Giardia* cysts to reduce the yearly risk of infection to 1-in-10,000. This risk level is based on the assumption that the raw surface water has a cyst concentration of 0.7 cysts per 100 liters of water. In studies conducted in California, *Giardia* concentrations found in source waters were significantly lower than this. Concentrations averaging 0.007 cysts per liter (or 0.7 cysts per 100 liters) were found in one study conducted in 1984 in the California Sierra Nevada's (Suk, Sorenson, and Dileanis 1987). In 1987, MWD found an average cyst concentration of 0.012 cysts per 100 liters in 12 raw water samples (MWD 1987).

Cryptosporidium

A conventional surface water treatment plant appears to reduce *Cryptosporidium* by 99 to 99.9%. Therefore, the major risk of waterborne cryptosporidiosis is probably confined to those occasions when the number of viable cysts in the raw water exceeds levels of 100 oocysts per liter (Colburne 1990).

In one study, streams sampled in Oregon and California had the lowest levels of contamination (0.05 and 0.04 oocysts per liter, respectively) compared to waters sampled in Arizona and Utah which had substantially higher concentrations (18 and 19 oocysts per liter, respectively). *Cryptosporidium* was found more frequently and at higher concentrations than *Giardia* in California, though at lower concentrations than other parts of the western United States (Rose 1988). Source waters subject to agricultural discharges or that receive treated sewage discharges have the highest concentrations of *Cryptosporidium* (Rose 1989).

Virus

The estimated annual risk of infection from one enterovirus in 1,000 liters of water consumed could range from 1-in-100 to 1-in-5,000 (Gerba 1990). The Department has required that surface water treatment achieve a 99.99% reduction of viruses to reduce the yearly risk of infection to 1-in-10,000 in persons exposed.

The only monitoring for viruses in source waters available for California waters was conducted by MWD. Sampling of six raw water reservoirs, averaging 870 gallons (230 liters) in each sample, found no detection of virus particles.

Legionella

The bacteria, *Legionella*, was first identified in 1977, six months after an outbreak of pneumonia occurred among 221 people attending the annual convention of the Pennsylvania American Legion. There were 34 deaths among those affected. Since the initial identification, other *Legionella*-like organisms have been discovered and classified into a new family of bacteria, legionellaceae. It has been estimated (USEPA 1985) that 50,000 to 100,000 cases of legionellosis occur annually within the United States. The number of cases attributable to drinking water is unknown. Legionnaire's Disease typically develops in individuals that are immunologically suppressed or have other underlying illness, and has been known to cause death. Pontiac Fever is a milder, non-pneumonia form of legionellosis, which typically occurs in healthy individuals.

Legionella is commonly found in aquatic habitats, such as rivers and lakes. Conventional treatment may not provide a sufficient barrier against entry of legionellae into the distribution system. One study found that *Legionella* organisms are much more resistant to chlorine disinfection than are coliform bacteria (Witherell, et al. 1988). The organism may escape the disinfection process by hiding inside certain amoebas, which form inactive cysts when stressed, such as by exposure to chlorine.

There is good epidemiologic evidence that Legionnaire's Disease is transmitted by aerosolized potable water from showerheads and other devices containing legionellae. There is great variation in virulence, and the mere presence of large populations of legionellae in the domestic water supply does not necessarily represent a health threat.

b. Disinfectants and Disinfection By-Products

Disinfection has long been practiced by surface water systems in the United States and throughout the world to control pathogenic microorganisms and to reduce the risk of waterborne disease. Disinfection practices, however, have introduced undesirable and potentially toxic oxidation by-products into the water supply. The evaluation of the toxicological hazards associated with the use of disinfectants must therefor consider two problems: (1) the toxicology of residual disinfectant at the tap, and (2) the toxicology of by-products that the disinfectant produces in the water.

In any risk assessment of disinfectants and their by-products, the public health risk from consumption of trace quantities of the DBPs must be weighed against the benefits to public health in reducing microbiological contamination. Consequently, there will be the trade-offs between waterborne disease and toxicological hazards associated with disinfection. It is imperative that ways of reducing these risks without increasing the probability of waterborne infectious disease be studied and developed, while weighing the high cost to remove the disinfection by-products.

Disinfectants

Chlorine is the most common disinfectant used in California drinking water supplies. Chloramines and ozone are gaining increasing use as a means to control trihalomethane THM formation, which are the oxidation by-products of chlorine disinfection. Chlorine dioxide has only recently been approved by the Department for use in California, under certain restrictions (CDHS 1990a).

Chlorine, chloramine, and ozone have not been found to be mutagenic or carcinogenic. At extremely high concentrations (typically not applied to drinking water) various acute effects may occur.

Chlorine dioxide and its reaction products, chlorite and chlorate, produce hematological effects (blood disorders) in humans and animals. In particular, they can cause methemoglobinemia and hemolytic anemia. The hemolytic anemia was associated with oxidative damage to the red blood cell membrane. Individuals undergoing dialysis and those with certain enzyme deficiencies are particularly sensitive to these chemicals. In addition, irreversible thyroid and developmental neurologic effects have been observed in laboratory animals. Chlorite is the most potent of the three compounds.

There is no available information to show whether chlorine dioxide, chlorite, or chlorate are mutagenic or carcinogenic. Epidemiological studies of volunteers and of customers in water systems whose water was disinfected with chlorine dioxide showed no significant effects.

To protect against the hematological effects, the Department has developed the following ALs: chlorine dioxide - 0.02 mg/L; chlorite - 0.02 mg/L; chlorate - 0.2 mg/L (CDHS 1990a). ALs for chlorite and chlorate are set at the analytical detection limits for these chemicals.

Disinfection By-Products

THMs are formed from the reaction between chlorine, the most widely used disinfectant, and natural organic (carbon-based) matter which may be present in raw water. Most of the carbon in typical surface water is from natural humic materials produced mainly from decaying vegetation. Surface waters usually have significantly higher levels of organic matter than ground water. Ground water undergoes a natural filtration process as it percolates through the soil, eliminating many of the organic materials. To reduce the formation of THMs, alternative disinfectants to chlorine have been considered for water treatment. Some of these alternative disinfectants, however, will produce low levels of THMs, as well as other oxidation by-products which may also be toxic.

Chloroform, bromodichloromethane, dibromochloromethane, and bromoform, are the major THM species formed by chlorination. Chloroform will typically be present in the greatest amount, and bromoform the least, though this relationship may change when water is pre-ozonated or when high levels of bromide are present. When bromide is present in the water, as in areas of seawater intrusion, bromine-containing THMs may be more prevalent. The health effect of most concern from exposure to THMs, and in particular chloroform, is carcinogenicity, although none of the THMs have been shown to be carcinogenic in humans. The health effects of other DBPs produced by some of the disinfectants have not yet been well-defined. Many of the by-products formed as a result of disinfection have not been toxicologically characterized at all; others have had only limited testing. While information on the type of DBPs produced by chlorine and their toxicology is far from complete, there is far more information than there is for the alternative disinfectants. For this reason, the relative importance of the risks associated with THMs is unknown with respect to the potential risks of other less characterized DBPs.

The theoretical carcinogenic risk for trihalomethanes has been estimated to be 1-in-10,000 for each species in the following concentrations: 600 μg/L for chloroform; 30 μg/L for bromodichloromethane; and 400 μg/L for bromoform. Dibromochloromethane is not a carcinogen but has been shown to cause liver and kidney damage in rodents.

As a result of the potential carcinogenic effects posed by THMs and, in particular, chloroform, the Department established an MCL of 0.100 mg/L (100 μg/L) for any single THM constituent or the sum of the four constituents, TTHMs. All water systems in California with greater than 10,000 population that provide disinfection have been required to conduct quarterly monitoring for TTHMs which conforms with USEPA's TTHM monitoring criteria (USEPA 1983).

USEPA's Office of Drinking Water is developing regulations for disinfection and DBPs that takes into consideration the risks of both waterborne infectious disease and DBPs, balanced with the high cost to reduce DBP concentration. All public water systems will be required to meet the USEPA DBP rule, including those with less than 10,000 population. Table 5.5 presents the disinfectants and DBPs proposed for regulation by USEPA. This is a working list of disinfectants, chlorination by-products, and ozonation by-products. MCLs or treatment techniques could be established by USEPA for some or all of the contaminants listed.

MCLs for DBPs are not expected to be proposed by USEPA until at least 1993.

Table 5.5 Disinfectants and Disinfection By-Products Considered for Regulation by the USEPA

Disinfectants	**Disinfection By-Products**
Chlorine	**Chlorination By-Products**
Chloramine	Cyanogen chloride
Chlorine dioxide	Haloacetonitriles
Chlorate	Dichloroacetonitrile
Chlorite	Trichloroacetonitrile
	Trihalomethanes
	Bromodichloromethane
	Bromoform
	Chloroform
	Chlorodibromomethane
	Other
	Chloral hydrate
	Chloropicrin
	Ozonation By-Products
	Bromate

Disinfection By-Product Precursors

DBPs are formed from the reaction of the disinfectant and organic matter or bromide that may be present in the source water. These compounds in the raw water are known as precursors of DBP formation. The Sacramento River Delta, from which SWP obtains its water, is especially impacted by the DBP precursor issue because of the high levels of natural organic materials and bromide present in this water, which results in greater DBP formation than other surface water sources used within California.

Dr. Richard Bull's testimony (1990) before SWRCB, Bay-Delta Hearings, was introduced with the following statement:

> "To a large extent the health concerns in drinking water stem from the relatively high bromide levels in salt water and the reactions that this ion enters into with the use of chemical disinfectants of drinking water. The disinfectants activate the bromide to a brominating species and in some cases the bromide is oxidized to

bromate. This occurs at low concentrations of bromide. Most of the bromine containing by-products identified in substantive concentrations in drinking water have been shown to be carcinogenic and some have been shown to be teratogenic. A number of these chemicals (brominated acids) have yet to be investigated toxicologically, but are structurally similar to other carcinogens and limit the concentrations of these chemicals that are allowed in drinking water. Consequently, inadequate protection of the estuary from salt water intrusion may either prevent use of the waters as drinking water sources or considerably increase the costs of treatment."

In addition, numerous agricultural drains dispose of overflow irrigation water into the Delta waterways. Since much of the useful land in the delta is recovered from peat bogs, the agricultural drainage contains high levels of organic material, increasing the level of DBP precursors in SWP.

Water from the Bay-Delta system is used by many community systems serving drinking water to some 19 million people. There are over a dozen large water systems using SWP that have exceeded, or are on the verge of exceeding, the existing TTHM standard of 100 μg/L. In addition to the anticipated lowering of the TTHM standard by USEPA, the establishment of an RPHL for THMs is mandated by AB 21. RPHLs are to be based strictly on health effects and, as such, will likely result in an RPHL for THMs that is even lower than the USEPA probable MCL. Large water systems with more than 10,000 service connections will be required to take any feasible action to lower THM concentrations in their treated water to as close to RPHL as is possible. To compound this problem, the new SWTR recently promulgated by the Department will require most water systems using surface water to increase their disinfection capability to meet the microbial inactivation requirements.

It is the position of the Department that, in view of this situation, it is essential that all reasonable steps be taken to prevent the introduction of THM and other DBP precursors into the Bay-Delta system and to protect the quality of this important domestic water supply (CDHS 1990b).

2. Ground Water Contaminants of Concern

Most of the chemical contamination of California's drinking water has involved ground water rather than surface water because of the use and disposal of chemicals. The main source of contaminants has been agricultural and industrial uses, but in some cases the source has been military bases, dry cleaners or even the natural environment. Soil fumigants (especially nematicides) have been the major class of agricultural contaminants whereas solvents have been the major class from industrial and military sources.

a. Industrial Contaminants

Tetrachloroethylene

Cancer is the primary health concern from exposure to PCE. Exposure is carcinogenic for rodents, inducing liver cancer in mice by inhalation or ingestion, and leukemia in rats by inhalation.[CDHS 1988c] Statistically significant increases in the incidence of tumors at several sites have also been observed in certain studies of workers in the dry-cleaning industry. However, a relationship between PCE exposure and human cancer could not be established. Therefore, the predictions of human cancer risk from PCE exposure are based upon animal studies. There is little evidence of adverse effects during pregnancy despite widespread use and relatively high occupational exposures. Therefore, the concentrations of PCE present in California drinking water are unlikely to pose a threat of reproductive toxicity to humans.

Exposure to PCE in drinking water can result from ingestion, but also from inhalation and dermal absorption of the solvent, primarily while bathing and showering. In urban areas, exposure to PCE in outdoor air (as an industrial air pollutant) may be high. Indoor air exposure may also be significant, resulting from paint, building materials, household cleaners, and freshly dry-cleaned clothing.

The California MCL for PCE has been established at 0.005 mg/L (5 μg/L). This corresponds to a theoretical lifetime risk of one excess cancer case per 400,000 persons exposed.

Trichloroethylene

Cancer is the primary health concern from exposure to TCE. Exposure produces cancer in rodents, inducing liver cancer in mice after ingestion. Exposure to TCE in drinking water can result from ingestion, but a significant exposure can result from inhalation, and minor exposure from dermal absorption of the solvent, primarily while bathing and showering. Ingestion, indoor inhalation, and dermal absorption accounted for 21%, 65%, and 14% respectively, of the total daily dose of TCE from drinking water in one study (CDHS 1987b).

The major environmental degradation by-products of TCE include cis- and trans-1,2-dichloroethylene and the known human carcinogen vinyl chloride. The biological half-life of TCE in ground water is reported to be from 43 to 300 days. Depending upon the particular conditions of the ground water aquifer (temperature, presence of oxygen and bacteria), the complete degradation of TCE to the chlorinated metabolites could require 1 to 70 years.

The Department has promulgated an MCL for TCE at the one in one million risk level of 0.005 mg/L (5 μg/L).

b. Agricultural Contaminants

1,2-Dibromo-3-chloropropane

The suspension of the use of DBCP came as a result of studies indicating sterility and lowered sperm counts among workers at the manufacturing plant where the chemical was formulated. DBCP has been shown to be an animal carcinogen in two species, although it is not known with certainty whether DBCP can cause cancer in humans. It has been shown that DBCP exposure from bathing, showering, and other domestic activities (i.e., dermal absorption and inhalation routes of exposure) may be at least as great as that received via direct ingestion of DBCP-contaminated water. Data shows that the median half-life for DBCP in ground water is estimated to be 20 years. Detectable concentrations of DBCP may continue for at least the next 140 years or longer for some of California's aquifers (CDHS 1987a).

The Department's MCL for DBCP of 0.2 μg/L is the level at which it was determined to be cost-effective to treat for the removal of DBCP from water, while still providing an acceptable level of protection to the public. The MCL of 0.2 μg/L provides an estimated theoretical risk of 1-in-10,000 of contracting cancer. DBCP concentrations of 0.4 μg/L or less are not expected to cause human reproductive toxicity.

Ethylene Dibromide (EDB)

EDB is a reproductive toxin for both humans and animals, causing reduced sperm counts in human males. The chemical is a potent carcinogen for laboratory rodents whether it is inhaled, ingested, or applied to the skin. Data indicate that EDB exposure from bathing, showering and other domestic activities may be at least as great as that received via direct ingestion of EDB-contaminated water. Data suggests that EDB has a half-life of approximately 8 years in the soil/water environment.[CDHS 1988d]

The Department has promulgated an MCL for EDB at 0.02 μg/L, which results in an estimated theoretical lifetime risk of one excess cancer case per one million people exosed. This is also the detection limit for EDB using current laboratory techniques. Based on animal and human data, concentrations of EDB equal to or less than 1.0 μg/L in drinking water are not expected to cause human reproductive toxicity.

Nitrate

The toxicity of nitrate in humans is due to the reduction of nitrate to nitrite in the digestive tract. Nitrite absorbed in the body will react with hemoglobin, which enables red blood cells to transport oxygen from the lungs to the tissues and transports carbon dioxide from the tissues to the lungs. Nitrite interacts with hemoglobin to form methemoglobin, which will not transport oxygen to the tissues, and thus can lead to asphyxia which, if sufficiently severe, can lead to death. Infants under three months old are the most susceptible to methemoglobinemia (commonly referred to as "blue baby syndrome") for a variety of reasons including greater water consumption per body weight, increased percent conversion of nitrate to nitrite due to an alkaline stomach (lower stomach acidity), and a higher requirement for hemoglobin (USEPA 1985). Infants up to the age of about nine months have gastric juices that are alkaline in pH rather than acidic, as in adults. This difference is the reason why nitrates, when present in excess of 45 mg/L in drinking water, are so much more toxic to infants than adults. Alkaline gastric juices enhance the activity of microorganisms that reduce nitrates to the more acutely toxic form of nitrite. Infants with gastrointestinal disease (e.g., diarrhea) are the most sensitive members of the infant population (USEPA 1990). Dialysis patients are also susceptible to methemoglobinemia, and water used in dialysis treatment should not contain more than 2 mg/L nitrate.

The current standard for nitrate is based on the previous Public Health Service recommended permissible level of 45 mg/L (as NO_3), which was based on a literature survey by Walton (1951). Walton found that while serious methemoglobinemia, including death, was observed in human infants exposed to high levels of nitrate, no cases were observed in infants exposed to 45 mg/L or less of nitrate. This level is NOAEL for nitrate.

There is no evidence to indicate that exposure to nitrate in drinking water at the 45 mg/L level produces adverse reproductive or teratogenic effects. The evidence that nitrates present a cancer risk is inconclusive. Some epidemiologic studies have correlated an increased exposure to nitrate or nitrite in the diet or drinking water with an increased prevalence of stomach cancer, but a causal relationship has not been established. Nitrate conversion in the human stomach to N-nitroso compounds, some of which are highly carcinogenic, is known to be possible; however, there is no evidence to conclude that nitrates or nitrites themselves are carcinogenic, and data are inadequate to determine the biological significance of this type of exposure to N-nitroso compounds (Russell et al. 1987).

c. Naturally Occurring Contaminants

Selenium

Selenium is an essential element in animal and human diets. The National Academy of Sciences (NAS) has estimated an adequate and safe intake of selenium for adults of 0.05 to 0.20 mg/day with correspondingly lower intake levels for children and infants. A deficiency of selenium in animals results in congenital white muscle disease and other diseases. Drinking water is generally not considered a significant source of selenium in the diet.

Acute and chronic toxic effects have been observed in animals and humans exposed to high levels of selenium. NAS (1980) has reported several epidemiological studies in humans exposed to high levels of selenium in the diet. Although symptoms of chronic selenium poisoning varied, the subjects were found to experience physiological disturbances, extreme listlessness accompanied by dizziness, impaired ability to concentrate, hair loss, weakened nails, and dermatitis. Naturally occurring selenium compounds have not been shown to be carcinogenic in animals. On the contrary, many studies have shown selenium compounds to result in the inhibition of tumors of various types.

The current California MCL for selenium is 0.01 mg/L. USEPA recently adopted an MCL for selenium of 0.05 mg/L. The California MCL of 0.01 mg/L is fiev times more stringent than the USEPA proposed standard of 0.05 mg/L.

Arsenic

Arsenic compounds have been shown to produce acute and chronic toxic effects which include systemic irreversible damage. One of the most important factors in arsenic toxicity is the chemical form of the arsenic itself. In general, soluble trivalent (As^{3+}, arsenate) arsenic compounds are more toxic than pentavalent (As^{5+}, arsenite) forms, and tend to accumulate in the body.

There have been conflicting epidemiological studies relating the carcinogenicity of arsenic in drinking water. In Taiwan (NAS 1983a), there was a correlation between arsenic in the drinking water and skin cancer, hyperpigmentation, and keratosis. In three epidemiological studies conducted in the United States, no relationship was found between high levels of arsenic and adverse health effects. Several possible explanations for the apparently conflicting results include the difference in arsenic content of the water supplies (the concentrations in the supplies in Taiwan greatly exceeded those in the United States studies), the types of arsenic compounds present in the waters and differences in the nutritional status of those exposed. Arsenic has been classified by USEPA as a known human carcinogen through inhalation and ingestion exposure.

Based upon the study of increased incidence of skin cancer in humans in Taiwan, the USEPA Carcinogen Assessment Group has calculated that concentrations of 22 nanograms per liter (ng/l), 2.2 ng/L and 0.22 ng/L would result in an incremental theoretical increase of cancer risk over a lifetime of 10^{-5}, 10^{-6} and 10^{-7}, respectively (USEPA 1985).

The current California MCL for arsenic is 0.05 mg/L. Based on human epidemiological data and USEPA risk estimates, this level of arsenic corresponds to a theoretical excess cancer risk of 2.3×10^{-2}, or 2.3 excess cases of skin cancer per 100 people exposed to arsenic over a 70 year lifetime at concentrations greater than 0.05 mg/L. Although this risk level is high, it is based upon skin cancer, a condition which is considered non-fatal by USEPA. This level is below the concentration at which toxicity is demonstrated, and is in the range which may be essential for humans. It must be emphasized that the toxicity of arsenic is highly dependent upon the form of the arsenic compound. Title 22, CCR do not require the form of the arsenic to be determined, and hence, the monitoring results may provide an over-estimation of the risk to exposed populations because it is assumed that all arsenic concentrations are due to the trivalent form, arsenate. The Department is in the process of reevaluating the current MCL for arsenic.

<u>Fluoride</u>

Fluoride occurs naturally in ground water and has been added to drinking water for the reduction of dental caries (cavities) for more than 30 years in some public water supplies. There are approximately 74 water systems in California which fluoridate, serving over 4 million consumers (CDHS 1991). The Department encourages fluoridation of public water supplies because of the known benefits of reduced cavity formation from consumption of fluoride. There are, however, known adverse health effects when the amount of fluoride consumed exceeds the optimum dosage that provides a reduction in cavities.

Chronic toxicological studies indicate that teeth and bone are the most fluoride-sensitive tissues. Short-term ingestion of drinking water containing excessive fluoride can result in dental fluorosis, which is characterized by mottled enamel of the teeth, but only in persons in whom the teeth are under mineralization, i.e., children 7 years or younger (World Health Organization 1984). The severity of the mottling varies with the exposure. Dental fluorosis does not impair the health of the teeth, but is cosmetically objectionable.

At high doses fluoride has been found to have some health effects. Chronic ingestion of high-fluoride water can lead to osteosclerosis. In a 1983 report to the Surgeon General, it was concluded that the chronic consumption of drinking water with 5 mg/L fluoride is associated with the development of radiologically detectable osteosclerosis in a small fraction of the population. It was previously concluded that osteosclerosis is not an adverse health effect. However, at unusually high levels, chronic fluoride ingestion can result in a severe form of osteosclerosis designated as crippling skeletal fluorosis. Thus, slight increases in bone density are not considered adverse health effects; but, as the bone density increases, a point is reached after which the effects become adverse. Crippling skeletal fluorosis is the only adverse health effect associated with fluoride, and is extremely rare. Only two cases of crippling skeletal fluorosis associated with the consumption of drinking water have been observed in this country (USEPA 1990).

The existing California MCL for naturally occurring fluoride is especially protective of all chronic health effects. The standard is based upon the annual average of maximum daily air temperatures for each utility. This allows water consumption to be taken into account, since it has been found that the fluoride concentration in drinking water is not as critical for cavity protection as the total amount of fluoride consumed. The California MCL provides for a lower, optimum, and upper level of fluoride in drinking water for cavity prevention, as well as MCLs to protect against mottling of the teeth. MCL for naturally occurring fluoride has been established at 1.4 to 2.4 mg/L, depending on temperature. The average concentration of fluoride during any month, if added, is not to exceed the upper concentration, which ranges from 0.8 to 1.7 mg/L, depending on air temperature.

USEPA has promulgated an MCL for fluoride of 4 mg/L. California has not raised its MCL thereby providing a greater margin of safety for the known effects of excess fluoride exposure, namely dental mottling and fluorosis. The California Legislature has, in recent years, enacted legislation granting exemptions for three public water sytems to serve water with up to 3 mg/L of fluoride.

Radon

Radon-222 is a gaseous radioactive decay product found in uranium deposits. Of specific concern is the indoor air concentration of radon. The predominant source of radon in homes generally appears to be the soil adjacent to the foundation. Radon enters a home through cracks and other openings in walls and floors that are in contact with the soil. Other sources include potable water and building materials.

Drinking water contributes radon to indoor air during showers, washing clothes and dishes, flushing toilets, and other similar activities which allow the radon gas to escape from the water into the home atmosphere. Inhalation of radon gas is more toxic than is ingestion. It is estimated that radon in drinking water contributes 2 to 5% of the annual exposure to radiation.

USEPA has advised that, as a rule of thumb, there will be a one pCi/L) increase in radon in the air inside the home for every 10,000 pCi/L of radon in the household water supply, and recommends that action be taken to reduce the indoor air radon concentration when the indoor air exceeds 4 pCi/L.

Several studies of miners have found a direct link between exposure to radon and its progeny and the incidence of lung cancers in the human population. Animal studies confirm the results found in the human population. Radon is considered by USEPA to be a known human carcinogen based on sufficient evidence from epidemiological studies that support a causal association between human exposure to the substance and cancer. It is not radon itself, but decay products that are thought to cause lung cancer.

There are currently no drinking water standards for radon. However, USEPA is considering an MCL for radon at 300 pCi/L. This will result in a theoretical lifetime risk of 9- to 39-in-100,000 of developing lung cancer.

3. Distribution System Water Contaminants of Concern

a. Lead in Tap Water

Lead may contaminate public water supplies in two ways: (1) as a result of lead in source water, or (2) as a result of corrosion of lead plumbing materials by water. The most significant sources of lead in corrosive drinking water are lead solder, flux, and pipes used in household plumbing. If constructed more than three decades ago, the service connection from the water main to a building may be made of lead. Another potential source of lead in drinking water are the old lead-lined water coolers which may still be in use.

In January 1986, a California law became effective prohibiting the use of lead pipes and lead solders containing lead exceeding 0.2%. Although this law was primarily directed toward the use of such materials in household construction, it is also applicable to public water systems.

Lead is harmful to human health if inhaled or ingested. The total lead exposure to an individual may be due to lead-contaminated ambient air, dust, soil, food, and water. A high concentration of lead in the human body can impair functioning of the nervous system, kidneys, red blood cell formation, reduce oxygen absorption ability of blood, and can cause high blood pressure, low birth weights, and premature births. Even short-term lead exposure is a great risk to young children and pregnant women. Symptoms of lead poisoning include loss of appetite, weight loss, headache, insomnia, and abdominal, muscle or joint pain.

In young children, approximately 30% to 45% of lead exposure comes from food, 30% from dust, 10% to 20% from drinking water and 5% to 20% from ambient air, according to USEPA. It is estimated that 2.4 million children in the United States are at risk of adverse health problems due to lead exposure. Every year in the United States, 241,000 children are exposed to lead sufficient to impair their intellectual development. Approximately 10,000 to 70,000 six-month to five-year-old children have high concentrations of lead in their blood (Lin 1989).

The current California MCL for lead is 0.050 mg/L. This was based upon an estimation that this level in drinking water would contribute 25% to 33% of the lead normally ingested for a child and 33% for an adult. NAS has stated that the current drinking water standard of 0.050 mg/L may not, in view of other sources of environmental lead exposure, provide a sufficient margin of safety, particularly for fetuses and growing children.

The 1987 federal Public Notification regulations required public notification regarding the hazards of lead in drinking water on or before June 19, 1988. This public notification has been conducted by most public water systems in California.

USEPA is considering a Lead and Copper Rule that would require all systems serving greater than 50,000 persons (large systems) to install corrosion control treatment to minimize lead and copper levels at consumer taps unless they could demonstrate that the water delivered to users is already minimally corrosive. Under this proposal, systems serving less than 50,000 persons (small to medium-size systems) would be required to treat only if exceeding the lead and copper action levels, as established by the rule (AWWA 1991).

E. POPULATION EXPOSURE ESTIMATES

1. Recommended Public Health Levels

To determine the benefits of RPHLs, which were placed into law under AB 21, the population that would benefit from a reduction in risk based on RPHL numbers currently under discussion was conducted. There will be a health benefit only for those contaminants for which the drafted RPHLs are more stringent than MCLs, which currently includes nine of the draft RPHLs. By law, RPHLs are only effective for water systems with 10,000 or more service connections. RPHLs drafted to date only include contaminants known to impact ground water. All contaminants regulated as MCLs will eventually have RPHLs.

The estimate of the population exposed is based on a determination of the population exposed to drinking water which is contaminated to levels above the proposed RPHLs but below MCLs. Estimates of population exposed were calculated assuming that each source of supply serves an equal share of the utility's population. Not all sources identified as exceeding an RPHL had population data available for the water system. For these systems, no population was assumed, which affects the exposure estimate by underestimating the population exposed. Also, wells that are known to be treated were eliminated from the data used to determine the population exposed. However, the database may not have been up-to-date with regards to the treatment of or compliance status of those sources exceeding RPHLs. Due to these and other inaccuracies in the database, an over- or under-estimation of the exposure of the population to a contaminant may have occurred.

a. Benefits to Systems With More Than 10,000 Service Connections

The ODW database shows that there are about 1.7 million people potentially exposed to contaminants at concentration above MCLs for which RPHLs have been drafted. Aggressive enforcement of current state regulations and drinking water standards effectively has removed this exposure in the majority of large water systems. For the few systems which are exceeding an MCL on an on-going basis, public notification is being conducted while a solution to the contamination problem can be found.

The proposal of RPHLs for public water systems with greater than 10,000 service connections provides a means for further reducing the health risk of all chemical contaminants to a negligible level, where feasible, for these systems. Table 5.11 shows the population that may benefit by the imposition of the RPHLs. This table only provides population figures for those contaminants for which the drafted RPHL is more stringent than the MCL. Only for these contaminants will there be a direct benefit by a reduction in the population exposed to concentrations above the RPHL. The column in Table 5.11 identified as "Large" includes large water systems with 10,000 or more service connections. In these water systems, a population of about 1.8 million may benefit by reducing their exposure to below the RPHL concentration if it is reasonable for the utilities. This is roughly 6% of the state's population. The greatest benefit will be seen from RPHL for PCE, as currently drafted, accounting for 60% of the population exposed in utilities with greater than 10,000 service connections. The proposed RPHLs for DBCP and TCE will account for an additional 35% of the population exposed above RPHLs.

This correlated with the ground water contamination findings in Chapter IV in which PCE, TCE, and DBCP were the most frequently found ground water contaminants. PCE and TCE contamination is also more prevalent in heavily urbanized areas, hence the potential to affect large populations through any contamination of the ground water supply.

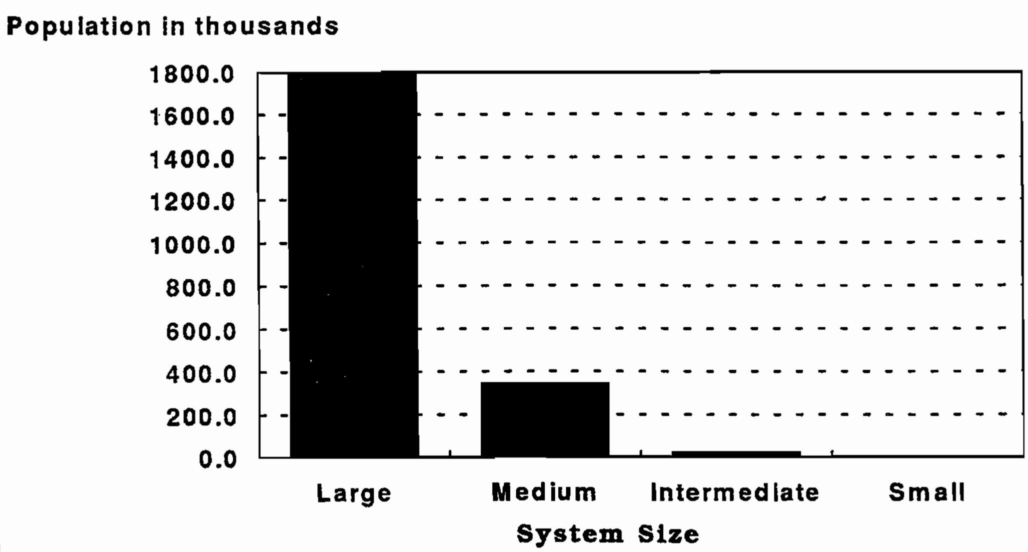

Figure 5.2. Population Exposure Estimate to Determine Risk Benefits for Draft RPHLs

b. Benefits to Systems With 15 to 10,000 Service Connections

To determine the benefits if the proposed RPHLs were imposed on the water systems with 15 to 10,000 service connections, a similar population exposure estimate was conducted. These results are also shown in Table 5.11 for the medium (1,000 to 9,999 service connections), intermediate (200 to 999 service connections), and small (15 to 199 service connections) water systems. The population in the medium-size utilities that would benefit if RPHLs (as drafted) were imposed would be about 350,000 or 1% of the state's population. For the intermediate and small-size water systems, less than one-tenth of 1% of the state's population would benefit, with basically no benefit to the small water systems. These relationships are shown in Figure 5.2.

The significant risk from drinking water contamination in small water systems is mostly a result of poor operation and maintenance of the system, resulting in a high rate of failure of the bacteriological water quality standards and also significant failures of the turbidity standard. The major threat or risk from this exposure is acute gastrointestinal effects of the microbial agents. Although there is a smaller year-round population (approximately one million people, which are primarily residents, employees, school children, and individuals in state institutions) exposed to this higher risk, there is a significant transient population (approximately 260 million person-days) using the non-community small water serving facilities such as serving parks, resorts, and restaurants. The imposition of the proposed organic and inorganic chemical RPHLs on small water systems will not address the issue of reducing the highest risk in these systems, that of waterborne disease resulting from the high rate of noncompliance with the bacteriological standards. This confirms the results of the population exposure assessment which identified a very small population of 350,000 in the 15 to 10,000 service connection range that would benefit from the implementation of RPHLs from the standpoint of improving the risk to health. To abate bacteriological problems in small water systems, operation and maintenance issues must be addressed. Also, improved surface water treatment practices as required by the California SWTR must be implemented.

2. Other Contaminants

a. Surface Water

The use of surface waters pose a great risk from a health-effects standpoint, and due to the larger population exposed. A population of approximately 21 million are potentially exposed to the acute risks from microbial agents which may pass through the water treatment process. In addition, the same population may be exposed to chronic risks from DBPs, some of which are potential human carcinogens, specifically the THM species. Most systems that use surface water also have ground water supplies for drinking water, hence these populations may not always be exposed strictly to the risks associated solely with surface water or ground water contaminants.

Most of the water utilities in California are able to reliably provide water which meets the standard for TTHM, currently the only regulated DBP. The concentration of TTHMs in treated water, however, will vary seasonally as agricultural discharges into the surface water channels increases the potential for disinfection by-product formation, or rain waters reduce or dilute the salt water intrusion into the Delta.

b. Ground Water

As stated earlier, there is a population of approximately 1.7 million, or 5.7% of the state's population, which are potentially exposed to ground water contaminants for which RPHLs have been proposed in public water systems in excess of the MCLs. The majority of this population may be exposed to the long-term chronic effects of potentially carcinogenic contaminants, such as PCE, TCE, and DBCP.

All of the inorganic constituents regulated in drinking water occur naturally. Nitrate in ground water, however, has increased due to fertilization and dairy practices. Nitrate poses a acute risk to infants under three months of age and also to dialysis patients from short-term exposure, causing methemoglobinemia by impairing the ability of the blood to carry oxygen to the body tissues. There is no adverse effect in infants below the established MCL. The population exposed to nitrated in excess of MCL has been estimated at 500,000, or less than 2% of the state's population.

Other inorganic contaminants which have been found in drinking water in excess of MCLs include aluminum, chromium, fluoride, mercury, selenium, and arsenic. Both aluminum and mercury have RPHLs drafted. The population exposed above MCLs for the remaining inorganic contaminants has been estimated to be less that 225,000 people.

Radiochemicals, another naturally occurring group of contaminants, pose carcinogenic and non-carcinogenic risks. There is a potential that a vast majority of ground water supplies used for drinking water will exceed the drinking water standard under discussion by USEPA for radon of 300 pCi/L.

c. Distribution System Water

Lead in drinking water in excessive concentrations is usually a result of leaching from lead pipe and lead-based solders which may have been used in water distribution systems. Lead is classified as a probable human carcinogen, but the major concern is developmental effects in children. There is insufficient data to determine the overall lead exposure in California from home plumbing and/or the public water systems. To protect consumers, the state enacted legislation in 1987 sthat bans the use of lead-based solders for use on pipes supplying drinking water.

CONCLUSIONS AND RECOMMENDATIONS

Water Quality and Health Risks

Monitoring information has demonstrated that the water sources in California generally provide a high quality water supply. Even so, there are acute and chronic health risks associated with the consumption of some drinking waters. Aggressive enforcement of the California SDWA has minimized these risks to the greatest extent possible such that these risks are less compared to other risks commonly taken by individuals daily.

Even though health risks from drinking water have been minimized the public perception of health risks associated with drinking water does not correspond to actual risks, either in terms of the likelihood of suffering an adverse health effect or the hazards of specific contaminants. Contamination of ground water has received the most attention due to news media coverage of toxic waste sites and spills. Yet, the exposure and risks from ground water contaminants are significantly lower than the exposure and risks from surface waters. The most significant water quality concerns are of the risk and exposure to the population of about 21 million or 70% of California's population that use water derived from surface sources, and potential exposure to the acute risks from microbial agents. In addition, the same population may be exposed to chronic risks from DBPs, some of which are potential human carcinogens.

The public also often perceives a risk associated with constituents for which there are secondary drinking water standards where no risk to health exists. This is because they may actually see or smell a change in the water delivered. At the concentrations typically found in public drinking water sources, contaminants of health concern cannot be seen, nor is there any taste or odor.

Concerning the misperception surrounding the risks from drinking water contaminants, the public is undoubtedly reacting to the presentation of the issue by the media. However, it is likely that the public is also including other values in their risk judgements, such as the fact that exposure to drinking water contamination is involuntary, and their degree of trust in decision-making institutions may be low.

ODW needs to better communicate the risks associated with drinking water contamination. Such actions would help to realign the public perception of risks with priorities in the drinking water program for reducing risks, and to re-establish trust in the decision making bodies.

Recommendation: A public education and information program should be established by which develops and distributes information regarding the quality of the drinking water in California and the associated risks. The public should be advised of the risks of the various health threats and the associated costs of reducing these risks. The communication of risks from various environmental exposures is critical to obtaining and directing resources to where risks in California can best be managed.

Risk Assessment and Risk Management

Because of public concerns and legislative mandates, California has the most stringent and comprehensive drinking water standards of any state in the country. These standards continue to be expanded to include more contaminants that may potentially impact drinking water. For MCLs and proposed RPHLs which are more stringent than USEPA standards, or for which there are no proposed or existing federal standards, ODW will conduct a risk assessment to determine the appropriate level to set the standard

In performing risk assessments, there are many assumptions which must be made while interpreting the data from animal toxicological studies and human epidemiological studies. For contaminants that may be carcinogenic, mathematical models are used to estimate the dose-response relationship from the high doses observed in human exposure incidents and in laboratory animal studies, and then are extrapolated to the low doses of human environmental exposure that the public may be exposed to through drinking water. For non-carcinogens, uncertainty factors are applied to the NOAEL to compensate for the uncertainties due to differences between animals and humans when using this information to set standards. There are also many limitations concerning using either epidemiological or toxicological data to set drinking water standards. These relate to the differences between humans and between animals and humans, as well as specific concerns regarding the methods used in conducting toxicological animal studies. Because of these limitations, the results of risk assessments, which present theoretical values or estimates of risk, can only be used to rank contaminants in terms of level of concern in the risk management process.

There are finite resources within the state to pay for risk reduction. In prioritizing the use of those resources on a state-wide basis to reduce the overall risk to the population, the relative risk from each source of contamination must be compared to the cost to reduce the risk resulting from that source. Since California must adopt the same or more stringent drinking water standards as USEPA, the Department and the California Legislature must communicate to the federal government the need to begin a more coordinated risk management strategy that provides the greatest health benefits for the least cost to the consumers. California and USEPA must move away from resolving health threats using single issue strategies. The risk management process must begin to look at all sources of health threats (e.g., contaminants in air, food, and water) and their relative risk, and propose regulatory controls on those first that will result in the greatest health benefits to the entire state population for the least cost.

Recommendation: In lieu of the single issue strategy currently being carried out by each state regulatory agency, California should develop a coordinated risk management program to address the most serious health threats to the population. This will require the reorganization of the of the various units within each agency that conduct risk assessments and risk management.

Due to the fact that no health risk exists when a water system exceeds a secondary standard, there is a need to reevaluate Section 4017, HSC which requires water utilities to monitor for and provide treatment for secondary standards to the same level as for primary drinking water standards. The cost burden for such monitoring and treatment may preclude water utilities from having adequate revenues to also meet the requirements of the public health based primary drinking water standards. The Department's current policy that specifies conditions under which a waiver for secondary standards may be given to a water utility is adequate. It provides that consumer acceptance of the aesthetic quality of the water along with a willingness to accept the burden for the cost of treatment be determined.

Research Needs

In performing risk assessments, the Department's HHAD makes assumptions due to the remaining uncertainties concerning the mechanisms by which chemicals induce harm to living organisms, and the means to properly apply information from animal studies to humans. For example, the extrapolation of doses from animals to humans is based on mathematical models that may not accurately describe the true relationship of observed health effects in animals to potential health effects in humans. In order to provide sound risk assessments, HHAD has identified areas of research necessary to fill these technological gaps, reduce the amount of assumptions made, and improve the quality of the risk assessments conducted.

Research to increase understanding of chemical carcinogenesis mechanisms is essential to develop sound risk estimates. Research is also needed to develop approaches for refining and/or improving methods employed by state regulatory agencies to assess the risk/benefit relationship of a potential standard. Emphasis should be placed on defining both real and intangible costs and benefits, and differential effects on segments of the regulated community.

The California SDWA of 1989, Section 4021(b), HSC provides the Department with the ability to conduct research and studies relating to the provision of a dependable, safe supply of drinking water which may include: "Improved methods to identify, measure, and assess the potential adverse health effects of contaminants in drinking water."

Recommendation: A research and development unit should be established that is given the responsibility of carrying out Section 4021(b), HSC of the California SDWA. Funding for specific research/development projects should be considered as eligible costs under a future long-term state financial assistance program.

Contaminants of Concern

The major risks to health from consumption of treated surface water are DBPs and microbial agents such as *Giardia lamblia*, *Cryptosporidium*, *Legionella*, viruses, and bacteria. The major risks to health from consumption of ground water is from contamination by industrial chemicals, primarily the solvents PCE and TCE. Agricultural chemicals that pose the greatest risk to health are the soil fumigant DBCP, EDB, and nitrates. There are few naturally-occurring constituents in ground water that may a significant risk to health. However, the Department has estimated that a vast majority of the state's population may be exposed to radon, a naturally occurring radiochemical, from drinking water at levels exceeding the drinking water standard of 300 pCi/L under consideration by USEPA. Radon exposure has been shown to produce lung cancer in humans.

Microbial agents are found in all surface water sources. Although significantly reduced due to water treatment and disinfection practices, certain microbial agents have been found to pose a continuing threat to human health through drinking water. The risk of acute effects from the microbial agents *Giardia lamblia, Legionella*, viruses, and bacteria will be effectively reduced by the implementation of the California SWTR to an estimated annual risk of infection of 1-in-10,000 persons exposed to surface water used as a source of drinking water. Even with the stricter treatment criteria specified in the SWTR, *Legionella* may pose a significant threat to the distribution system due to its resistance to disinfection and an ability to use other disinfectant-resistant organisms, such as amoebas, to pass through the treatment process.

The goal of disinfection is to reduce the risk of waterborne disease. It has been shown, however, that every disinfectant currently being used in California produces DBPs through the interaction of the disinfectant with naturally occurring organic material in the water. New health effects information indicates that some disinfectants and DBPs are a significant risk to health. At present, the data shows that non-carcinogenic effects are of importance in association with the disinfectants themselves, whereas carcinogenic risks may be associated with some of the identified disinfection by-products. For TTHMs currently the only regulated DBPs the risk of contacting cancer from consuming water containing TTHMs is 1-in-1-million over a lifetime of exposure. These carcinogenic risks for DBPs are likely to limit the concentrations allowed in drinking water by USEPA. Consequently, it is important to understand the trade-offs between the every day acute effects of waterborne disease and the long-term carcinogenic risks of DBPs. It is imperative that ways of reducing the carcinogenic as well as the non-carcinogenic risks of DBPs be studied and developed, while balancing the high cost to remove the DBPs without increasing the probability of waterborne infectious disease.

Population Exposure Estimate

Considering all contaminants regulated, there is a statewide population of more than 2.4 million (8%) whose sources of drinking water may be contaminated above one or more of the established MCLs. Aggressive enforcement of current state regulations and drinking water standards that require treatment of these sources, however, was effectively reduced any significant exposure to consumers in the large water systems. An additional 21 million (70%) may be exposed to microbial agents and

DBPs, which form as a result of the treatment process in some surface waters, at concentrations below MCL.

The proposed RPHLs for public water systems with greater than 10,000 service connections provides a means for further reducing the health risk of chemical contaminants to a negligible level, where feasible, for these systems. Implementation of RPHLs in these systems, assuming feasible reduction measures are available to achieve RPHL levels, may reduce the statewide exposure by an additional 1.8 million persons. Implementation of RPHLs on water systems with 15 to 10,000 service connections would only reduce the exposure by an additional 350,000 persons.

There is a significant risk in consuming drinking water served by small water systems as evidenced by the high rate of noncompliance with the drinking water standards. This risk is mostly a result of poor operation and maintenance of the system, causing a high rate of failure of the bacteriological water quality standards and significant failures of the turbidity standard. The major risk from this exposure is that of acute gastrointestinal effect of the microbial agents. Although there is a smaller year-round population (about one million people, mainly residents, employees, school children, and individuals in state institutions) exposed to this higher risk, there is a significant transient population (about 260 million person-days) using the non-community small water systems serving facilities such as parks, resorts, and restaurants. The imposition of the proposed organic and inorganic chemical RPHLs on small water systems will not address the issue of reducing the highest risk in these systems, that of waterborne disease resulting from the high rate of noncompliance with the bacteriological standards. This confirms the results of the population exposure assessment that identified a very small population of 350,000 in the 15 to 10,000 service connection range that would benefit from the implementation of RPHLs to reduce the health risks.

Recommendation: Upon reviewing the small population that would benefit from the reduction in risks, it does not appear beneficial to impose RPHLs on smaller water systems.

Table 5.6 Health Risk Assessment for Organic Chemicals

Chemical Name	Uses	Synonyms and Trade Names	MCL	Draft RPHL[a]	Route of Exposure	Health Effects[b]	Risk[c]
Atrazine[d]	Herbicide; used for non-selective weed control along highways and RRs; used for selective weed control on sorghum, corn and other crops	Syn: 2-Chloro-4-ethylamino-6-isopropyl amino-1,2,5-triazine TN: Atrazine; AAtrex; Atranex; Atred; Chrisatrina; Crisazine; Farmco Atrazine; Griffex; Shell Atrazine Herbicide; Vectal SC Gesaprim; Primatol	0.003 mg/l	0.003 mg/l	Ingestion Dermal Absorption	*Decreased food intake, increased heart and liver weights, changes in blood parameters, and tremors in beagles*; reproductive effects in female rats and rabbits, with developmental effects in offspring; marginal increase in mammary tumors in rats only; not a carcinogen	-------
Bentazon[d]	Herbicide; an active ingredient in post emergent selective broadleaf herbicides, predominantly used on soybeans, corn, rice, dry beans and peanuts	Syn: 3-Isopropyl-1H-2,1,3-benzothiadiazin-4(3H)-one-2,2-dioxide; sodium bentazon; bentazone TN: Bentazon; Basagran; BAS 351-H	0.018 mg/l	0.018 mg/l	Ingestion	*Prostatis (inflammation of the prostate gland) and signs of gastrointestinal distress in beagles*; changes in hemoglobin in female rats and reproductive toxicity (testicular calcification) in male mice; no evidence of mutagenicity or carcinogenicity	-------
Benzene[d]	Solvent; used in gasoline, detergents, pesticides, plastics, nylon, and dyes	Syn: Benzol, cyclohexatriene, phenyl hydride, coal naphtha	0.001 mg/l	0.00035 mg/l	Ingestion Inhalation	*Leukemia in humans*; blood disorders; toxic to the bone marrow; known human carcinogen	10^{-6}
Carbofuran[d]	Broad spectrum carbamate insecticide, nematicide, and miticide; used mainly to control water weevil, alfalfa weevil, and nematodes in grape vineyards	Syn: 2,3-Dihydro-2,2-dimethyl-7-benzofuranyl-N-methylcarbamate TN: Çarbofuran; Furadan; Curaterr; Bay 70143; Brifur; Crisfuran; D 1221; ENT 27164; FMC 10242; Yaltox; NIA 10242	0.018 mg/l	0.018 mg/l	Ingestion Dermal Absorption	*Depression of cholinesterase activity (CNS effect) in dogs* and two other species; increased testicular degeneration in beagles; not carcinogenic in three species; little potential for mutagenic activity	-------
Carbon Tetrachloride[e]	Solvent; used in manufacture of refrigerants; minor uses include pesticides, chlorine, pharmaceuticals, and synthetic rubber		0.0005 mg/l	0.0005 mg/l	Ingestion Inhalation Dermal Absorbtion	*Liver tumors in three animal species*; human epidemiological data inconclusive; suspected human carcinogen	10^{-6}

nd - No RPHLs drafted to date
Note: Footnotes shown at end of table

Table 5.6 Health Risk Assessment for Organic Chemicals

Chemical Name	Uses	Synonyms and Trade Names	MCL	Draft RPHL[a]	Route of Exposure	Health Effects[b]	Risk[c]
Chlordane[d]	Insecticide; used especially for termites, cutworms, ants, root weevils, rose beatles, and grasshoppers in residential, commercial and agricultural applications	Syn: 1,2,4,5,6,7,8,8-octachlor-2,3,3a,4,7,7a-hexahydro-4,7-methano-1H-indene TN: Aspon; Belt; CD68; Chlorindan; Chlorkil; Corodan; Cortilan-nea; Dowchlor; NCS 3260; Kypchlor; M140; Niran; Octachlor; Octaterr; Ortho-Klor; Synklor; Tat Chlor 4; Topichlor; Toxichlor; Velsicol 1068	0.0001 mg/l	0.00003 mg/l	Ingestion Inhalation	*Liver tumors in three mouse studies*; decreased fertility and viability of offspring in rats and mice; a potential human carcinogen; no indication of teratogenicity or mutagenicity	10^{-6}
2,4-D[d]	Systemic herbicide; used to control broadleaf weeds in agricultural crops, range and pasture lands, industrial and commercial lawns, and for aquatic weed control	Syn: 2,4-Dichlorophenoxyacetic acid	0.10 mg/l	nd	Ingestion Inhalation	*Toxic to the liver and kidney, resulting in increased liver weight and decreased body weight in animal studies*; not carcinogenic in animal studies	-------
1,2-Dibromo-3-chloropropane[d]	Nematicide; formerly used for grapes, tomatoes, tree fruit and soy beans	Syn: 1,2-Dibromo-3-chloropropane; DBCP TN: Fumazone; Nemagon; Nemafume; Nematox; OS1897	0.0002 mg/l	0.000002 mg/l	Ingestion Inhalation Dermal Absorption	*Forestomach tumors in male mice*; stomach, nasal, liver, mammary, and renal tube tumors in animal studies; human testicular toxin at high doses, causing reduced sperm counts and hormonal disturbances with decreased libido or impotence; probable human carcinogen; no evidence of teratogenicity or female reproductive effects	10^{-4}
1,4-Dichlorobenzene[d]	Used in mothballs; as a preservative for furs and natural fibers; and as a toilet and garbage deodorizer	Syn: para-dichlorobenzene; p-dichlorobenzene; para-chlorophenyl chloride; p-DCP TN: Parazene; Paracide; Santochlor; Parazol; PDB; Paramoth; Di-chorlcide	0.005 mg/l (T&O thrshld = 0.0003 to 0.001 mg/l)	0.005 mg/l	Ingestion Inhalation Dermal Absorbtion	*Benign and malignant liver tumors in male mice*; liver and kidney tumors and leukemia in rats and mice; potential human carcinogen	10^{-6}
1,1-Dichloroethane[d]	Extraction and degreasing solvent; fumigant; used in manufacture of pharmaceuticals, stone, clay and glass products	Syn: Ethylidene chloride; ethylidene dichloride; 1,1-ethylidene dichloride; chlorinated hydrochloric ether; ethane; 1,1-dichloro; 1,1-DCA TN: NCI-C04535	0.005 mg/l	0.005 mg/l	Ingestion Inhalation Dermal Absorption	*Increased mortality, clinical signs of intoxication, and depressed body weight gain in rats*; no human or animal evidence of carcinogenicity	-------

nd - No RPHLs drafted to date
Note: Footnotes shown at end of table

Table 5.6 Health Risk Assessment for Organic Chemicals

Chemical Name	Uses	Synonyms and Trade Names	MCL	Draft RPHL[a]	Route of Exposure	Health Effects[b]	Risk[c]
1,2-Dichloroethane[d]	Used in the manufacture of chlorinated solvents (TCE, PCE, 1,1,1-TCA) and vinyl chloride; a lead scavenger in tetraethyl lead gasolines; solvent and pesticide	Syn: Ethylene chloride; ethylene dichloride; s-dichloroethane; 1,2-DCA	0.0005 mg/l (Limit of quantification)	0.0005 mg/l	Ingestion Inhalation Dermal Absorption	*Cancer at various sites in rats and mice*; potential human carcinogen	2.8×10^{-6}
1,1-Dichloroethylene[f]	Used in the production of latexes for coatings, carpet, plastics, and extruded pipes	Syn: Vinylidene chloride; VDC; 1,1-DCE	0.006 mg/l	0.006 mg/l	Ingestion Inhalation Dermal Absorption	*Hepatocellular fatty degeneration in female rats (increased fatty deposition in the liver)*; liver and kidney effects in animal studies; no human or animal evidence of carcinogenicity	-------
cis-1,2-Dichloroethylene[d]	Major biodegradation by-product of TCE and PCE ground water contamination; limited use as a solvent	Syn: 1,2-Dichloroethylene (also known as acetylene) is made up of a mixture of cis- and trans-isomers ; cis-1,2-DCE	0.006 mg/l	0.006 mg/l	Ingestion Inhalation Dermal Absorption	*Liver effects in rats*; liver and kidney effects in animal studies (increased fatty deposition in the liver); no human or animal evidence of carcinogenicity	-------
trans-1,2-Dichloroethylene[d]	Minor biodegradation by-product of TCE and PCE ground water contamination; limited use as a solvent; used to decaffeinate instant coffees	Syn: 1,2-Dichloroethylene; (also known as acetylene) is made up of a mixture of cis- and trans-isomers ; trans-1,2-DCE	0.01 mg/l	0.01 mg/l	Ingestion Inhalation Dermal Absorption	*Decreased immune response in body fluids and increased serum glucose levels in subchronic studies in mice*; pulmonary, CNS, kidney, liver, cardiac, eye and dermal toxicant in acute, subacute and subchronic animal studies; no chronic toxicity data available	-------
1,2-Dichloropropane[d]	Primary component of some fumigants	Syn: 1,2-DCP	0.005 mg/l	0.005 mg/l	Ingestion Inhalation Dermal Absorption	*Benign breast tumors in female rats*; liver, kidney, lung and CNS toxicant	10^{-6}
1,3-Dichloropropene[d]	Insecticide, soil fumigant for control of nematodes	Syn: 1,3-D (Others noted at end of table)[h]	0.0005 mg/l (T&O thrshd= 0.001 mg/l)	0.0002 mg/l	Ingestion Inhalation Dermal Absorption	*Forestomach and liver tumors in rats; bladder, pulmonary, and forestomach tumors in mice*	10^{-6}
Di(2-ethyl-hexyl)pthalate[d]	A plasticizing additive in the production of polyvinyl chloride (PVC) resin; inert ingredient in pesticides; component of dielectric fluids	Syn: DEHP (Others noted at end of table)[i]	0.004 mg/l	0.004 mg/l	Ingestion Inhalation Dermal Absorption	*Liver tumors in rats and mice*; liver and testes toxicant; liver cancer; reproductive and developmental effects in animal studies	10^{-6}

nd - No RPHLs drafted to date
Note: Footnotes shown at end of table

Table 5.6 Health Risk Assessment for Organic Chemicals

Chemical Name	Uses	Synonyms and Trade Names	MCL	Draft RPHL[a]	Route of Exposure	Health Effects[b]	Risk[c]
Endrin[g]	Insecticide and rodenticide; registered only for control of cut worms, grasshoppers and moles	Syn: 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo-1,4-endo-5,8-dimethano-naphthalene	0.0002 mg/l	nd	Ingestion	*Increased heart and kidney weights in dogs*; decreased body weight in rats; not carcinogenic in four animal studies	-------
Ethylbenzene[d]	Solvent; used in the manufacture of styrene; dilutant for gasoline and insecticides	Syn: Ethylbenzol; phenylethane	0.680 mg/l (T&O thrshd= 0.029 mg/l)	0.680 mg/l	Ingestion Inhalation Dermal Absorption	*Increased liver and kidney weights in subchronic toxicity study on female rats*; liver, kidney, and CNS toxicant in animal studies; no chronic toxicity data available	-------
Ethylene dibromide[d]	Formerly used as a nematicide and a fumigant for soil, grain and fruit; currently used as a scavenger in leaded gasoline and aviation fuel	Syn: 1,2-Dibromoethane; EDB TN: Dowfume; Pestmaster	0.00002 mg/l (Limit of quantification)	0.00001 mg/l	Ingestion Inhalation Dermal Absorption	*Stomach, nasal, and lung tumors in rats and mice*; potent animal carcinogen; human reproductive toxin, causing reduced sperm counts in males; probable human carcinogen; mutagenic in short-term tests	10^{-6}
Glyphosate[d]	Herbicide; used for agricultural, recreational, road-side, and home applications	Syn: Isopropylamine salt of N-(phosphonomethyl)glycine TN: Roundup; Rodeo; Accord; Roundup L&G; Shackle; Shackle C; Cleanup	0.7 mg/l	0.7 mg/l	Ingestion	*Kidney toxicant in male rats*; not carcinogenic, mutagenic, or teratogenic	-------
Heptachlor[d]	Insecticide; formerly used for soil insects and termites; all use prohibited after April 1988	Syn: 1,4,5,6,7,8,8-Heptachloro-3a,4,7,7a-tetrahydro-4,7-methano-1H-indene TN: Aahepta; Agroceres; Basaklor; Drinox; E 3314; GPKh; Heptachlorane; Heptagran; Heptagranox; Heptamak; Heptamul; Heptasol; Heptox; Rhodiachlor; Soleptax; Velsicol 104	0.00001 mg/l	0.00001 mg/l	Ingestion Inhalation Dermal Absorption	*Liver tumors in rats and mice*; reproductive toxicant in rats; tumors at all sites in rats and mice; not a teratogen	10^{-6}
Heptachlor epoxide[d]	Degradation by-product of heptachlor, not commercially available	Syn: 1,4,5,6,7,8,8-Heptachloro-2,3-epoxy-3a,4,7,7a-tetrahydro-4,7-methanoindan; epoxyheptachlor; Velsicol 53-CS-17; ENT 25, 584	0.00001 mg/l	0.000007 mg/l	Ingestion Inhalation Dermal Absorption	*Liver tumors in rats and mice*; tumors at all sites in rats and mice; not a teratogen	10^{-6}

nd - No RPHLs drafted to date
Note: Footnotes shown at end of table

Table 5.6 Health Risk Assessment for Organic Chemicals

Chemical Name	Uses	Synonyms and Trade Names	MCL	Draft RPHL[a]	Route of Exposure	Health Effects[b]	Risk[c]
Lindane[g]	Insecticide; used in prescription shampoos for head lice; for elimination of fleas and lice on pets and farm animals	Syn: Gamma is isomer of 1,2,3,4,5,6-hexachoro-cyclohexane	0.004 mg/l	nd	Ingestion	*Liver, kidney, and other effects in rats*; liver tumors in two strains of mice	-------
Methoxychlor[g]	Insecticide; used in home and garden for insect control; used for fly control on domestic animals; for elimination of black fly larvae; and for control of Dutch Elm disease	Syn: 2,2-Bis(p-methoxyphenyl)1,1,1-trichloroethane	0.10 mg/l	nd	Ingestion	*MCL based upon a human study in which no adverse effects were observed at the doses given (the NOAEL)*; CNS effects observed in dogs; kidney effects including tubular degeneration in swine and rats, fatty changes in the liver in swine and marked testicular atrophy in rats and swine; not a carcinogen, mutagen or teratogen	-------
Molinate[d]	Herbicide; used for weed control in rice fields	Syn: S-ethyl hexahydro-1H-azepine-1-carbothioate TN: Ordram; Hudram; Yalan	0.02 mg/l	0.02 mg/l	Ingestion Inhalation Dermal Absorption	*Reproductive toxicant in male rats, inducing infertility and interfering with sperm production*; not a carcinogen, mutagen or teratogen	-------
Monochloro-benzene[d]	Solvent for degreasing and dry-cleaning; used in the manufacture of resins, dyes and perfumes; used in the synthesis of pesticides	Syn: Chlorobenzene; chlorobenzol; phenyl chloride; benzene chloride; benzene monochloride	0.030 mg/l (T&O thrshd= 0.003 mg/l)	0.030 mg/l	Ingestion Inhalation Dermal Absorption	*Abnormal growths in liver of male rats*; liver, kidney, respiratory system, and CNS toxicant in animal studies; no evidence of carcinogenicity	-------
Simazine[d]	Herbicide; selective preemergent herbicide for control of annual grasses and broadleaf weeds; nonselective herbicide for weed control in industrial areas, along highways and railway rights-of-ways	Syn: 2-Chloro-4,6-bis(ethylamino)-1,3,5-triazine; 2-chloro-4,6-bis-(ethylamino) S-triazine TN: Aquazine; Cekusan; Framed; G-27692; Gesatop; Primatol S; Princep; Simadex; Simanex; Tranzene	0.01 mg/l	nd	Ingestion Inhalation Dermal Absorption	*PMCL of 0.035 mg/l derived from thyroid and mammalian tumors in female rats*[i]; systemic toxicant; no suitable animal studies to determine carcinogenicity; farm animals appeared to be more sensitive to acute toxicity than laboratory animals	-------
1,1,2,2-Tetrachloroethane[d]	Solvent; used in production of TCE, pesticides, varnish and lacquers	Syn: Acetylene tetrachloride; sym-tetrachloroethane TN: Acetosal; Bonoform; Cellon; Westron	0.001 mg/l	0.001 mg/l	Ingestion Inhalation Dermal Absorption	*Body weight depression and changes in liver fat content in rats*; liver and CNS toxicant in humans; liver, kidney, CNS toxicant in animal studies; limited evidence of carcinogenicity	-------

nd - No RPHLs drafted to date
Note: Footnotes shown at end of table

Table 5.6 Health Risk Assessment for Organic Chemicals

Chemical Name	Uses	Synonyms and Trade Names	MCL	Draft RPHL[a]	Route of Exposure	Health Effects[b]	Risk[c]
Tetrachloroethylene[d]	Solvent in textile processing, dry-cleaning, and in metal degreasing	Syn: Perchloroethylene; PCE	0.005 mg/l	0.0007 mg/l	Ingestion Inhalation Dermal Absorption	*Liver cancer in mice and leukemia in rats*; some evidence in exposed human workers; no teratogenicity; possible fetotoxicity at high doses	2.5×10^{-6}
Thiobencarb[d]	Herbicide; used for weed control in rice fields	Syn: S-(4-chlorophenyl-methyl)diethylcarbamothioate; benthiocarb TN: Bolero; Saturn; Saturnio; IMC 3590; XE-362; Siacarb; Tamariz	0.07 mg/l (T&O thrshld = 0.001 mg/l)	0.07 mg/l	Ingestion Inhalation Dermal Absorption	*Toxic effects in rats and dogs:* decreased fertility and fetal survival in one rat study; not a carcinogen in three animal species; no observed teratogenic effects	-------
Toxaphene[a]	Broad spectrum insecticide; formerly used extensively on food and fiber crops, but current registered uses are limited	None	0.005 mg/l (T&O thrshld)	nd	Ingestion Inhalation	*MCL based on T&O threshold;* liver tumors in mice, thyroid tumors in rats; mutagenic in short-term tests; probable human carcinogen	7×10^{-3}
2,4,5-TP[a]	Herbicide; formerly used for weed control on pastures, commercial and home landscape, along canals and waterways, and in rights-of-ways	Syn: 2-(2,4,5-Trichlorophenoxy) propionic acid TN: Silvex	0.01 mg/l	nd	Ingestion	Changes in the liver and kidney at high doses, including organ to body weight ratios and other chronic adverse effects; inadequate evidence of carcinogenicity	-------
1,1,1-Trichloroethane[d]	Manufacture of food wrappings	Syn: 1,1,1-TCA; trichloroethane; TCA; methylchloroform; chloroethane; methyl-trichloromethane TN: Aerothene TT; Chlorotene; Chlorothane; Alpha-T; Inhibisol	0.200 mg/l	0.200 mg/l	Ingestion Inhalation Dermal Absorption	*Liver tumors in mice only*; depression of the CNS, increase in liver weight and cardiovascular changes in animals and humans; insufficient evidence of carcinogenicity	-------
1,1,2-Trichloroethane[d]	Solvent and a component of adhesives; major use is in manufacture of 1,1-DCE	Syn: 1,1,2-TCA; vinyl trichloride	0.032 mg/l	0.032 mg/l	Ingestion Inhalation Dermal Absorption	*Liver tumors in mice only*; no mutagenicity in animal studies; insufficient evidence of carcinogenicity	-------
Trichloroethylene[d]	Solvent; paint stripper; degreasing agent	Syn: TCE; 1,1-dichloro-2-chloroethtylene; acetylene trichloride; ethylene trichloride; trichloroethene TN: Tri-Clene; Dow-Tri; Germalgene; Westrosol	0.005 mg/l	0.0025 mg/l	Ingestion Inhalation Dermal Absorption	*Liver, lung and kidney tumors in two species (rats and mice)*; probable human carcinogen	10^{-6}

nd - No RPHLs drafted to date
Note: Footnotes shown at end of table

Table 5.6 Health Risk Assessment for Organic Chemicals

Chemical Name	Uses	Synonyms and Trade Names	MCL	Draft RPHL[a]	Route of Exposure	Health Effects[b]	Risk[c]
Trichlorofluoro-methane[d]	Aerosol propellant and a refrigerant; degreasing solvent; and blowing agent for plastic forms	Syn: Fluorocarbon 11 TN: Freon 11	0.15 mg/l	0.15 mg/l	Ingestion Inhalation Dermal Ab-sorption	*Sensitization of the heart in certain animal species at very high doses*, but not observed in human epidemio-logical studies; considered relatively inert and of low toxicity; no evidence of carcinogenicity in animal studies; not a mutagen in short-term studies	------
1,1,2-Trichloro-1,2,2-trifluoromethane[d]	Used in the dry-cleaning industry; as a refrigerant; for degreasing and drying applications; as a cutting fluid; and for removal of solder flux	Syn: Fluorocarbon 113, 1,1,2-trichlorotrifluoroethane; 1,2,2-trifluoro-1,1,2-trichloroethane; TTE TN: Freon 113; Aration 63; Ark-lone; Arklone P; F 113; FC 113; Forane 113; Freon 113 TR-T; Freon R 113; Frigen 113; Frigen 113 TR-T; Frigen 113A; Genetron 113; Halocarbon 113; Hostron Precision Solvent Cleaner; Isotron T Solvent; R-113; Refrigerant 113; Ucon; Ucon 113; Ucon Fluorocarbon 113	1.2 mg/l (T&O thrshld= 300 mg/l)	1.2 mg/l	Ingestion Inhalation Dermal Ab-sorption	*Sensitization of the heart in certain animal species at very high doses*, but not observed in human epidemio-logical studies; considered relatively inert and of low toxicity; no evidence of carcinogenicity in animal studies; not a mutagen in short-term studies	------
Vinyl chloride[d]	Used in the production of polyvinyl choride (PVC); a biodegredation by-product of TCE and PCE ground water contamination	Syn: Monochloroethylene; chloroethene	0.0005 mg/l (Limit of quantifica-tion)	0.000015 mg/l	Inhalation Ingestion Dermal Ab-sorption	*Cancer in male and female Osborne Mendel rats*; known human car-cinogen; results in a rare form of malignant liver tumor in animals and humans, and tumors at other sites in animals	$2.5x10^{-5}$
Xylene Isomers[d]: m-xylene p-xylene o-xylene	Solvents used in fuels, coatings, lacquers, enamels, cleaning agents, and resins; used in manufacture of dyes, insecti-cides, and pharmaceuticals	Syn: Dimethylbenzene; methyl-toluene; xylol; violet 3 TN: Agrisolv 50; Apco 467; Dilan; Ksylen; Socal Aquatic Solvent 3501; NCI-C55 232	1.750 mg/l (for single or sum of the isomers)	1.750 mg/l (for single or sum of the isomers)	Inhalation Ingestion Dermal Ab-sorption	*Dose-related mortality in male rats:* irritation of the skin and lungs, CNS and immunological effects, and liver and kidney damage due to acute and chronic exposure in humans and animals; developmental toxicant in rats and mice; no evidence of teratogenicity, mutagenicity, or carcinogenicity	------

nd - No RPHLs drafted to date
Note: Footnotes shown at end of table

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[a] Draft RPHLs developed for internal discussion as of February 14, 1991.
[b] Health effect endpoint for the determination of the California MCL is highlighted in italicized and underlined lettering.
[c] The theoretical risk of contracting cancer if exposed to a carcinogenic substance through drinking water at a concentration equal to the MCL, assuming exposure has continued over a 70 year lifetime and 2 liters of water were consumed each day.
[d] Health effects information obtained from CDHS PMCL document.
[e] Health effects information obtained from CDHS Proposition 65 document.
[f] Health effects information obtained from CDHS Notice of Proposed Rulemaking.
[g] Health effects information obtained from Federal Register, Nov 13, 1985.

[h] **1,3-Dichloropropene** - Synonyms: 1,3-D; cis-1,3-dichloropropylene; alpha-chloroallyl chloride; 1,3-dichloropropylene 3-(Z)-1,3-dichloropropene; 1,3-dichloropropene.
Trade names: Telone; Di-Trapex; D-D Super; D-D; Dowfume N; Vidden D; Telone II; Telone C-17; Vorlex; Fum-A-Cide 15-D; Fum-A-Cide 30-D; Bac-Fume D Soil Fumigant; Britz Brand Vidden D Soil Fumigant; Bee Bee D-D Soil Fumigant; Telonell Soil Fumigant; Terr-O-Gas 57/43 T; Terr-O-Cide 15-D; Terr-O-Cide 30-D; Vorlex; Nematicide D-D; D-D Soil Fumigant; Pic-Clor-60; Brom 70/30; Pic-Clor-30; Pic-Clor-35; Soilserv D-D soil Fumigant; John Taylor Chemicals Fumigant D; Tri-Con D; Union Telone II; Lesco D-C Fumigant 70-30; Lesco D-C Fumigant 85-15; Red Top D Soil Fumigant.

[i] **Di(2-ethylhexyl)pthalate** - Synonyms: DEHP; 1,2-benzenedicarboxylic acid bis(ethylhexyl) ester; bis(s-ethylexyl) 1,2-benzenedicarboxylate; bis(2-ethylhexyl) ester of phthalic acid; bis(2-ethylhexyl) phthalate; BEHP; di(2-ethylhexyl) ortho-phthalate; di(ethylhexyl) phthalate; dioctyl phthalate; DOP; ethylhesyl phthalate; 2-ethylhexyl phthalate; phthalate acid dioctyl ester.
Trade names: Bisoflex 81; Bisoflex DOP; Compound 889; DAF 68; Ergioplast FDO; Eviplast 80; Eviplast 81; Fleximel; Flexol DOP; Good-Rite GP 264; Hatcol DOP; Dodaflex DOP; Mollan O; Nuoplaz DOP; Octoil; Platinol AH; Platinol DOP; Pittsburg; PX-138; Reomol DOP; Reomol D 79P; Sicol 150; Staflex DOP; Vestinol AH; Vinicizer 80; Witicizer 312.

[j] **Simazine** - The US Food and Drug Administration (USFDA) has established a 0.01 mg/l tolerance level for combined concentrations of simazine and its degradation by-products in drinking water as a result of simazine application to aquatic weeds. An MCL of 0.01 mg/l was therefor promulgated in California to be consistent with the USFDA standard.

nd - No RPHLs drafted to date
Note: Footnotes shown at end of table

Table 5.7 Health Risk Assessment for Inorganic Chemicals

Chemical Name	Occurrence and Uses	MCL	Draft RPHL[a]	Route of Exposure	Health Effects	Risk[b]
Aluminum[c]	Occurs naturally; aluminum compounds used as coagulants during water treatment; extensively used world-wide in many fields and types of products; present in nearly all unprocessed foods, baking powder, food additives and antacids	1.0 mg/l	1. mg/l	Ingestion Inhalation	Short term: Effects to the gastrointestinal tract Long term: Phosphate depletion and osteomalatia; possible neurological effects	-------
Arsenic[d]	Occurs naturally as arsenic sulfide, arsenate (As^{3+}) and arsenite (As^{5+}); by-product of smelting of copper, lead and zinc ores; present in some coals and in foods	0.05 mg/l	nd	Ingestion	Long term: Arsenate (As^{3+}) causes skin disorders including skin cancer, hyperpigmentation and keratosis; tumors of the skin, lungs, genital organs and visual organs	$2x10^{-2}$
Barium[d]	Occurs naturally; present in coal, petroleum, natural gas and oil deposits, and is a combustion by-product of these compounds; used as a filler for automotive paints; used in bricks, tiles and jet fuels; present at high levels in some nuts	1.0 mg/l	nd	Ingestion	Long term: High blood pressure and nerve block	-------
Cadmium[d]	Occurs naturally in rocks, coal and petroleum; used in electroplating, nickel-cadmium batteries, paints and pigments and plastic stabilizers; present in cigarettes at high levels; present in most foods at low levels	0.010 mg/l	nd	Ingestion	Long term: High blood pressure; anemia; impaired kidney and liver function	-------
Chromium[d]	Occurs naturally; used in chrome plating and other metallurgical and chemical applications; present in fossil fuels and unprocessed foods	0.05 mg/l	nd	Ingestion	Long term: (Cr^{6+} only)- Liver and kidney damage; internal hemorrhage and respiratory disorders; ulceration of skin and dermatitis; Cr^{3+} is nutritionally beneficial, Cr^{6+} is not	-------

nd - No RPHLs drafted to date
Note: Footnotes shown at end of table

Table 5.7 Health Risk Assessment for Inorganic Chemicals

Chemical Name	Occurrence and Uses	MCL	Draft RPHL[a]	Route of Exposure	Health Effects	Risk[b]
Fluoride	Occurs naturally; added to some drinking water and dental care products for cavity prevention	1.4-2.4 mg/l depending on air temperature	nd	Ingestion	Long term: Ingestion of excessive amounts may cause permanent stained spots on teeth (mottling) in children under 7 undergoing enamel mineralization, dental fluorosis and skeletal fluorosis; ingestion of the optimum amount has the beneficial effect of reducing the occurrence of tooth decay	-------
Lead[d]	Occurs naturally; used for batteries, gasoline additives, pigments, ammunition, plumbing solder, cable coverings, caulking and bearings; present in unprocessed foods (levels may increase as a result of food processing); leaded gasoline	0.05 mg/l	nd	Ingestion Inhalation	Long term: Impaired functioning of the nervous system, kidneys and red blood cell formation; reduces oxygen absorbability of the blood; causes high blood pressure, low birth weights and premature births; even short term exposures can be toxic for infants and pregnant women	-------
Mercury[d]	Occurs naturally; used in electrical equipment (batteries, lamps, switches and rectifiers); used in thermometers; present in coal and unprocessed foods (primary source of exposure)	0.002 mg/l	0.002 mg/l	Ingestion Inhalation	Long term: Toxic to the CNS, characterized by mental disturbances, impaired coordination of bodily movements, disturbances in speech and hearing impairment; impaired kidney function; may cause birth defects	-------
Nitrate (as NO_3)[d]	Occurs naturally; present in many unprocessed foods (primary source of exposure); used to cure meats; a fertilizer	45 mg/l	nd	Ingestion	Short term: Causes methemoglobinemia in infants under three months of age (blue baby syndrome) and in dialysis patients by impairing the ability of the blood to carry oxygen to the body tissues	-------
Selenium[d]	Occurs naturally; commercially produced from copper ore; used for electronic and photocopy applications; glass manufacture, pigments, chemicals, pharmaceuticals, fungicides and as a livestock feed additive; present at low levels in unprocessed foods	0.01 mg/l	nd	Ingestion	Long term: Listlessness, dizziness, impaired ability to concentrate, hair loss, weakened nails and dermatitis; causes deformities in bird and livestock offspring; essential element at low doses	-------

nd - No RPHLs drafted to date
Note: Footnotes shown at end of table

Table 5.7 Health Risk Assessment for Inorganic Chemicals

Chemical Name	Occurrence and Uses	MCL	Draft RPHL[a]	Route of Exposure	Health Effects	Risk[b]
Silver[d]	Occurs naturally, though relatively rare; present in some meats; used in some granular activated carbon point-of-use water treatment units to prevent bacterial growth in carbon beds	0.05 mg/l	nd	Ingestion	Long term: Permanent blue-gray discoloration of the skin and internal organs, including the eyes	-------

[a] Proposed RPHL as of February 14, 1991.
[b] The theoretical risk of contracting cancer if exposed to a carcinogenic substance through drinking water at a concentration equal to the MCL, assuming exposure continues over a 70 year lifetime and 2 liters of water are consumed each day.
[c] Health effects information obtained from the CDHS PMCL document.
[d] Health effects information obtained from the Federal Register, Nov 13, 1985.

nd - No RPHLs drafted to date
Note: Footnotes shown at end of table

Table 5.8 Health Risk Assessment for Radiochemicals

Constituent	Occurrence	MCL	Route of Exposure	Health Effects	Risk[a]
NATURAL RADIOCHEMICALS					
Gross Alpha[b]	The general group of naturally occuring radioisotopes which are alpha particle emmitters; health effects are the result of the emmission of radiation as the radioactive isotopes decay	15 pCi/l (including Ra 226 but excluding radon and uranium)	Ingestion	Long term: Cancer	Unavailable
Combined Radium 226 & 228[b]	Occurs naturally; health effects are the result of the emmission of radiation as the radioactive isotopes decay	5 pCi/l	Ingestion	Long term: Bone and brain cancer; leukemia	$5x10^{-5}$
Uranium[c]	Occurs naturally; health effects are the result of the emmission of radiation as the radioactive isotopes decay	20 pCi/l	Ingestion Dermal Absorption	Long term: Kidney damage; no evidence of carcinogenicity when ingested	----------
MAN-MADE RADIOCHEMICALS					
Gross Beta[b]	Man-made radioisotopes produced by nuclear fission; health effects are the result of the emmission of radiation as the radioactive isotopes decay	50 pCi/l	Ingestion	Long term: Cancer	Unavailable
Tritium[b]	Man-made radioisotopes produced by nuclear fission; health effects are the result of the emmission of radiation as the radioactive isotopes decay	20,000 pCi/l	Ingestion	Long term: Cancer	Unavailable
Strontium-90[b]	Man-made radioisotopes produced by nuclear fission; health effects are the result of the emmission of radiation as the radioactive isotopes decay	8 pCi/l	Ingestion	Long term: Cancer	$1.3x10^{-5}$

[a] The theoretical risk of contracting cancer if exposed to a carcinogenic substance through drinking water at a concentration equal to the MCL, assuming exposure continues over a 70 year lifetime and 2 liters of water are consumed each day.
[b] Health effects information obtained from the Federal Register, September 30, 1986.
[c] Health effects information obtained from the CDHS PMCL document.

TABLE 5.9 Health Risk Assessment for Microbiological Contaminants

Constituent	Common Forms	MCL	Route of Exposure	Health Effects	Risk[a]
Bacteriological Contaminants	Non-pathogenic forms: Coliform, fecal coliform, *Escherichia coli*	Function of the number of samples required	Ingestion	The presence of these bacteria indicate that other disease-causing organisms may be present	10^{-4}
Virus	Rotavirus, Norwalk virus, echovirus	Treatment Technique	Ingestion Inhalation	A variety of illnesses including gastroenteritis; less common viruses can cause respiratory illnesses, meningitis, hepatitis and fever	10^{-4} [b]
Giardia	*Giardia lamblia*	Treatment Technique	Ingestion	Giardiasis: gastrointestinal disorders; onset of symptoms average 9 days after infection and can last up to 3 months or longer	10^{-4} [c]
Legionella	*Legionella pneumophila*	Treatment Technique	Inhalation	Legionellosis (Legionaire's Disease): pneumonia with severe gastrointestinal sypmtoms, fever, cough,lethargy, and disorientation; Pontiac Fever: fever, headache, muscle ache, malaise; no respiratory symptoms	10^{-4}
Heterotrophic Plate Count Bacteria (HPC)		Treatment Technique	Ingestion	Opportunist bacteria	10^{-4}

[a]The theoretical health risk of one case of microbiologically-caused illness per year per 10,000 people exposed to treated surface water.
[b]Assuming 99.99% removal of viruses by treatment
[c]Assuming 0.07 *Giardia* cysts per 100 liters of source water and 99.9% removal by treatment

Table 5.10 Health Risk Assessment for Disinfection By-Products: Trihalomethanes

Chemical Name	Occurrence	Synonyms	MCL	Route of Exposure	Health Effects	Risk[a]
Total Trihalomethane	Disinfection by-product	THM; TTHM	0.100 mg/l[e]	Ingestion Inhalation Dermal Absorption	(Refer to individual THM species below)	10^{-4}
THM SPECIES						
Chloroform[b]	By-product of chlorination	Syn: Trichloromethane	0.100 mg/l[e]	Ingestion Inhalation Dermal Absorption	Kidney and liver tumors in rats and mice; potential human carcinogen	$1.7x10^{-5}$
Bromodichloro-methane[c,d]	By-product of chlorination; formation is enhanced by pre-ozonation	Syn: Dichlorobromomethane, BDCM, DCBM	0.100 mg/l[e]	Ingestion Inhalation Dermal Absorption	Tumors of the large intestine and kidney in rats, and tumors in kidney and liver in mice; potential human carcinogen	$3x10^{-4}$
Dibromochloro-methane	By-product of chlorination; formation is enhanced by pre-ozonation	Syn: Chlorodibromomethane, CDBM, DBCM	0.100 mg/l[e]	Ingestion Inhalation Dermal Absorption	Liver and kidney damage in rats and mice; liver tumors in mice; not considered a carcinogen by USEPA	-----
Bromoform[d]	By-product of chlorination or ozonation when bromide is present	Syn: Tribromomethane, TBM	0.100 mg/l[e]	Ingestion Inhalation Dermal Absorption	Liver damage in male rats, kidney damage in female rats; liver damage in male mice; intestinal tumors in male and female rats	$2.5x10^{-5}$

[a]The theoretical risk of contracting cancer if exposed to a carcinogenic substance through drinking water at a concentration equal to the MCL, assuming exposure has continued over a 70 year lifetime and 2 liters of water were consumed each day.
[b]Health effects information obtained from Drinking Water and Health, Vol 7.
[c]Health effects information obtained from the Federal Register 40 CFR, September 30, 1986.
[d]Bull 1990.
[e]MCL is for any single or sum of the forms.

Table 5.11 Population Exposure Estimate to Determine Risk Benefits for Draft RPHLs[a]

			Population Removed from Exposure If RPHL Imposed, Broken out by System Size[b]			
Chemical Name	MCL	Draft RPHL	Large	Medium	Intermediate	Small
Benzene	0.001 mg/l	0.00035 mg/l	96,754	7,335	0	0
Chlordane	0.0001 mg/l	0.00003 mg/l	0	2,500	0	0
1,2-Dibromo-3-chloropropane (DBCP)	0.0002 mg/l	0.000002 mg/l	288,916	118,818	12,586	0
1,3-Dichloropropene	0.0005 mg/l	0.0002 mg/l	0	0	0	0
Ethylene dibromide (EDB)	0.00002 mg/l	0.00001 mg/l	3,979	0	180	0
Heptachlor epoxide	0.00001 mg/l	0.000007 mg/l	0	0	0	0
Tetrachloroethylene (PCE)	0.005 mg/l	0.0007 mg/l	1,067,600	163,990	10,620	59
Trichloroethylene (TCE)	0.005 mg/l	0.0025 mg/l	331,059	55,228	919	0
Vinyl chloride	0.0005 mg/l	0.000015 mg/l	0	0	0	0
Total			**1,788,308**	**347,871**	**24,305**	**59**

[a]a reduction in population exposed due to implementation of the proposed RPHLs will only occur for contaminants for which the proposed RPHL is less than the MCL.

[b]Service Connections: Large - >/= 10,000; Medium - 1,000 to 9,999; Intermediate - 200 to 999; Small 15 to 199.

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CHAPTER VI

WATER TREATMENT COST ESTIMATES FOR COMPLIANCE WITH RECOMMENDED PUBLIC HEALTH LEVELS

A. INTRODUCTION

This chapter provides an economic assessment for public water systems in the size range of 15 to 10,000 service connections, as required by Section 4022b(2)A, HSC. Based on these cost estimates, the Legislature may decide to extend RPHLs to include these water systems. This chapter will determine the cost of using treatment technology to meet RPHLs and recommend to the Legislature a course of action if RPHLs are imposed on water systems in the 15 to 10,000 service connection size range. Although treatment costs do not influence the levels at which RPHLs are set, the cost of treatment may not warrant extending the protection of RPHLs to systems with 15 to 10,000 service connections.

Water quality protection for the purpose of supplying a safe, wholesome, and potable supply of water relies on an set of laws and regulations to ensure the safety of the public water supply. The primary drinking water standards and future RPHLs are vital links in California's drinking water program. Unfortunately, the promulgation of many drinking water standards has come about after water quality studies have discovered the compounds in public drinking water supplies. Consequently, whenever a standard is exceeded, the source water must be treated or cleaned up before being distributed to the public.

Like drinking water standards, treatment technology should never be considered a viable alternative to the lack of a good source protection program. ODW realizes water treatment technology should never be used to compensate for failure to protect drinking water sources or to manage land-use. Good land-use management practice dictates using an efficient and effective watershed and ground water basin protection scheme. The application of such practices should extend beyond the simple manmade physical or political boundaries, (e.g., county or state lines), into regional protection schemes because recharge areas for ground and surface water supplies may be located remotely from the area of use. As our experience with hazardous waste sites has demonstrated, cleanup is a poor substitute for good resource management.

As the state's population increases, greater pressure will be placed on our watersheds making them more vulnerable to contamination from human activities as discussed in Chapter IV. If the use of watersheds is not carefully managed, a greater degree of reliance will be required of treatment technologies to ensure the safety of California's drinking water supplies.

Water resources are too valuable to waste through the indiscriminate or inadvertent pollution of a watershed or ground water basin. Using present technology, the flow of water within a watershed or ground water basin should be mapped so that land use planners may site disposal facilities and control industrial growth, with some degree of assurance that the threat of pollution to surrounding wells has been minimized. There is no excuse for indiscriminate disposal practices to continue when ground water basins and watersheds can be managed by utilizing techniques such as computer modelling to make resource management less of an art and more of a science, which is discussed later in Chapter IX. As stated previously, preventing the contamination of drinking water supplies should transcend economic and political boundaries because maintaining the quality of our drinking water supplies is a universal goal.

Okun (1991) points out that local, state, and regional officials as well as water purveyors need to realize that their responsibilities extend beyond supplying and meeting MCLs. Officials at all levels and in all offices must realize that the higher the water quality at the source, the higher the quality of the finished product. Therefore, the need to strike a balance between protecting a watershed or recharge area and water quality exists, but requires a scientific framework to clearly define the goals and requirements.

Indeed there is economic incentive to institute good watershed and ground water basin management practices. USEPA (1990) estimates the average annual expenditures in the early 1990s of $36 million will increase, by more than an order of magnitude, to $539 million by 1994 as the capital costs for meeting the 1986 federal SDWA amendments are implemented. USEPA estimates that this annual cost will continue to rise through the 1990s to reach annual high of $830 million before dropping to $500 million by the year 2000. While it is recognized that an unknown portion of these costs will be spent on capital replacement and expansion projects, good water resource and land-use management practices would have avoided some of them.

Primarily in response to ground water contamination problems, ODW will establish RPHLs for individual compounds that will apply to water systems with greater than 10,000 service connections. Setting RPHLs will only consider the adverse health effects and will not consider the cost of treatment to meet the standards. Since many MCLs (23 of 32) were set at levels that also meet the criteria for an RPHL, most of the proposed RPHLs will not be set at lower concentrations. When an MCL and RPHL are identical, enforcement of an MCL will take precedence over an RPHL because the MCL is an enforceable standard that all water systems are required to meet. Unlike RPHLs, water systems must comply with MCLs regardless of the economic impact. Whereas for water systems not in compliance with an RPHL, ODW must determine whether or not the addition of treatment is economically feasible for the utility. Again, had good land use planning and management practices been established (based on fundamental research) much earlier, the need for RPHLs may not exist or may be significantly lessened.

B. DISCUSSION

1. Scope and Limitations of Treatment Cost Estimates

In the past, ODW has received criticism for the way in which treatment cost estimates are produced. ODW conducts water quality or water treatment plant surveys to determine the need for treatment that would be established by a proposed standard. Once this need has been established, ODW looks at the way treatment would be applied. For the VOC MCLs, treatment was assumed to be applied at the wellhead, but new regulations, (e.g., the new lead/copper rule,) may require the use of treatment processes in the distribution system, making treatment cost estimating efforts more difficult. Therefore, in the case of VOCs centralized treatment was not considered a viable treatment option.

The accuracy of these treatment cost estimates depends on several factors. Just how accurate these cost figures are is a question that requires a statistical evaluation of the water quality and water system inventories. The accuracy of the cost estimates presented herein depend on the accuracy of the information contained in the water quality and water system databases.[17] Since the water quality data is used to determine compliance with RPHLs, the accuracy of the water quality database is critical to identifying those systems potentially out of compliance with the proposed RPHLs. Aside from the water quality data,

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[17]It is impossible to estimate the total error that may be incurred in these treatment cost estimates as a result of inaccurately or unreported data, but the error associated with the rounding the to the nearest hundred dollars is estimated to be at least 13%.

part of the water system inventory is missing water production, service connection, and population data.

Treatment costs are based on the size of the process unit, which is determined by the quantity of water to be treated. Lack of flow information means that water treatment units cannot be sized properly to meet the needs of a water source, making it possible to determine the number of sources potentially out of compliance with the RPHLs, but unable to determine treatment needs. Since sources without annual production, population served, or service connection information were not included in the cost estimates, the costs reported will underestimate the cost of treatment. Such problems could be avoided in the future by mandating the reporting of basic water system information through the water quality and monitoring regulations.

Similar data gaps of such basic information exist in the small water systems. Overall, the data on the small water systems, below 200 service connections, is scarce. Prior to 1990-1991, these systems were under the jurisdiction of LEHJ programs. As noted in Chapter VIII, many of these local programs did not have the capability or the capacity to provide detailed information to ODW on the small water systems program. The small water system database held by ODW probably contains 60% or less of all the small water systems in the state since the non-community water systems are not included in it (Wilson 1990). The database does contain non-community, non-transient; community; and state small water systems. While this limited database contains address data so that the system can be located or found, vital statistical information such as water production or population served is missing. Therefore, to facilitate the calculation of treatment costs, a population served and water production rate (350 persons served, 15 gallons per minute (gpm) per source) for the small water systems was assumed whenever a source was positive for a chemical. The estimated size and capacity was consistent with the statistical information used in the economic impacts of the small water systems during the preparation of MCL documents. This information was gathered by a random survey of small water systems in several counties.

As with the large water systems, the lack of small water system data reduces the accuracy of the treatment cost estimates. Whenever MCLs are set, ODW has looked at the range of costs to the water systems based on the system size, by using either service connection or population data. ODW is continually hampered by the lack of reporting from the smaller water utilities because the Department depends on the accuracy of the statistical data filled out in the annual reports for the development of the treatment cost estimates that are used in cost/benefit analyses.

The cost/benefit analysis, conducted as part of the regulation setting procedure, provides risk managers with the ability to optimize treatment cost and public health protection to achieve an economically viable balance. The lack of reporting may, in part, be due to poor record maintenance at the county level, but a portion of this is also due to incomplete or lack of information submitted to ODW by the systems themselves. The failure to supply ODW with vital information will result in skewed cost information. In the long run, the smaller water systems only hurt themselves by failing to accurately report such vital information because the economic impact of MCL regulations, as reviewed by ODW management, are based on the vital statistics submitted in the annual reports and entered into the water system inventory.

Other sources of error in the treatment cost estimate include the inability to distinguish between surface water and ground water production in the database. Typically, surface water sources produce more water than ground water sources. However, since there is no simple way to apportion production between the sources, cost estimates are based on the equal distribution of flow among the ground water and surface water sources in water systems using a combined source. While it is generally believed that surface sources could represent the majority of water produced in a system, there is no way of evaluating and confirming this without a careful detailed survey of each water system. Such a survey was beyond the scope and resources available to produce this report, and would not have been valuable without a complete response.

The economic impact of imposing RPHLs on systems serving between 15 and 10,000 service connections was determined by using existing water quality information to count the potential sources that *may* exceed RPHLs. Since the water quality data entry for this report was cut off as of September 30, 1989 and monitoring to determine compliance with the organic chemicals began in the first quarter of 1989, a complete year of data was not available for this report.[18] The information that was used was taken from ODW's large and small water system water quality database discussed in Chapter IV and IX.

Systems not in compliance with the Department's sampling and reporting regulations have also been excluded from these cost estimates because they have not provided any water quality data to ODW. These

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[18]The costs for TTHM RPHLs of 25, 50, and 100 µg/L are based on the third quarter running averages for 1989 and only for systems with more than 10,000 service connections.

omissions will further contribute to an underestimate of the costs of treatment to meet the proposed RPHLs.

There are also site specific costs that these cost estimates cannot anticipate without a more detailed study. Site specific costs include land, utility design and operating standards, and local regulatory requirements. For example, Air Quality Management Districts may require granular activated carbon (GAC) for aeration towers, thereby increasing the costs of treatment. Such site specific costs were not covered in this study.

a. BAT Designation

Formal designation of Best Available Treatment (BAT) will be done as part of RPHL regulation setting process after appropriate review and analysis of existing treatment technology. Since the determination of BAT requires the Department to consider technical efficacy and viability of the processes being considered for BAT, the treatment processes discussed herein are only recommended for use as BAT and should not be considered BAT until ODW evaluates the risks and benefits of their use.

Table 6.1 is a list of the compounds for which the first round of RPHLs may be proposed. The table also identifies the treatment processes which, for the purposes of this report will be considered BAT, and used in this cost assessment.

ODW requires the consideration of the costs and benefits of the treatment technology when determining BAT for an MCL. These considerations will also be required for RPHLs. In order to be complete, a risk and exposure assessment is required to determine the cost of mitigating or reducing exposure to the problem and the benefit, such as, prevention of theoretical cancer cases. A complete cost/benefit analysis should also include the social costs of an illness, (i.e., the medical costs of treating the illness, loss of work-time due to sick leave, and diminished productivity.) Only after a complete cost/benefit analysis is finished can the risk managers decide the level at which an MCL should be set. The exposure assessment needed to conduct a cost-benefit analysis was unavailable for this report. As such, a complete cost-benefit analysis could not be completed as part of this section. However, a cost-benefit analysis; for a single chemical, based on several theoretical systems, is included, as an example of how such an analysis can be accomplished.

Table 6.1 Recommended Treatment Technology for Meeting the Draft RPHLS[1]

Constituent	Recommended Treatment Process	Ref.
Inorganics		
Aluminum	TR[2]	
Barium	IX, Lime Softening, RO	USEPA 1989
Chromium	Coag./Filt., IX, RO, Lime Softening	USEPA 1989
Mercury	GAC, Coag./Filt., IX, RO (<10 mg/L, influent)	USEPA 1989
Nitrate (as NO_3)	IX, RO	USEPA 1989
Selenium	RO, Activated Alumina, Lime Softening, Coag./Filt.	USEPA 1989
Fluoride	Coag.	ASCE, AWWA 1990
Organics		
Lindane	GAC	USEPA 1989
Methoxychlor	GAC	USEPA 1989
Toxaphene	GAC	USEPA 1989
2,4,5-TP (Silvex)	GAC	USEPA 1989
Atrazine	GAC	USEPA 1989
Bentazon	GAC	
Benzene	GAC, PTA	USEPA 1985
Carbon Tetrachloride	GAC, PTA	USEPA 1985
Carbofuran	GAC	USEPA 1989
Chlordane	GAC	USEPA 1989
1,2-Dibromo-3-chloropropane	GAC, PTA	USEPA 1989
1,4-Dichlorobenzene	GAC, PTA	USEPA 1985
1,1-Dichloroethane	GAC, PTA	CDHS 1989
1,2-Dichloroethane	GAC, PTA	USEPA 1985
cis-1,2-Dichloroethylene	GAC, PTA	USEPA 1989
trans-1,2-Dichloroethylene	GAC, PTA	USEPA 1989
1,1- Dichloroethylene	GAC, PTA	USEPA 1987
1,2-Dichloropropane	GAC, PTA	USEPA 1989
1,3-Dichloropropene	GAC, PTA	
Di(2-ethylhexyl) phthalate	GAC	
Ethylbenzene	GAC, PTA	USEPA 1989
Ethylene Dibromide	GAC, PTA	USEPA 1989
Glyphosate	GAC	
Heptachlor	GAC	USEPA 1989
Heptachlor epoxide	GAC	USEPA 1989
Molinate	Chem. Oxid.	
Monochlorobenzene	GAC, PTA	USEPA 1989
Simazine	GAC	
1,1,2,2-Tetrachloroethane	PTA	
Tetrachloroethylene	GAC, PTA	USEPA 1989
Thiobencarb	Chem. Oxid.	
1,1,1-Trichloroethane	GAC, PTA	USEPA 1989
1,1,2-Trichloroethane	GAC, PTA	
Trichloroethylene	GAC, PTA	USEPA 1985
Trichlorofluoromethane	GAC, PTA	
1,1,2-Trichloro-1,2,2-Trifluoroethane	PTA	
Vinyl Chloride	PTA	USEPA 1987
Xylenes	GAC, PTA	USEPA 1989

[1] Underlined chemicals have a proposed RPHL that may be less than the MCL.

[2] Concentration controlled by the treatment process.

Aside from the risks associated with adverse health effects there are two other risks that should be considered in any risk management analysis: (1) the potential costs and consequences of not implementing a good resource management program, and (2) the risk of failure of a treatment process. Both risk concepts could be incorporated into a "fault-tree" type of analysis to determine the risks associated with different regulatory decisions.

Some consideration should be given to the inherent risk associated with using a treatment process to meet RPHLs, (i.e., process variability produced under normal circumstances by the daily, weekly, monthly, yearly, or seasonal variations challenging the process.) This additional risk will in all likelihood increase the risk of an adverse outcome to the population exposed. However, a great deal of study needs to be completed before such an analysis may become feasible.

b. Special Water Quality Concerns

Finally, this report will not cover the treatment costs for any proposed MCL as the proposed MCL may change prior to adoption. Beyond the proposed RPHLs there were three additional areas of concern that this chapter addresses: (1) the pending federal and state primary drinking water standards for THMs, which will probably be regulated by the rule disinfection by-products sometime in 1995, (2) radon, which will be proposed in June 1991, and (3) the lead/copper rule, which was finalized on May 7, 1991. ODW does not have a sufficient quantity of water quality information on which to base the potential economic impact associated with these three concerns. However, this only makes cost estimating difficult, not impossible. Using appropriate assumptions, reasonable water treatment cost estimates can be projected for these pending regulations, and are detailed in the sections that follow.

2. MCL Cost Summary

ODW's cost projections completed for MCL regulations will only be summarized briefly because the focus of this economic impact assessment will be on systems that *may exceed* the proposed RPHLs. It should be understood that whenever an RPHL is less than an MCL, additional costs for meeting RPHLs may only add a small increment to whatever costs are incurred for MCL compliance. However, because the cost of meeting the MCLs will, in all cases, be borne by the water utility.

Cost estimates for compliance with the primary drinking water standards MCLs have already been detailed in the regulation packages prepared for the promulgation of these standards (CDHS 1988a-i;1989). The estimated one-time capital treatment costs to meet the "new" VOC MCLs promulgated in 1988 and 1989 is $51 million with average annual operating and maintenance and monitoring costs of $3.1 million. Since monitoring to determine compliance with these VOC MCLs has not yet been completed, systems which are not in compliance with the VOC MCLs have not been identified, and the validity of the state's cost estimates has not been tested.

However, in addition to the cost of meeting the primary drinking water standards in California, a report entitled "Economic Impact of Granular Activated Carbon Treatment for California Water Suppliers" was prepared (James M. Montgomery 1987) in order to determine the potential impact of Assembly Bill 859.[19] JMM estimated the cost of requiring the installation of GAC as BAT for surface waters and ground waters to be $8.4 billion for construction and $1.4 billion/yr for amortized capital construction costs plus operation and maintenance. In addition to the chemical MCLs, the economic impact of California's implementation of SWTR, for the control of waterborne pathogens, has been estimated by ODW to be $448.6 million in one-time capital equipment costs and $46.9 million in operation and maintenance (O&M) costs. Amortizing SWTR capital equipment costs over 25 years at a discount rate of 7% and adding to the annual operation and maintenance costs results in an annual cost of $85.4 million to meet the new SWTR.

3. Concept of Best Available Technology

An amendment to California SDWA (Section 4023.2 HSC) states that:

> "On or before January 1, 1992, the department shall propose, hold a public hearing, and promulgate a finding of the best available technology for each contaminant for which a recommended public health level and a primary drinking water standard have been adopted. Thereafter, the department shall promulgate a finding of best available technology for each contaminant for which a recommended public health level and a primary drinking water standard have been adopted. ... The finding of the department shall take into consideration the costs and benefits of best available treatment technology that have been proven effective under full-scale field applications."

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[19]AB 859 was one of the forerunners to AB 21 and included the RPHL requirement; AB 859 never became law.

The reason for specifying BAT for removing contaminants for which there are proposed RPHLs is that the California SDWA now requires any water system with greater than 10,000 service connections and that exceeds an RPHL (based on a running quarterly average, probably four quarters of sampling) to submit a water quality improvement plan (WQIP) to the Department which will:

> "... evaluate in writing all reasonable means of reducing the level of the contaminant to as close to the recommended public health level as feasible, and submit the written evaluation to the department at least once annually.
>
> The water quality improvement plan shall identify all reasonable measures available to the water system to reduce the level of the contaminant, the costs to consumers and the water systems implementing the measures, ...
>
> The department shall review the water quality improvement plan and may approve it as submitted or may require additional information from the water system."

In any case, a plan of operation (e.g., WQIP) should be required in order to assure ODW that some remediation is taking place, and that the application of BAT treatment has been considered. The intent of Section 4023.2, HSC is to require ODW to determine BAT for each of the specific compounds or elements to be regulated so that BAT can be identified and costed out by the water utilities in their WQIPs. In order to proceed, ODW must also decide on the criteria or principles that will be used to determine which treatment processes or operational practices can be construed as BAT.

Some may argue that, in reality, it may be difficult to set specific criteria on which to determine BAT and that by listing specific treatment processes, the Department will discourage the development of innovative and alternative technologies. ODW can and should, in order to facilitate the development of alternative treatment technology, develop criteria under which new technologies can be evaluated and designated BAT. The need to develop new technology will not be abated by the designation of BAT, as both ODW and the American Water Works Association (AWWA) strongly endorse the use of BAT in setting drinking water standards. AWWA has reinforced their views on this issue as noted by the following excerpt from a recent position statement (AWWA 1990):

> "AWWA strongly endorses the use of best available technology (BAT) in setting drinking water standards, provided such technology has been proven effective under full-scale field application and cost is weighed versus benefits derived."

AWWA points out a very important principle that should be followed when identifying BAT, that is the process must be "proven effective under full-scale field application." The processes identified in this report have been designated "recommended treatment processes" to facilitate the development of treatment cost estimates with the understanding that, if RPHLs were to be proposed today, the processes identified herein for specific chemicals, may, in all likelihood, be considered BAT. However, treatment technologies may change to such an extent that by the time RPHL regulations are finally proposed and/or finalized, new treatment processes may be classified as BAT at that time.

Since RPHLs, for which a BAT is designated, are only based on health considerations, RPHLs can be lower than the limit of detection. This means that a BAT will be specified because the California SDWA requires the utilities to do everything possible to meet RPHLs even though RPHLs may be lower than the analytical limits of detection. Since compliance with RPHLs, requires a utility to do all that is feasible to meet the RPHL, ODW will find it necessary to set up operational parameters to determine how a treatment process will be operated in order to comply with the amendment provisions of the California SDWA.

BAT determination should, as part of the cost-benefit analysis, identify a treatment process that can *reliably* meet RPHLs or MCLs. Proposing an MCL or RPHL without also identifying a reliable treatment process will provide a false sense of security to those employing treatment that the water is safe. The need to demonstrate reliability means undertaking a research program or conducting studies, such as those conducted on wastewater treatment plant unit operations, Culp/Wesner/Culp (1979) looked at existing plants to determine how well each unit process was operated. This would not only provide the regulators and legislators with a measure of how effective the drinking water regulations are, but would give regulators reliability standards on which to base and/or judge equivalency for alternative treatment technologies.

Under process reliability there are two areas that need to be addressed. First, regulatory agencies and water utilities need a better understanding of how frequently public health threats to the water supply are encountered. This should address questions such as: Are the water treatment plants constantly under challenge by the threat or is there some frequency of an event that the plants should be designed for? This requires some knowledge of the water quality, the frequency of contamination events, and how contamination might vary with time and location. Our inability to answer these questions points out the need for extensive water quality studies prior to regulation setting so that questions of risk can be addressed.

Secondly, reliability studies should be developed so that alternative treatment technologies can be substituted, as long as they meet the same degree of performance reliability as the process identified as BAT. This means not only conducting reliability studies, but also acquiring some knowledge of why certain processes have been accepted as BAT.

A reliability study requires more than collecting a few data points to show that a process can achieve 95% removal of some constituent. Such a study must also show that a process can function to produce consistent removals over extended periods of time. Turbidity is a good example of a water quality parameter that is used as a surrogate to measure reliability of a treatment process. Under the new SWTR, filtration plants must not exceed a turbidity of 0.5 nephelometric turbidity units (NTU) 95% of the time, which in reality means they are actually meeting a much lower average turbidity. Applying water quality measurements in this manner ensures water quality with a greater degree of assurance than a simple arithmetic average because, in contrast to an average, that is being met 50% of the time, the turbidity standard is being met 95% of the time. In fact, by conducting reliability studies it may be discovered that utilities could decrease their operating costs by finding new ways to optimize plant performance.

If a treatment process cannot reliably meet performance standards, it should not be listed as BAT or even as BAT generally available. Specifying a treatment process as BAT may give the public the impression that the water will meet drinking water standards all of the time. In fact, depending on the reliability and how compliance is determined, based on an arithmetic average, a source water may, 50% of the time exceed an MCL.

The problem of defining process reliability can be accomplished, in part, by examining well operated water treatment plants. For example, the USEPA (1989) has a Composite Correction Program (CCP) and Comprehensive Performance Evaluation (CPE) Program to evaluate filtration plant performance. The purpose of CCP and CPE program was to identify treatment systems that were operating properly and document their practices. The next step was to identify systems that were not functioning properly and attempt to apply the practices used at the well operated plants to these systems. The final step was to then determine if the corrections made and programs initiated were successful in improving plant operation. USEPA hopes that by improving system operation, the compliance rates would improve and an overall cost savings in O&M costs could be obtained without sacrificing the overall efficiency of plant operation.

CCP and CPE program makes it sound easy to modify treatment processes to improve process performance, but modifying plant operation does not guarantee that the process is being run efficiently or properly. For example, reverse osmosis, can be modified to change performance by regulating the operating pressure and the rejection rate. However, by changing the operating conditions, the economics of treatment are also altered. By changing process parameters, the concentration of the brine in the rejection stream can be raised or lowered to effect a better or poorer removal of dissolved solids. Similar effects can be affected by changing the gas-to-liquid ratio on a packed tower aerator or air stripper. In order for ODW to determine when a utility has done all that is feasible to comply with and meet RPHLs, specific operational criteria needs to be developed.

It is important to consider the ramifications of specifying a reliable treatment process and an MCL or RPHL. By specifying a technology as BAT, the implication can be drawn that there is technology available to control public exposure to the contaminant(s) of concern. For every RPHL or MCL, a BAT should be specified. Without treatment, setting an RPHL or MCL becomes an exercise in futility because without BAT there is no solution to the problem of contamination short of shutting down the supply. Without specifying some means of mitigating the problem, there will be violations of MCLs or RPHLs, and the water utilities will be left without means of controlling the problem, short of removing water source(s) from service.

4. Treatment Cost Estimates

Since different treatment processes could be selected for meeting proposed RPHL there is a range of values for the total capital and total annual treatment costs. Within the framework of these cost estimates, it was not possible to identify the specific treatment process that would be best suited for an individual utility. Such a determination must be made by the water system, after careful study, on a case-by-case basis.

The summary of the treatment cost estimates is presented as a range of values in which the least costly alternatives are summed to give the lowest value and the most costly alternatives are used to establish the high end of the range. Due to an economy of scale, one treatment process may not be the least cost alternative for the entire range of flows considered, there may in fact, be more than two processes that could be the least or most costly alternatives over the range of flows considered. However, for each flow category only one treatment process will be the lowest or highest cost alternative.

Treatment costs were based on an average flow rate from a given source. The average flow rate was obtained by dividing the water system's annual production by the number of sources in the system. In reality, a well may be pumped at a greater flow rate for a shorter period of time and the water stored in order to meet periods of peak demands. Selleck and Diyamandoglu (1986) point out that, on the average, wells may operate for only 30% of the time, allowing time for routine maintenance and to meet periods of peak demand.

As noted earlier, there is a lack of flow information for the small water systems. The Department does not have a small water system inventory with annual production data, therefore treatment costs were estimated by assuming a 0.022 million gallons per day (MGD) (15 gpm) flow rate for small water systems, and is consistent with the treatment cost estimates presented in the MCL regulation package for PCE (CDHS 1988b).

Treatment cost estimates were based on wellhead or individual source treatment. If a well or source was found to be contaminated, treatment costs were generated for that source. This means that centralized treatment in a well field was assumed to be not feasible. While this may not always be the case, in most cases this will be true and represents a worst-case scenario (i.e., an overestimation of the treatment costs).

All treatment costs cover construction and O&M for plants ranging in size from 2,500 gallons per day (gpd) to 200 MGD and were taken from Gumerman et al. (1979a; 1979b). The October 1978 costs reported by Gumerman et al. (1979a; 1979b) were updated to January 1990 dollars by using the Engineering News Record cost indices. Due to assumptions made in developing these treatment costs, it was felt that providing each treatment process, with thirteen flow categories (0.0025, 0.025, 0.05, 0.1, 0.25, 0.5, 1.0, 2.5, 5.0, 10, 50, 100, 200 MGD), for which one-time capital and annual O&M costs could be developed, would be adequate. All capital equipment costs were amortized over 20 years at 10%.

a. Treatment Costs to Meet the Proposed RPHLs

The following treatment cost summary was designed to address one of the requirements setforth by the Legislature in the California SDWA Amendments of 1989 (Section 4022b(2)A), HSC. The Legislature asked the Department to estimate the economic impact of imposing RPHLs on water systems with 15 to 10,000 service connections.

Costs for water systems with greater than 15 service connections including those systems with more than 10,000 service connections, are shown in Table 6.2. The total capital equipment costs estimated to treat the 853 sources potentially out of compliance with RPHLs and MCLs will range from $89 million to $270 million. The wide range in costs is due to the disparity between treatment techniques for the individual compounds, (i.e., no single treatment process will be applicable for meeting every need.) Overall, at least six different treatment techniques for inorganic chemicals and three techniques for organic chemicals were considered viable treatment processes for the purposes of these treatment cost estimates.

Summing the amortized capital equipment with annual O&M cost, for systems with more than 15 service connections that exceed the RPHLs and MCLs, results in a range of total annual treatment costs of $110 to $160 million. According to the data on the population served by these systems, over 15.5 million people in the state will be impacted. If the cost of treatment is evenly distributed over this population, the average increase in the annual water bill would be on the order of $7 to $10 per capita per year. For the average household, with 3.9 persons per service connection,[20] the annual bill will increase by $28 to $39 per household per year. This figure may be misleading because of the large population base over which these treatment costs are distributed. If the population base and treatment costs are restricted to systems with 15 to 10,000 service connections, a much more interesting finding results.

As shown in Table 6.3, there are 454 sources in water systems with 15 to 10,000 service connections. The total capital equipment costs to treat to meet the proposed RPHLs and MCLs would range from $47 to $96 million. Total annual costs to meet the proposed water quality standards would be $85 to $97 million, and affect 2.3 million people. Translating the total annual costs into a per capita increase in water bills shows an increase of $37 to $42 per year. Assuming that there are 3.9 persons per service connection means that an average household in these systems would increase by $145 to $164 per year. It is apparent from these calculations that the cost of water treatment to the individual consumers would be most heavily borne by consumers using the water systems in

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[20] This is consistent with the population per service connection number used in Chapter VII and was taken from the water system survey referenced in that Chapter.

the 15 to 10,000 service connection range. However, the customers in these systems will be required to meet MCLs.

Table 6.2 Water Treatment Costs for Systems with Greater than 15 Service Connections Whose Drinking Water Quality May Exceed the Draft RPHLs

Constituent	No. Sources Exceeding Proposed RPHL	Total Capital Equipment Costs ($)	Total Annual Treatment Costs ($/yr)
Inorganics			
Chromium	1	$21,500-88,800	$11,000-31,200
Nitrate	53	$9,456,200-39,151,200	$2,415,800-11,339,500
Selenium	1	$156,300-688,700	$38,500-198,600
Fluoride	19	$22,672,700	$93,871,400
Organics			
Toxaphene[a]	1	$86,300	$25,000
Benzene	4	$326,000	$92,000
Carbon Tetrachloride	29	$1,598,200-8,205,300	$257,500-1,591,600
1,2-Dibromo-3-chloropropane	327	$25,942,000-37,665,200	$6,871,800-9,788,400
1,1-Dichloroethane	5	$180,600-703,800	$33,600-205,200
1,2-Dichloroethane	23	$1,229,700-12,341,600	$197,300-$1,968,300
cis-1,2-Dichloroethylene	2	$61,400	$11,300
trans-1,2-Dichloroethylene	1	$86,300	$25,000
1,1- Dichloroethylene	5	$448,000-971,200	$132,300-303,900
1,2-Dichloropropane	2	$61,400	$11,300
Ethylene Dibromide	11	$478,000-1,524,300	$104,000-447,400
1,1,2,2-Tetrachloroethane	1	$178,100	$15,000
Tetrachloroethylene	254	$18,128,000-76,656,700	$4,043,400-23,528,400
Trichloroethylene	114	$7,895,300-70,957,400	$1,544,500-12,446,200

[a]Underlined compound names indicate those compounds whose proposed RPHL is less than the present MCL.

The cost figures presented previously can be misleading because many RPHLs are equivalent to MCLs. In those cases where an RPHL is equal to an MCL, treatment costs will be incurred in all water treatment systems that are not in compliance with an MCL. Assuming that all systems with chemical contaminants that presently exceed MCLs will also not be in compliance with RPHLs, the treatment costs for these systems should be subtracted from the treatment costs. This will provide a better representation of the economic impact of applying treatment to comply with RPHLs when an RPHL is lower than an MCL, which occurs for only 10 compounds in this discussion.

Once the treatment costs for meeting MCL requirements is removed from the treatment cost estimates, the revised cost figures decrease dramatically. These revised figures represent the cost estimates for meeting the proposed RPHLs in systems with 15 to 10,000 service connections. For these systems, the capital equipment costs drop from a range of $47 to $96 million to $15 to $29 million and the total annual costs fall from a range of $85 to $97 million to $3.6 to $7.1 million. Assuming the treatment costs would affect all of the individual homeowners in the 15 to 10,000 service connection systems equally, the annual water bill in these systems is projected to increase by as much as $10 to $20 per household per year if RPHLs are extended to these systems. However, the benefit of extending RPHLs to systems in this size category means extending the extra protection offered by RPHLs to more people, specifically the estimated 350,000 people, exposed to contaminants above the proposed RPHLs Chapter V.

Similar reductions in the treatment costs were obtained for water systems with greater than 10,000 service connections (Table 6.4) when the potential MCL violations were removed from the list. The total capital equipment costs ranged from $19.2 to $42.6 million with total annual costs ranging from $4.9 to $18.6 million. While the total annual costs for systems with greater than 10,000 service connections overlaps the total annual costs for systems with 15-10,000 service connections, the annual water bills for systems with greater than 10,000 service connections will not increase dramatically. Systems with grater than 10,000 service connections have a larger population base over which the treatment costs will be spread.

Table 6.3 Water Treatment Costs for Systems with 15 to 10,000 Service Connections to Meet the Draft RPHLs.

Constituent	No. of Sources Exceeding Proposed RPHL	Total Capital Equipment Costs ($)	Total Annual Treatment Costs ($/yr)
Inorganics			
Nitrate	27	$4,263,900-15,699,700	$1,074,100-4,569,300
Fluoride	13	$18,553,500	$78,305,800
Organics			
Toxaphene[a]	1	$86,300	$25,000
Benzene	4	$326,000	$92,000
Carbon Tetrachloride	14	$541,300-1,965,300	$99,900-481,900
1,2-Dibromo-3-chloropropane	210	$12,731,100-17,427,600	$3,280,600-3,949,600
1,1-Dichloroethane	4	$147,900	$30,000
1,2-Dichloroethane	20	$1,026,700-11,156,300	$153,500-1,819,800
cis-1,2-Dichloroethylene	2	$61,400	$11,300
trans-1,2-Dichloroethylene	1	$86,300	$25,000
1,1- Dichloroethylene	1	$30,700	$5,700
1,2-Dichloropropane	2	$61,400	$11,300
Ethylene Dibromide	10	$422,300-1,468,600	$91,000-434,400
1,1,2,2-Tetrachloroethane	1	$178,100	$15,000
Tetrachloroethylene	102	$5,746,600-19,029,200	$1,405,500-4,674,800
Trichloroethylene	42	$2,867,800-9,413,100	$737,000-2,013,600

[a] Underlined compound names indicate those compounds whose proposed RPHL is less than the present MCL.

Table 6.4 Water Treatment Costs for all Systems with Greater than 10,000 Service Connections to Meet the Draft RPHLs.

Constituent	No. of Sources Exceeding Proposed RPHL	Total Capital Equipment Costs ($)	Total Annual Treatment Costs ($/yr)
Inorganics			
Chromium	1	$221,500-88,800	$11,000-31,200
Nitrate	26	$5,192,300-23,451,500	$1,341,700-6,770,200
Selenium	1	$156,300-688,700	$38,500-198,600
Fluoride	6	$4,119,200	$15,565,600
Organics			
Carbon Tetrachloride	15	$1,056,900-6,240,000	$157,600-1,109,700
1,2-Dibromo-3-chloropropane[a]	117	$13,210,900-20,237,600	$3,591,200-5,838,800
1,1-Dichloroethane	1	$32,700-555,900	$3,600-175,200
1,2-Dichloroethane	3	$203,000-1,185,300	$43,800-148,800
1,1- Dichloroethylene	4	$417,300-940,500	$126,600-298,200
Ethylene Dibromide	1	$55,700	$13,000
Tetrachloroethylene	152	$12,381,400-57,627,500	$2,637,900-18,853,600
Trichloroethylene	72	$5,027,500-61,544,300	$807,500-10,432,600

[a]Underlined compound names indicate those compounds whose proposed RPHL is less than the present MCL.

As an example of the "economy of scale," annual treatment cost estimates were determined for four typical community water systems, assuming that only one source required treatment. Results are summarized in Table 6.5 and vital statistics, for the four systems may be found in Appendix 2. In the small water system the total annual cost for reverse osmosis will be $14,600 per year. Spreading this cost over 100 service connections would result in an annual increase in the water bill of $150. As the size of the system increases to an intermediate size the annual cost of reverse osmosis increases to $62,400, but the number of service connections over which the cost is spread increases to 488. The resulting annual water bill would increase by $130, which could still be a substantial increase to the individual homeowner, but is 14% lower than the increase that could be incurred by the homeowner in the small system. Similar results illustrating the "economy of scale" are obtained for medium and large water systems using the data. The annual cost of reverse osmosis to the homeowners in these respective systems is $57 and $11 per year, both of which are substantially less than the costs experienced in the small and intermediate water systems. This cost trend and economy of scale also applies to other treatment technologies.

While the costs of treating water to meet RPHLs in the 15 to 10,000 service connection range does not appear to have a significant fiscal impact on utilities in this size range, the economy of scale in the smaller water systems plays an important role in the decision to extend the RPHLs to the smaller systems. The cost to the individual household was estimated for small (<200 service connections), intermediate (200 to 1000 service connections), medium (1,000 to 10,000 service connections), and large (>10,000 service connections) water systems. Total system flow was estimated using the average population and assuming an average consumer consumption of 125 or 150 gallons per capita per day (gpcd). The total system flow was then divided by the average number of sources to determine the production per source. The range of annual treatment costs on a per service connection basis is presented in Table 6.6, and illustrated in Figure 6.1, and 6.2 for the organic and inorganic, respectively.

Medium and smaller size water systems serve fewer people, consequently relying on a smaller revenue base. There is no question that many small water systems will have a difficult time meeting the present drinking water standards and monitoring requirements. Aside from being able to raise the capital for meeting treatment requirements, the question of supporting personnel with the technical capability to operate and maintain a centralized water treatment plant will invariably be raised. While this may point out the need for a circuit rider program or "good neighbor" type of program with a nearby large water system, as discussed in Chapter X, it does not address the larger question of whether or not the public in these water systems, given the choice, would want the extra protection afforded by RPHLs.

5. Point-of-Use and Point-Of-Entry

One proposed solution to the cost impact brought about by the economy-of-scale problem created by centralized treatment in small water systems, is to use of point-of-use (POU) or point-of-entry (POE) treatment devices. As the terminology might indicate, POU devices do not treat all the water entering a building or structure in which it is to be used. Such devices commonly are placed on a faucet or below a sink to treat only the water that is drawn from that "point of use." POE devices, in contrast, treat all the water entering a building, which means that all water used inside or "entering" the building or structure is treated to meet drinking water standards.

Table 6.5 Annual Treatment Costs for Four "Typical" Community Water Systems

	Number of Service Connections			
	<200 (small)	200-<1000 (intermediate)	1000-<10,000 (medium)	≥10,000 (Large)
Organics Removal				
Granular Activated Carbon ($/yr)	$5,700	$13,000	$40,900	$175,200
Air Stripping ($/yr)	nr[a]	nr	nr	$7,250
Chem Oxid ($/yr)	$9,200	$9,700	$15,800	$18,700
Inorganics Removal				
Ion Exchange ($/yr)	nr	$25,700	$40,900	$68,000
Reverse Osmosis ($/yr)	$14,600	$62,400	$198,600	$368,900
Coag/Filt ($/yr)	$33,500	$35,200	$90,900	$3,099,800
Lime Softening ($/yr)	nr	nr	nr	$57,700
Activated Alumina ($/yr)	$21,900	$30,700	$38,600	$61,700
Granular Activated Carbon ($/yr)	$5,700	$13,000	$41,000	$58,100
Disinfection	$6700	$7200	$11,100	$11,200

[a]Not recommended for use at this flow.

Table 6.6 Treatment Cost Estimates ($/service connection/yr) for Meeting the Draft RPHLs in Very Small, Small, Intermediate, Medium, and Large Water Systems When One Source is not in Compliance.

	Very Small	Small	Intermediate	Medium	Large
Organics	$380.00-613.33	$57.00-92.00	$19.88-26.64	$4.52-11.69	$0.22-5.23
Inorganics	$380.00-2233.33	$57.00-335.00	$26.64-127.87	$11.03-56.76	$1.72-92.51

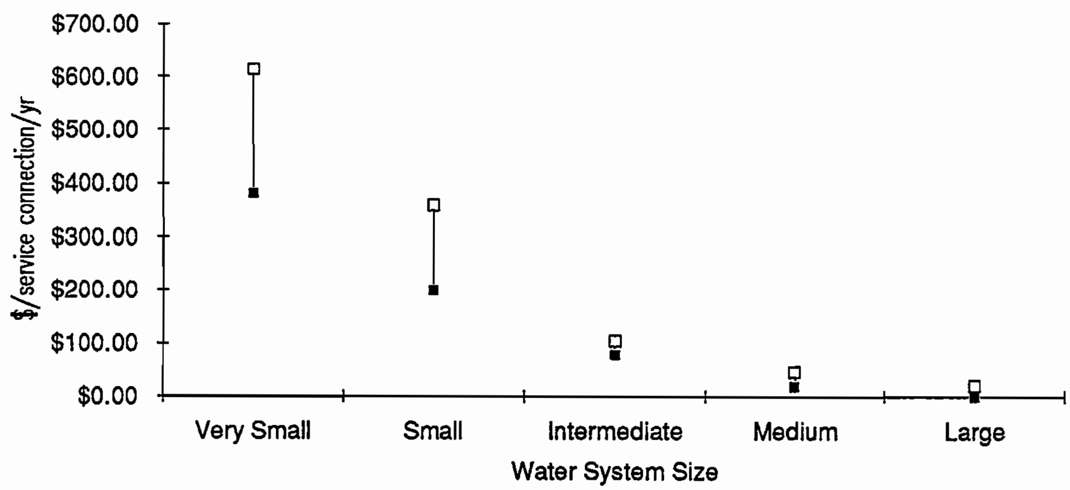

Figure 6.1. Range of Estimated Treatment Costs to Meet an Organic MCL or RPHL for a "Typical" System.

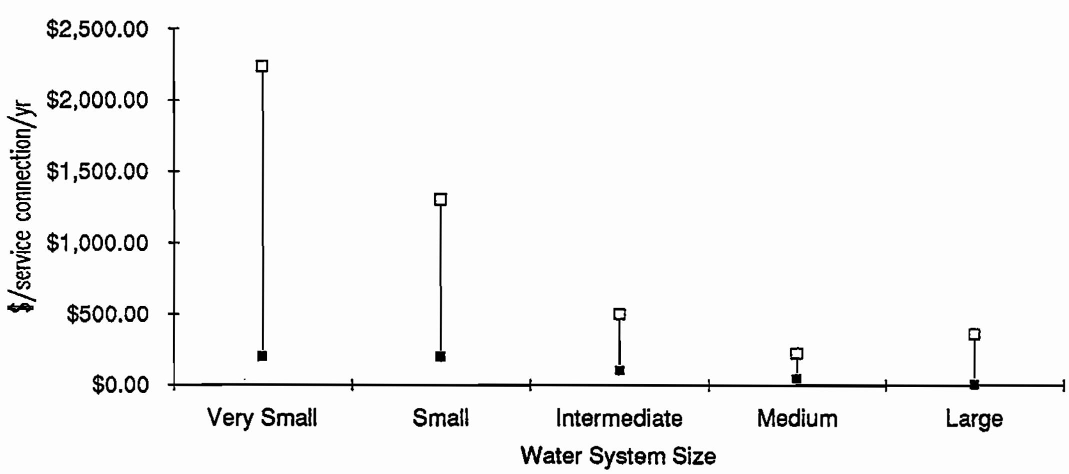

Figure 6.2. Range of Estimated Treatment Costs to Meet an Inorganic MCL or RPHL in "Typical" System.

The most common types of POU/POE devices noted by Chambers and Janszen (1990) were aeration and GAC for VOCs, reverse osmosis and deionization for inorganic chemicals, and ceramic filters or ultra violet disinfection for microbial contaminants. They found that most POU/POE devices used at the superfund sites were for organics removal and the most common devices were GAC or aeration systems.

Since these devices can be used within or prior to individual homes, they represent an economically feasible alternative to centralized treatment for small water systems. USEPA has recognized the use of POU/POE devices as an alternative to centralized treatment, for the removal of VOCs under certain conditions. USEPA has made it contingent upon the states to determine when the use of POU/POE is applicable, and first setforth a general set of requirements in the Federal Register in their November 13, 1985 proposed rule for synthetic volatile organics. Presently, it is not the lack of technology that is preventing the use of POU/POE devices, but the lack of data which demonstrates the viability of such alternatives.

Mayer (1986) outlined some of the concerns surrounding the use of POU/POE devices that must be addressed before the state can accept the devices as alternatives to centralized treatment. In fact, the concerns outlined by Mayer are almost identical to the 1985 requirements laid out by USEPA that allowed states to approve the use of POU/POE devices. Unfortunately, many of these requirements have yet to be demonstrated, as illustrated by the recommendations made by the Chambers and Janszen report (1990).

While USEPA has set the basic criteria for the use of POE/POU devices for the treatment of water, there remain several concerns regarding the monitoring, operation, maintenance, and performance of these devices, as determined by Chambers and Janszen (1990) who looked at the use of POU/POE devices for water systems with sources contaminated by Superfund sites. After concluding their study, Chambers and Janszen made the following recommendations regarding the use and operation of POU/POE treatment devices:

- Some design considerations need to be addressed. These include the design flow requirements, life of activated carbon (i.e., critical physical characteristics that might effect design, e.g., pore size, and particle size), loading rates, and the effects of mixtures on the adsorptive characteristics of the carbon.

- POU/POE devices need to be monitored to ensure proper operation.

- Utilities considering POU/POE devices should try to determine whether or not it is cheaper to replace carbon on a regular basis or cheaper to monitor and replace the carbon as needed.

- Assurance that the POE/POU device is operating properly is needed. A good monitoring program or operation and maintenance program should provide this assurance.

In order to ensure consistent and proper operation and maintenance, POU/POE devices should be owned by public water systems with a state approved operation and maintenance plan. To ensure proper operation, POU/POE devices must be tested and certified. Testing should ensure that the degree of public health protection is equivalent to that of centralized water treatment. It is important that POU/POE devices meet the equivalency requirements and not just demonstrate that there is no significant increase in risk posed by POU/POE devices. However, trying to define what constitutes "no significant increase" in risk would be difficult to define. In addition to equivalency, POU/POE devices should also be capable of maintaining the microbiological quality of the water and every building that has a POU/POE device should be constantly monitored and on a periodic maintenance schedule. Because of these concerns, POU/POE devices were not considered potential candidates for proposed BAT, and were not included in the treatment cost analysis or the cost-benefit analysis that follows. However, ODW will not reject any proposals to use POE/POU devices, as long as the proponent can meet the previously listed concerns and demonstrate the reliability of the treatment devices.

6. Cost-Benefit Analysis

Aside from the financial aspects of treatment, any decision on whether to apply RPHLs to systems serving between 15 and 10,000 service connections should not be based solely on the cost of treatment. There is a need to perform a cost-benefit analysis (i.e., to balance the health benefits against the economics of treatment.)

While the exposure data needed to conduct a full cost-benefit analysis was not available, it is possible to use the four typical community water systems (small, intermediate, medium, and large), as an example of extending RPHLs to smaller systems. Such an example can only be made with several assumptions. To begin with, this example will only consider the case of DBCP, realizing that a similar analysis could and should be extended to all compounds on the RPHL list. DBCP was selected because it is one of the compounds whose proposed RPHL is lower than it's MCL.

The present DBCP MCL (0.02 μg/L) regulates this compound at a 1-in-10,000 risk level (i.e., 1 person in 10,000 theoretically will contract cancer as a result of exposure to this chemical at the MCL.) In general, it is known from the ODW water quality database that the average number of DBCP contaminated sources in small, intermediate, medium, and large systems, which have any DBCP contamination, is 2.0, 1.3, 2.5, and 6.1, respectively. If it is assumed that the exposed population in a system contaminated with DBCP is proportional to the number of contaminated sources and the population served by the systems is uniformly served by all sources, the resulting theoretical excess cancer cases between the 1-in-10,000 (MCL) and 1-in-1,000,000 (RPHL) risk levels will be 0.04, 0.06, 0.54, and 3.1 in the small, intermediate, medium, and large water systems, respectively. These theoretical excess cancer cases also represent the incremental benefit of reducing the DBCP MCL (1-in-10,000 risk) to an RPHL (1-in-1,000,000). The cost of treating water to meet the RPHL can be estimated by assuming that GAC will be used on each contaminated source (i.e., wellhead treatment). The annual per capita cost for treatment in the small, intermediate, medium, and large systems would be $32.60, $8.60, $5.90, and $8.20, respectively.

Dividing the total annual treatment costs which includes amortized capital combined with operation and maintenance costs, by the number of lifetime theoretical excess cancer cases prevented, results in an annual dollar amount per theoretical excess cancer case avoided. For the small, intermediate, medium, and large systems the annual treatment costs are $285,000; $273,000; $189,400; and $348,100 per lifetime theoretical excess cancer case avoided, respectively. Compared with the reported human life values of $500,000 used for USEPA's radio chemical standards and the $200,000 to $1,000,000 used by the Consumer Product Safety Commission (Baram 1981), the treatment cost to lifetime theoretical excess cancer case avoided for all four typical water systems fall well within this range. However, it is not known whether these costs can be compared directly because RPHL treatment costs estimates do not include social costs (e.g., medical care, and loss of productivity), which may be included in the other cost-benefit ratios. However, ODW has regulated contaminants at lower cost-benefit ratios. For example, PCE was regulated at an annual treatment cost per lifetime theoretical cancer case avoided of $115,000 (Spath 1988). If the $115,000 level is used as a cut-off, the cost-benefit ratios indicate that an RPHL for DBCP in these systems is not warranted.

For the sake of consistency within the Department, it can be argued that the cost-benefit example used above argues for not extending RPHL to water systems in the 15 to 10,000 service connection range. However, the Department may opt to increase the cost-benefit ratio used to determine the feasibility of extending RPHLs because the individual annual treatment per capita costs for the typical systems in the 200 to 10,000 service connection range may not be unreasonable. However, the treatment costs in systems under 200 service connections are four times higher, and clearly indicate that RPHLs should not be extended to systems below 200 service connections. The ramifications of adding the RPHL cost impacts to the existing regulations is discussed in Chapter VIII of this report.

7. Special Problems

a. Radon

USEPA has announced consideration of a proposed radon standard of 300 pCi/L. Based on this proposal, ODW estimates that 59% or 4600 of the large water system wells in California potentially will be out of compliance (Sakaji and Michael 1991). Using a survey conducted of their member agencies, which does not include every water system in the state, the Association of California Water Agencies (ACWA) estimates that 14,000 wells in California (Brookes 1990) would require remediation. Since California will have to be at least as stringent as USEPA in order to maintain primacy, the California MCL probably will not be any lower.

Unfortunately, an RPHL for radon may be significantly lower. In their advance notice of proposed rulemaking, USEPA estimated the radon concentration that corresponds to the *de minimus* (one-in-a-million) risk level to be 10 pCi/L, thirty times lower than MCL and one order of magnitude below the limit of detection.

While ODW estimates that 59% of the large water system wells in the state would exceed the proposed radon standard, but ODW cannot identify the specific wells that may actually violate such a standard. Since ODW does not have individual source production or flow data for many ground water sources, the efforts to project treatment costs for a radon MCL or RPHL were curtailed. However, since it is generally agreed that radon can be removed by PTA or GAC, and because radon is much more volatile than many VOCs, the cost estimates for PTA based on a 35 gallons per minute per square foot (gpm/ft^2) surface loading rate, would be a conservative estimate of the treatment costs for an individual source. These costs are summarized in Table 6.5. The costs presented for GAC treatment in Table 6.5 are based on an empty-bed-contact-time of 10 minutes. There are also lower cost alternatives that can be used by some smaller water systems, however, the use of these alternatives must be considered on a case-by-case basis.

b. Trihalomethanes

Symons *et al.* (1988) looked at four treatment trains that might be considered BAT for DBPs. These were: (1) conventional treatment (coagulation, flocculation, sedimentation, and dual media filtration [using GAC]) with chlorine as the primary disinfectant, (2) item 1, but with pre-oxidation using ozone or chlorine, (3) use of ozone as the primary disinfectant and only use ozone in the pre-oxidation step, and (4) use of pre- and post-ozonation followed by GAC treatment.

USEPA recognizes that the cost estimates and results of their report are not applicable to all water systems, but they do not state the reason why. One may conclude from the report that they do not feel comfortable using TOC as a reliable surrogate on which to base the treatment models. The variable composition of TOC among sources may be one reason for their hesitation. USEPA does conclude that free chlorination must be eliminated from any treatment process if the TTHM standard is reduced to 20 μg/L, and when the raw water source exceeds a TOC of 3 mg/L. They draw the same conclusion for raw water sources containing a TOC of 10 mg/L, if the TTHM standard is set at 50 μg/L. USEPA further concludes that GAC treatment for raw water sources with a TOC less than 20 mg/L is unnecessary.

The potential costs for meeting these lower TTHM standards are summarized in Table 6.7. These costs only represent the costs for the addition of GAC treatment because most surface water treatment plants will already have installed coagulation, flocculation, and filtration in order to comply with the California SWTR. However, it is too early to determine the strategy that will eventually be used to reduce the concentration of TTHMs in the drinking water supply. Whether some sort of chemical pre-oxidation should be selected to reduce THM precursors or just using post-disinfection following GAC treatment to remove THM precursor materials will be sufficient to reduce TTHMs in water to a "safe" level requires more analysis. Until such questions are answered, costs in Table 6.7 are just estimates and should be used very judiciously for making any decision.

Table 6.7 Water Treatment Costs for Meeting TTHM Standards of 25, 50, and 100 μg/L using Granular Activated Carbon.

	25 μg/L	50 μg/L	100 μg/L
Capital Equipment Costs ($)	$389,262,800	$238,173,600	$8,002,900
Amortized Capital Equipment Costs ($/yr)[a]	$21,035,600	$12,870,800	$432,500
Operation and Maintenance Costs ($/yr)	$21,577,400	$13,526,800	$1,155,400
Total Annual Costs ($/yr)	$42,613,000	$26,397,600	$1,587,900

[a] Amortized over 20 years at a 10% discount rate.

TTHM monitoring data from 284 large water systems was available in ODW database. Of these systems, 3 would exceed a proposed TTHM standard of 100 μg/L, 108 would exceed a standard of 50 μg/L, and 179 would exceed a standard of 25 μg/L. As the cost estimates in Table 6.7 summarize, the capital cost for meeting standards of 100 μg/L, 50 μg/L, and 25 μg/L are $8.0.; $238.2; and $389.3 million, respectively. Amortized over 20 years at 10% and added to the annual operation and maintenance costs, the annual costs would be $1.6; $26.4; and $42.6 million. It should be emphasized that water quality data for systems below 10,000 service connections, for the most part, does not exist. Therefore, water systems that may exceed the lower TTHM standards reflects the potential for failure only in the >10,000 service connections water systems. Therefore, these costs substantially underestimate the economic impact that lowering TTHM standards would have because not all systems are included.

Before adjusting the existing TTHM standards the Department should consider what might be BAT, and carefully weigh the cost and benefit of regulating TTHMs with available treatment technology before proposing a new TTHM standard. Such a cost-benefit analysis should consider the benefit of controlling waterborne pathogens in a water distribution system, versus the cost or risk associated with the inability to disinfect adequately. Regulators should to consider not only waterborne disease outbreaks and the variability of disinfectants with microbial pathogens, but regrowth in the distribution system leading to violations under the new coliform rule and the loss of pipe flow due to biological slimes. In addition, it may be appropriate to consider alternative technologies, if, in fact, new oxidation methods prove be effective in controlling TTHM precursors.

The Department should consider whether the technology presently available is adequate and appropriate for dealing with the TTHM problem. As pointed out in the (ODW 1991) on ozone, the use of ozone should not be recommended as BAT for controlling TTHM precursors, at this time.

c. Lead and Copper Rule

The intent of the USEPA Lead and Copper Rule is to control corrosion by-products in the distribution system. In order to achieve this goal, USEPA established "action" levels in their final rule package. Based on samples taken in the distribution system at the consumer's tap, with the number of samples to be taken dependent on the size of the system, the following levels trigger the treatment requirements: 90% of the samples must be below the 15 µg/L lead action level and less than 1.3 mg/L copper. USEPA will also require that corrosion control studies for all utilities serving more than 50,000 people, be conducted.

Since the Lead and Copper Rule is based on tap sampling in the distribution system, ODW has no data on which to base reasonable statewide treatment cost estimates. A cost estimate, similar to that produced for radon, was created for lime softening as systems out of compliance with this rule will be required to institute a corrosion control program. This cost is shown in Table 6.5. This program will in all likelihood consist of a chemical feeder(s) at the plant or in the distribution system for pH adjustment or to lay down a protective coating on the pipe wall. Production of a "scale" will reduce the rate of corrosion in the distribution system.

Alternatively, since the population of California is about 5% of the nation, it can be estimated that 5% of USEPA estimated $500 to $790 million national annualized costs ($25 to 40 million per year) will be incurred within California for the Lead and Copper Rule.

While corrosion as a process is relatively simple to understand, the factors or conditions that lead to the onset or continued corrosion are not. "Blue water" problems attributed to the release of copper in the distribution system or from indoor plumbing may be a serious problem in some areas of the state. Some problems may result from improper installation of household appliances that can lead to corrosion and the release of copper from household plumbing. Such problems may beyond the ability of the utility to control.

8. Research Needs

Section 4022, HSC gives ODW the opportunity, but no appropriations, to setup a research and development unit, as the statutes specifically state:

> "(b) The department shall also have the following responsibilities:
> ...
>
> (C) Conduct research, studies, and demonstration projects relating to the provision of a dependable, safe supply of drinking water, including, but not limited to, all of the following:
>
> (D) Improved methods to identify and measure the existence of contaminants in drinking water and to identify the source of the contaminants.
>
> (E) Improved methods to identify, measure, and assess the potential adverse health effects of contaminates in drinking water.
>
> (F) New methods of treating raw water to prepare it for drinking, so as to improve the efficiency of water treatment and to remove or reduce contaminates.
>
> (G) Improved methods for providing a dependable, safe supply of drinking water, including improvements in water purification and distribution, and methods of assessing health-related hazards.
>
> (H) Improved methods of protecting the water sources of public water systems from contamination.
>
> (I) Alternative disinfection technologies that minimize, reduce or eliminate hazardous disinfection by-products."

Water treatment should never be taken for granted. Just because water treatment technology is specified by regulation, does not automatically guarantee a safe wholesome potable supply. The American Academy of Environmental Engineers recognize this fact in their 1989 report. In general, it is understood that the effectiveness of most water treatment processes is not fully understood because experience tells us that; while some plants achieve effective removals, others do not. All those in the water industry should support funding, basic research projects that explore the fundamental principles of water treatment.

Both the Association of Environmental Engineering Professors (AEEP) and AAEE have published summaries that point out the needs for more exploratory and applied research (AEEP 1986; AAEE 1989). In general, both organizations agree that there is a need for a greater commitment towards the development of a sound scientific database upon which to base legislation that protects the environment and the public health. This calls for long-term, fundamental exploratory research that should be conducted in conjunction with the mission-oriented research required by current legislation. AEEP (1986) points out that the failure to establish such a research and database system in the past has resulted in: "slow progress in establishing maximum contaminant levels (MCLs)...," "failure to agree on control strategy for toxic substances being discharged in industrial and municipal wastewaters," and "the lack of a strategy to protect groundwater supplies for the future." These issues remained areas of high priority for research.

As examples of research needs, AAEE (1989) listed some of the examples published by AEEP. These included developing more effective treatment to remove suspended toxic substances, examining water treatment processes to determine if compounds produced may have a harmful side effects on humans, preventing the formation of new potentially hazardous chemicals by water treatment processes, reevaluation of the effectiveness of disinfection technology, and assessment of the protection offered to consumers of public water systems that use current state-of-the-art technology that has not changed in years.

Many of these research topics have been echoed by AWWARF (1990) in their five-year research plan. AWWARF's main objective in water treatment research is to evaluate, optimize, and improve current treatment practices while simultaneously developing new technologies to provide for improved water quality, minimize taste and odor, increase finished water capacity, and minimize operational costs while meeting all water quality objectives and standards. Some of the subject areas AWWARF is or will actively support include:

- Investigations into the use of ozone and other advanced oxidation processes for microbial, organic, and DBP control.
- Studies into the use of nonoxidant processes for organic chemical, microbial, and DBP control, specifically the use of *in-situ* biological processes.
- Evaluation of new particulate removal processes as well as means of optimizing conventional filtration.
- Examine the efficacy of optimizing conventional physico-chemical and biological treatment processes or developing innovative new techniques for the removing and controlling inorganic chemicals, especially radiochemicals and nitrate.

- Improving treatment strategies for taste and odor control.
- Developing technology for treating and disposing residual from water treatment.
- Devising techniques for accurate and real-time evaluation of treatment processes.
- Acting on the need to provide reliable, affordable, and simple treatment and operational techniques to assist small systems to meet drinking water standards.

The words "reliable" and "affordable" in the last research item highlight one of the main needs of the small water systems. David Schnare, leader of the Low-Cost Technology Initiative, in a short paper points out that all states should give low-cost technologies a reasonable opportunity to work. Given that opportunity, he believes the problem will be one-third solved, however, the need for a standing body of information on which to base such a decision is recognized. More important, it is also recognized that such a database does not exist. Aside from the 10 pilot projects being conducted by this initiative group, which will feed information into the database, a resource cooperative that functions as a integrated problem solving network is needed. Such a cooperative effort would make important strides toward solving the small water system problems.

CONCLUSIONS AND RECOMMENDATIONS

Treatment technology provides a secondary barrier to protecting the public drinking water supplies. As a primary barrier, good watershed management programs should be established. The state should establish a strong wellhead protection program within the drinking water program. If one had been established and in place, many of the groundwater contamination problems experienced throughout the state may have been avoided.

The cost of imposing RPHLs on water systems with less than 200 service connections would increase the financial burden on the individual consumers in these communities above the present monitoring and compliance costs. In addition, future federal and state drinking water regulations, aside from RPHLs, will also add to the financial burden of these consumers. The greatest cost burden to the individual customers would be in systems with less than 200 service connections. The cost of water treatment and the lack of financial resources, already a major impediment to compliance with the California SDWA in the small water systems, would only be exacerbated by extending the RPHL requirements to these systems. Therefore, ODW is unable to recommend extending RPHLs to smaller systems based on treatment cost estimates alone.

If the Legislature decides to extend RPHLs to water systems between 200 and 10,000 service connections, the cost of monitoring and the benefit of stricter health standards to individuals systems and to the individuals visiting the communities served by these smaller water systems needs to be assessed in greater detail. A complete cost/benefit analysis is needed before a decision is made to extend RPHLs to systems with 15 to 10,000 service connections.

With RPHLs, new regulations, and other water quality problems, there is a need to advance the present state of drinking water treatment technology. ODW should have a research and development component to fund not only research into existing technology, but also to start research into new alternative and innovative treatment technologies.

The need for innovative treatment technologies and alternatives in lieu of centralized treatment in smaller water systems is apparent. Small water systems are considered miniaturized versions of large water systems. Too often engineers attempt to apply large water system solutions to small water system problems, and are sometimes disappointed by the results. There is a need for research into small water system problems, but individually small water systems do not have the financial resources to support such research and development efforts. The state should consider pooling a portion of large and small water system fees to develop a research and development program for the small water systems. Research and development could be done with the cooperation of large utilities, engineering consulting firms, or universities. Such studies should be funded on both short-(one year or less) and long-(over one year not to exceed three years) term basis. While some larger utilities are capable of funding their own research and development programs to handle their individual problems, or the cost of research is often shared through industry organizations (e.g., AWWARF) or federally subsidized, (e.g., USEPA) such organizations are not yet in place to afford the same research and developments considerations to the small water systems.

Small water systems are not alone in the need for research and development. In some cases, both large and small water systems benefit from a research and development program. ODW should institute CCP and CPE programs, similar to USEPA's, to help improve the operation and maintenance of water treatment plants. One of the objectives of CCP and CPE programs would be to develop performance specifications to evaluate treatment processes. Reliability criteria could be developed to define BAT, and provide the framework under which alternative treatment technology may be approved.

With additional treatment requirements to meet the primary drinking water standards, the level of sophistication required to operate and maintain a successful treatment plant requires well-trained operators. ODW, through its operator certification program and testing, should upgrade testing and requirements to reflect a knowledge and ability that is commensurate with treatment processes and regulations.

Aside from treatment technology, there is a need for water quality studies that statistically identify the extent and frequency of water quality problems in California. Such studies could be conducted by ODW to address statewide water quality issues as they relate to public health.

Recommendation: The Legislature should evaluate the overall effect California's SDWA has had on water quality throughout the state in for greater detail. Part of this evaluation should determine whether the money spent on water treatment facilities was well spent. Such an evaluation should include, but not be limited to, establishing treatment process reliability and an evaluation of the risk levels under which the present MCLs and future RPHLs are set. This should include a statistical evaluation of the process reliability so that the uncertainty associated with treatment can be factored into a risk management scenario.

Part of the research effort should go into incorporating more rigor in the development and adoption of water quality standards to define process reliability. Risk assessment should recognize and include the fact that even with treatment, there is a probability that the process may fail to produce water meeting primary drinking water standards at least 50% of the time. While this may not substantially increase the risk to the population exposed, it should be considered in the overall risk assessment given to the risk managers. This question might be addressed by the need to define BAT with specific criteria. For example, fully evaluating the reliability and performance of treatment processes before proposing them as BAT would aid in defining the overall "safety" of any process. Such an evaluation should include a literature review and review of all bench- or pilot-scale studies conducted to date.

Aside from the treatment considerations, a cost/benefit analysis should also consider the impact of some of the intangible costs. Part of the cost/benefit analysis should include societal costs, such as medical treatment and lost productivity during the period of illness. While these costs may be more qualitative in nature, they will serve to help risk managers in their decision processes.

Treatment cost estimating would be greatly improved by making the annual reporting of production, population served, number of service connections, and other vital statistical system data mandatory for all public water systems. This should result in an improved water system inventory, which in turn will improve the accuracy of the treatment cost estimates and further allow ODW to improve treatment cost estimates to reflect the projected cost of water to the consumers.

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CHAPTER VII

WATER QUALITY MONITORING

Reliable, accurate, and timely information is vital to ensure public health protection.

Water quality monitoring and reporting are the foundation of the drinking water regulatory program in California. Reliable, accurate, and timely information is vital to ensure public health protection. While source protection and good treatment are important, monitoring serves as the final determination of a public water system's ability to assure the public that the water delivered is pure, wholesome, and potable. This requires proper sample collection, handling, preservation, and analysis. Results of testing by laboratories are reported to public water systems, who subsequently report to the Department. This requires close communication between all three parties to expedite corrective actions by public water systems when initial test results indicate a potential public health problem. In the event of an actual public health problem, the public is notified.

This chapter presents information relating to the four aspects of water quality monitoring: (1) monitoring requirements, (2) laboratory accreditation, (3) analytical methods, and (4) financial impacts of current and future monitoring requirements. Items 3 and 4 fulfill the requirements from Sections 4022 (b)(2)(A) and (b)(5), HSC for the SDWP. Issues affecting regulatory agencies, public water systems, and/or laboratories are identified, and conclusions and recommendations made.

A. MONITORING REQUIREMENTS

The provision for public health protection in drinking water is authorized under the California SDWA. The Department is charged with the responsibility of carrying out the drinking water program in California. As a condition of primacy, the Department must adopt requirements (i.e., statutes and regulations) that are equal to or more stringent than federal requirements. Federal requirements are currently established only for primary drinking water standards. In California, compliance with primary and secondary drinking water standards is mandated by statute. Prior to January 1, 1991, the Department had established monitoring regulations for 62 primary (17 more than federal requirements) and 12 secondary drinking water standards and 8 unregulated contaminants. The types of contaminants are microbial agent (total coliform), turbidity, general physical, general mineral, DBPs, inorganic chemicals, organic chemicals (volatiles and synthetics), and radiochemicals. On January 1, 1991, monitoring and enforcement of an additional 47 unregulated organic chemicals became effective in California.

Primary and secondary drinking water standards are established for contaminants found in drinking water; those that have an adverse effect on human health (primary) and those that affect the aesthetic quality of the water but pose no health risk (secondary). For contaminants where it is not technologically or economically feasible to determine the concentration of the contaminant in drinking water, a treatment technique is established in lieu of an MCL. However, establishing a treatment technique for a contaminant may still involve monitoring for associated parameters, and to demonstrate the need for treatment and effectiveness of treatment provided. For contaminants regulated via an MCL or a treatment technique, monitoring, reporting, public notification, and record keeping requirements are established in regulation. Responsibility for complying with the drinking water regulations lies solely with public water systems in terms of sample collection and analysis. Water quality reports are submitted to ODW and LEHJs for review.

The type of monitoring required in California consists of routine and follow-up monitoring. Routine monitoring is conducted at prescribed frequencies to assess the quality and changes in quality of water delivered to consumers over time. Follow-up monitoring is conducted to confirm results of routine monitoring, where an MCL has been exceeded or where an organic chemical or microbial agent (total coliform) has been detected. For some contaminants, such as organic chemicals and radiochemicals, routine monitoring consists of two monitoring schedules: (1) an initial, intensified, one-time monitoring schedule, and (2) a continuing, reduced monitoring schedule provided established criteria are met.

The overall monitoring requirements established in California are determined by a combination of various factors such as type of public water system (non-community; non-transient, non-community; and community), type of source (ground or surface water), and vulnerability of source and system to potential sources of contamination.[21] The

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[21] In California, vulnerability assessment is currently limited to organic chemicals. Critical factors used to determine vulnerability are: (1) previous monitoring results,

amount of monitoring required of a public water system generally increases with the size of population served, number of service connections, vulnerability to contamination, degree of treatment provided, and as a contaminant results in an acute (immediate) health effect. The type and basis of monitoring for each type of public water system is further discussed in the report *Monitoring and Analyses of Drinking Water in California* (CDHS 1991a).

Additional monitoring requirements will be established for new contaminants detected in California public water supplies, and to meet the requirements of the federal SDWA Amendments of 1986 (1986 Amendments). On-going monitoring of public water supplies has detected 29 unregulated contaminants in California (CDHS 1990a). Pending development of regulations for these contaminants, non-enforceable action levels have been established by the Department to serve as guidance to public water systems. Ten of the contaminants will be monitored for under federal special monitoring requirements. However, federal regulation of the ten contaminants through an MCL or treatment technique has not been proposed as of January 1, 1991. Development of drinking water standards for the 29 contaminants found in California may need to be addressed at the state level.

Under the 1986 Amendments, USEPA has been charged with establishing drinking water standards or treatment technologies for a multitude of contaminants at a specified schedule. This includes: (1) establishing MCLs for 83 contaminants over a period of three years, (2) a drinking water priority list of contaminants every three years, from which 25 MCLs are to be established every three years, (3) special monitoring requirements for unregulated contaminants, (4) disinfection requirements for all public water supplies, and (5) filtration requirements for surface water sources and ground water sources under the direct influence of surface water sources. By 1995, USEPA will have developed new or revised regulations for over 133 contaminants according to this schedule, in addition to special monitoring requirements for unregulated contaminants. The regulatory status of the 1986 Amendments and future monitoring requirements and treatment technologies proposed are further discussed in the report *Monitoring and Analyses of Drinking Water in California* (CDHS 1991a). Department activities relating to the enforcement of the monitoring and reporting requirements on public water systems will increase significantly.

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(2) user population characteristics, (3) proximity to sources of contamination, (4) surrounding land uses, (5) degree of protection of the water source, and (6) historical system operation and maintenance data including previous Department inspection results.

1. Issues

a. Self-Monitoring Program

To comply with primary and secondary drinking water regulations, public water systems are responsible for the collection and analysis of samples at prescribed frequencies, with submittal to accredited laboratories for analyses. This allows the cost of sampling and analyses to be borne directly by those customers served by a given public water system through established water rates. However, concerns have been raised over how much reliance should be placed on this self-monitoring program. While most public water systems are conscientious, there is potential for unintentional error in sampling and analysis as well as intentional data falsification. Examples of intentional data falsification include the addition of chlorine to eliminate the presence of bacteriological contamination in a sample and submitting a "completed" monthly turbidity report of test results for a surface water treatment plant without any actual testing having been conducted. Examples of unintentional in sampling and analysis error includes improper sample collection, handling, and preservation and improper preparation of calibration standards and standards. Furthermore, due to the necessary flexibility in monitoring regulations as to when and where samples are taken and the possible submittal of the best result when multiple analyses are performed and only one result is required, test results submitted to the state may not be totally representative of the water being consumed at various times. These occurrences may increase in the future due to substantially increased costs and the complexity of drinking water sampling and analysis.

Inaccurate water sampling or analyses, whether inadvertent or intentional, may produce results that mistakenly show the presence or absence of contamination. The first case is easily identified through follow-up sampling to confirm the initial test result. The second case, however, is difficult to identify. As the test result is negative to begin with, there is nothing to "flag" the occurrence of a sampling or analysis problem. Therefore, of the two outcomes, results that mistakenly show the absence of contamination pose the major concern as results may lead to the appearance that the water delivered is pure, wholesome, and potable when the water quality is actually unknown. While data falsification and inadvertent data error are not believed to be extensive, both have been detected in California (CDHS 1991a) and other states (USGAO 1990). In addition, the true extent of the problem is unknown in California as no actions are being taken to actively seek out if there is a problem. ODW does not routinely collect verification samples of public water systems due to lack of resources.

As part of it's regulatory program, ODW should conduct routine drinking water verification check sampling to substantiate drinking water test results submitted by all public water systems. This would be comparable to the existing program conducted by RWQCB's to verify test results on wastewater effluent quality. This drinking water quality assurance sampling program would serve to: (1) uncover sampling and analysis errors undetected by public water systems and laboratories, (2) provide a measure of assurance to the public that the water delivered is pure, wholesome, and potable, and (3) detect, identify the extent of, and deter the occurrence of intentional data falsification.

b. Routine Water Quality Monitoring by Public Water Systems

Water quality monitoring requirements in California have historically been more stringent than federal monitoring requirements. With the passage of the 1986 Amendments and its forthcoming increased monitoring requirements, there is a need to identify means by which current monitoring requirements in California can be revised to provide for flexibility in monitoring and yet maintain the same level of public health protection and consumer acceptance of the water.

For primary and secondary drinking water standards, one possible way would be to extend the vulnerability assessment criteria for organic chemicals to other contaminant groups, such as general physical, general mineral, inorganic chemicals, and radiochemicals. The criteria established for organic chemicals provides for flexibility in monitoring by considering a variety of critical factors. Public health protection and aesthetic concerns for primary and secondary drinking water standards, respectively, are maintained through establishment of stringent criteria, and monitoring becomes cost effective as it is applicable to a public water system. Establishing vulnerability assessments for other contaminants may be considered more stringent then current federal requirements, which is a condition of primacy delegation. An evaluation on the current source and distribution system monitoring requirements with respect to the factors used in determining the monitoring requirements and the frequencies of monitoring should be conducted.

This vulnerability assessment concept could also be extended to address the monitoring issue of small water systems receiving exemptions or reduced monitoring requirements at the federal level. USEPA has reduced monitoring of some contaminants due to factors such as the financial burden of monitoring on small water systems and the burden on primacy state's[22] of mandating the requirements on small water systems. Use of vulnerability assessment criteria could ensure that small water systems: (1) monitor for those contaminants that are applicable to small water systems, (2) sample at frequencies adequate to characterize the quality of the water, and (3) are not subject to an increased risk to contaminants by virtue of not monitoring for contaminants that may be present in their drinking water. The issue of the financial viability of small water systems to meet current and future requirements and the need for additional resources for primacy states to carry out the mandates of the federal and state SDWA for small water systems are further discussed in Chapter X.

Public water systems should also initiate or continue documenting land use practices in the system and in the vicinity of sources. This information could be provided to and considered by ODW when vulnerability assessments are conducted by ODW on the system and system sources. This type of information may play a greater role in the future should vulnerability assessments be established for other types of contaminant groups as previously described. Public water systems could also benefit in this information as it would serve to: (1) identify potential hazards to the system and system sources, (2) allow systems to initiate mitigative measures through monitoring, treatment, and if needed, removal of sources from service, and (3) assist in the proper siting of new sources away from known potential hazards. However, the identification and sources of potential hazards to the system and system sources may extend beyond the service area of a public water system. Establishment of a wellhead protection program, as described under Section 1428 of the federal SDWA, would serve to provide this information, in addition to protecting ground water supplies by identifying wellhead protection areas.

c. Routine Water Quality Monitoring by Small Water Systems

Of particular concern to ODW is the ability of local regulatory agencies to enforce the future monitoring and reporting requirements on small water systems. These systems, which represent 7,803 or 74% of the public water systems in California (excluding state small water systems), historically have had high rates of non-compliance with the current monitoring requirements, as compared to the relatively low rates of non-compliance from large water systems, due to a lack of technical and

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[22]USEPA requires public water systems serving chlorinated surface water to a population that is ≥10,000 to monitor for TTHMs. This requirement has not been extended to systems with <10,000 population.

financial resources and an understanding of the requirements needed to implement such a program. Rates of non-compliance for small water systems are presented in Table 4.4. This particular problem associated with small water systems is further discussed in Chapter X. The ability of small water systems to comply with current and future monitoring and reporting requirements with inadequate resources is an area of concern. From a regulatory perspective, small water systems represent an area in which substantial resources will be needed.

Efforts by ODW and small water systems should be coordinated to make the best use of existing resources to achieve public health protection in a cost-effective manner. One possible alternative would be a state-instituted sampling program for small water systems. Having the state conduct the required sampling for small water systems would appear to offer the following advantages: (1) provide a measure of assurance to consumers served by small water systems that the water is pure, wholesome, and potable as all monitoring would be routinely performed, (2) reduce the cost of monitoring for small water systems as sample collection, handling, preservation, and analysis is being conducted on a large scale, (3) eliminate monitoring non-compliance by small water systems thus saving considerable regulatory costs, (4) redirect time spent on enforcement activities relating to monitoring and reporting violations, (5) identify the extent of water quality problems occurring in small water systems and corrections needed to protect consumers, and (6) substantially reduce the number of public water systems to be included in a drinking water verification check sampling program.

Drinking water sampling programs currently exist in other states and in some counties in California through an annual fee-for-service assessment. However, with the passage of the 1986 Amendments, these states and counties are reassessing their role, responsibility, and feasibility in maintaining the drinking water sampling program. Further study on the scope, cost, benefits, and potential problems of a state-instituted sampling program will be needed to address these and other issues before such a program is implemented in California.

d. Compliance with Secondary Drinking Water Standards

With the passage of the 1986 Amendments and its forthcoming increased monitoring and treatment requirements for primary (health-related) drinking water standards, the issue has been raised as to whether secondary drinking water standards should be treated the same as primary drinking water standards. By state law, public water systems are required to comply with secondary drinking water standards. These standards are aesthetics-related, controlling those contaminants that may affect the appearance, taste, and odor of the water, but which pose no public health risk at the levels established in regulations. In addition, regulations provide for flexibility in compliance through a waiver provision when certain criteria are met, that is, the degree of consumer acceptance of the water and their willingness to pay for the cost of meeting the secondary drinking water standards.

However, ODW has not been able to consistently enforce compliance with secondary drinking water standards due to lack of clarity in the regulations, inadequate resources, and the fact it is not a high priority item as compared to compliance with primary drinking water standards. For example, current regulations do not specify the procedure to confirm a violation of a secondary drinking water standard. For mineralization secondary drinking water standards[23], three MCLs are provided (i.e., recommended, upper, and short-term) for a given contaminant. As such, compliance with or granting of waivers for secondary drinking water standards has therefore generally been conducted on a case-by-case basis in response to consumer complaints. When these situations arise, consumers served by a given public water system have been provided with facts concerning benefits of meeting the secondary drinking water standard and the projected cost increase in the water bill. The overall and informed decision is then left to the consumers as to whether the increase in the cost of water is worth improving the aesthetic quality of the water. ODW intends to further study this issue.

B. LABORATORY ACCREDITATION

As a condition of primacy, the Department must establish a laboratory accreditation program to certify laboratories performing drinking water analyses pursuant to the California SDWA. Laboratory accreditation serves to assure the validity of the analytical data as the information is vital in determining a public water system's compliance with established MCLs, and assuring that the water is pure, wholesome, and potable.

Laboratory accreditation activities are conducted by the ELAP under the Department's Division of Laboratories. ELAP was established as a result of AB 3739 (Chapter 894, Statutes of 1988) and became effective on January 1, 1989. AB 3739 served to consolidate the laboratory accreditation activities for drinking water, wastewater, and hazardous

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[23]Mineralization standards are established in California for total dissolved solids, chloride, and sulfate.

waste analyses by various state agencies under one state program. Accreditation for pesticide residuals in food was added in 1989. The Department is in the process of developing regulations to implement AB 3739. USEPA is proposing to develop regulations for laboratory accreditation to assure that accreditation programs in primacy states contain those basic program elements that are essential in assuring data validity.

ELAP currently administers five program elements which are: (1) fields of testing, (2) accreditation fees, (3) certificates of accreditation, (4) minimum criteria for accreditation, and (5) performance evaluation samples. There are currently 23 fields of testing administered by ELAP; six that are applicable to drinking water, with two[24] of the six overlapping with wastewater. Accreditation fees paid by laboratories to the ELAP consist of a basic fee of $930 (1991 annual fee) and a field of testing accreditation fee of $419 (1991 annual fee) for each field of testing for which accreditation is sought. These fees are mandated by law in order that ELAP be fee-supported, and are adjusted annually. Certificates of accreditation are issued, and subject to renewal every two years, provided laboratories meet minimum criteria, pass an on-site inspection, and satisfactorily analyze an annual set of performance evaluation samples. Minimum criteria consists of the use of specified analytical methods, development of a quality assurance plan and chain-of-custody procedure, and adequacy of trained personnel, equipment, and record keeping practices. Performance evaluations samples are prepared and distributed by USEPA and the Department's Division of Laboratories to laboratories at no cost. These samples contain an unknown concentration of contaminants that a laboratory must analyze for within a prescribed degree of accuracy and precision.

As of December 31, 1990, ELAP had accredited 405 laboratories (in- and out-of-state), with a matrix distribution of 193 drinking water, 276 wastewater, 206 hazardous waste, 37 asbestos (i.e., for bulk analysis of building material), and 2 radiochemistry (i.e., for water and/or wastewater). There is some overlap as several laboratories perform analyses on more than one type of matrix (i.e., drinking water {D}, wastewater {W}, and hazardous waste {H}). This distribution of laboratories is: (1) DWH-106, (2) DW-37, DH-2, WH-58, and (3) D-48, W-75, and H-40.

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[24] The two fields of testing are for microbial agent and radiochemical analyses.

1. Issue

a. Impact of the Drinking Water Program on ELAP

Laboratory accreditation activities by ELAP are expected to increase with the promulgation of monitoring requirements for regulated and unregulated contaminants under the 1986 Amendments. There may also be a need for greater enforcement and support (i.e., responsiveness, follow-up, and compliance activities) by ELAP for ODW activities as public water systems begin to implement the monitoring requirements. With the addition of new or revised analytical methods for drinking water, some which are similar to methods for wastewater and hazardous waste analyses, oversight by the Department will be greater than what has historically been necessary to ensure that laboratories are using the appropriate drinking water methods, and that public water systems are informed of the appropriate drinking water methods to be used. These drinking water regulatory program needs as a result of the federal and state SDWA will need to be met as ELAP continues laboratory accreditation and compliance activities in the area of wastewater, hazardous waste, and pesticide residuals in food.

The Department should consider coordinating and synchronizing the drinking water regulatory and laboratory accreditation process. Activities conducted by ODW and ELAP parallel the needs by public water systems and laboratories, respectively. These activities could include: (1) co-distribution of information to public water systems and laboratories of new federal and state drinking water regulations, analytical methods to be used, detection limits for reporting, and federal and state implementation dates, (2) co-identification of federal and state chemicals "expected to be promulgated in the next one to two years" for inclusion in the performance evaluation samples, and (3) promulgation of chemical MCLs by chemical groups that use the same method of analysis.

b. Field Analysis of Drinking Water Samples

Several analyses conducted pursuant to the California SDWA must be performed in the field as sample collection and delivery to the laboratory for analysis is not feasible. Examples of these circumstances include the need to affect immediate changes in process control (e.g., turbidity monitoring on a <u>daily</u> basis at surface water treatment plants) and changes in chemical concentrations or levels that occur from the time of sample collection to analysis (e.g., for pH and temperature). The need to provide for field testing of these contaminants is supported with existing federal and state regulations that allows analyses of certain contaminants to be conducted by "any person acceptable to the state" (CFR 1990) and by a certified water treatment plant operator (CCR 1990), respectively.[25]

While state regulation provides for the flexibility needed to perform certain analyses in the field, statutory authority is in reference to a laboratory and not an individual. To strengthen Section 64451(b), CCR, statutory authority should be revised to expressly provide for flexibility needed in performing field analyses conducted pursuant to the California SDWA.

A few of the contaminants typically fall under the category of secondary (aesthetics-related) drinking water standards and unregulated contaminants. However, some have an importance in the implementation and compliance with primary drinking water regulations when monitored as surrogate parameters. These surrogate parameters may also be used to determine the effectiveness of treatment provided and the need for treatment. Examples of these applications are the monitoring for turbidity and free chlorine residual under the California SWTR and pH under the federal Lead and Copper Rule.

As these types of contaminants have an importance in public health protection when used to comply with primary drinking water regulations, the Department should consider establishing a quality assurance program for contaminants that are analyzed in the field pursuant to the California SDWA. This program could be similar to that established by ODW for turbidity monitoring at surface water treatment plants, which will be strengthened under the California SWTR. This would serve to ensure the validity of the data as the analyses would be performed using the appropriate methods and equipment by properly trained personnel.

This program should also be extended to analyses of these contaminants in a laboratory. There is currently no mandatory requirement that laboratories be accredited for these contaminants as performance evaluation samples for some contaminants (e.g., temperature and odor) cannot be readily prepared. However, quality assurance activities should be established for laboratory analyses of these contaminants to assure data validity as recommended by the USEPA (USEPA 1990a).

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[25] The federal provision currently applies to turbidity, pH, temperature, and free chlorine residual analyses. The state provision currently applies to color, odor, and turbidity.

c. Laboratory Accessibility

Public water systems in remote locations have established individual, in-house laboratories for microbial agent (total coliform) analyses due to factors that limit the accessibility of commercial laboratories in the area. These factors include the need to collect and submit weekly microbial agent (total coliform) samples as required in regulations; the two to three hour one-way travel time typically required to deliver samples directly to a commercial laboratory, which may be longer during poor weather conditions; and the occurrence of monitoring violations as a result of exceeding the 30 hour sample holding time when samples are sent by mail. As analyses are conducted pursuant to the California SDWA, these in-house laboratories must be accredited by ELAP. Due to a combined annual accreditation fee of $1,349 (annual 1991 fees), several of these public water systems may consider ceasing operation of the laboratory. This in turn may cause these public water systems to experience monitoring violations as a result of exceeding the 30 hour sample holding time for microbial agent (total coliform) analysis.

Public water systems with in-house laboratories should consider alternatives by which monitoring and analyses in compliance with drinking water regulations can be conducted at a reduced cost. One possible alternative is to extend in-house laboratory services to other public water systems. Another would be to consolidate individual laboratories into a regional/local laboratory to be used by public water systems in a specific area. This would serve to reduce the cost of maintaining an in-house laboratory by sharing of resources and costs, and help to address the laboratory accessibility problem in certain areas with respect to microbial agent (total coliform) analysis.

d. Public Water System and Laboratory Communication

A drinking water laboratory plays an important role in public health protection. Actions taken by public water systems, where there may be a water quality problem, is dependant upon by how rapidly the initial test results are provided by the laboratory. This requires close communication between the laboratory and the public water system so that the public water system may expedite and comply with follow-up actions, some of which are mandated in regulations, to avoid a potential public health problem.

While many laboratories recognize the importance of their role in public health protection and are responsive to a public water systems needs, it has been the experience of public water systems and the Department that some laboratories have not been responsive in providing verbal and written test results to public water systems in a timely manner. There is currently no requirement for laboratories to provide verbal or written test results within a specified time frame.

This type of action by a laboratory has a potentially, adverse impact on public health protection as follow-up actions are subsequently delayed. In addition, late reports may cause a public water system to miss reporting deadlines mandated in regulations, and may leave the appearance that monitoring has not even been conducted. Communication, both verbal and written, between public water systems and laboratories needs to be improved to enable public water systems to meet the mandates of the California SDWA -- protection of public health and compliance with monitoring and reporting requirements.

C. ANALYTICAL METHODS

Drinking water analyses are required to be conducted using federally approved and state acceptable analytical methods. These methods have been demonstrated to detect contaminants within a consistent, prescribed degree of accuracy and precision needed to determine a public water system's compliance with an MCL during routine and follow-up monitoring. Analytical methods also serve as the fundamental basis for determining if a contaminant is to be regulated through a MCL or a treatment technique. An MCL is developed if the level of contaminant can be economically and technologically ascertained. USEPA and the Department are responsible for identifying methods that are approved and acceptable, respectively, for regulated and unregulated contaminants.

Under the 1986 Amendments, there is an increasing number of contaminants, both regulated and unregulated, for which analytical methods or treatment techniques will be established. This is in addition to the 29 unregulated contaminants found in California through on-going monitoring. The University of California Water Quality Task Force (1988) identified the need for accurate, easy-to-use, inexpensive analytical methods that could be used on a routine basis to detect chemical contaminants and microbial agents. As such, questions have been raised under Section 4022 (b)(5), HSC concerning the research needed to develop inexpensive methods and instruments to ensure better screening and detection of waterborne chemicals, and inexpensive detection methods which could be used by small utilities and consumers to detect harmful microbial agents in drinking water. To address these questions, a review of existing and proposed methods and treatment technologies for current and future monitoring requirements was conducted to identify areas that are in need of improvement.

1. Scope and Limitations

In order to identify those existing and proposed methods and treatment technologies for current and future monitoring requirements, it was necessary to identify what would be considered as current and future monitoring requirements and to establish a cutoff date. Current monitoring requirements were limited to state requirements in effect prior to January 1, 1991, for primary drinking water standards (CCR 1990). Existing methods and treatment technologies associated with these monitoring requirements consisted of those that were: (1) federally approved prior to January 1, 1991 (CFR 1990), and (2) state acceptable as identified through a survey of laboratories accredited for drinking water analysis (CDHS 1991a). Future monitoring requirements were limited to those federal and state requirements proposed as of January 1, 1991. Proposed methods and treatment technologies were associated with the following rules and regulations: (1) federal - Lead and Copper Rule[26], Phase II and V inorganic chemicals, Phase II and V organic chemicals VOCs and SOC, and special monitoring requirements for unregulated chemicals (inorganic chemicals and SOCs) (USEPA 1988, 1989a, and 1990c), (2) federal and state - SWT and Total Coliform Rule (CDHS 1990a and 1991a; USEPA 1989b, 1989c, and 1989d) and (3) special monitoring requirements for unregulated organic chemicals (VOCs and SOCs) (CRNR 1990). It is important to note that several of the federal and state requirements became effective after January 1, 1991, and that the final analytical methods and treatment technologies may not be reflected in the ensuing review.

The review of existing and proposed methods and treatment technologies is divided into two major groups: (1) microbial agents and (2) chemical contaminants. For each major group, methods and treatment technologies available or proposed, use and purpose, method description, availability of results, detection limits for purposes of reporting, relative technical expertise required to perform the analysis, and cost of analyses are summarized. For the chemical contaminant group, the discussion is organized by type of contaminants regulated and unregulated, as applicable: (1) turbidity and associated parameters, (2) inorganic chemicals, (3) corrosion by-products, (4) DBPd, (5) organic chemicals (VOCs), and (6) radiochemicals.

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[26]A review of the analytical methods contained in the supplement (USEPA 1990d) to the federal Lead and Copper Rule was excluded as copies of the analytical methods could not be obtained in time for the review.

2. Microbial Agents

Federal and state regulations currently exist for one microbial agent (total coliform). Revised federal regulations are in effect and revised state regulations will be proposed for total coliform. Total coliform is and will continue to be regulated through an MCL, and the presence of the bacteria determined through analytical methods. Federal and state regulations are in effect for *Giardia lamblia*, *Legionella*, viruses, and heterotrophic plate count (HPC) bacteria. These four microbial agents are regulated through a treatment technique.

a. Analytical Methods

The analytical methods available for total coliform analysis are the multiple tube fermentation technique (MTFT) and membrane filter technique (MFT). Under the federal Total Coliform Rule, which became effective December 31, 1990, the two additional analytical methods approved for use are the Presence-Absence (P-A) Coliform Test and the Minimal Media ONPG-MUG (MMO-MUG) Test (Autoanalysis Colilert System). The state Total Coliform Rule is expected to be proposed in mid-1991. These four methods screen for the presence of pathogenic organisms through the use of total coliform bacteria which serves as the indicator organism. Methods are currently available to identify several specific pathogenic organisms and enteric viruses, but are generally too time consuming and complicated, and therefore not suitable for routine use (APHA, AWWA, and WPCF 1989).

The MTFT method involves the inoculation of test tubes containing a nutrient-rich medium with a portion of the water sample, followed by incubation of the test tubes. The medium is designed to promote the rapid growth of coliform bacteria and inhibit the growth of most non-coliform bacteria. Preliminary treatment of the sample is not required. This method provides for an indirect count of total coliforms; where the mean density of coliforms is estimated based on certain probability formulas. Analytical results are available in 48 hours, but may take an additional 24 to 48 hour to confirm positive test results. Results are reported as <2.2 to >16 most probable number of total coliforms present per 100 mL sample (APHA et al. 1989). The lower limit is the detection limit for reporting purposes.

The MFT method involves the filtration of a water sample through a membrane filter that retains the total coliform bacteria. The filter is placed on a nutrient-rich absorbent pad in a petri dish and incubated. Preliminary treatment of the sample is not required. This method provides for a direct count of total coliform colonies in a sample.

Analytical results are available in 24 hours. Results are reported as <1 coliform per 100 mL sample as the lower limit and as 80 coliforms per 100 mL sample as the reliable upper limit (APHA et al. 1989). The lower limit is the detection limit for reporting purposes.

The P-A Coliform Test is a simplification of the MTFT method where a single 100 mL culture bottle is inoculated instead of five 10 mL tubes. Preliminary treatment of the sample is not required. Analytical results are available in 48 hours, but may take an additional 24 to 48 hours to confirm positive test results.

The MMO-MUG Test method is similar to the MTFT method except that a different nutrient-rich medium is used. A color change occurs with this medium as opposed to the development of a turbid sample with the evolution of gas under the MTFT method. Preliminary treatment of the sample is not required. Analytical results are available in 24 hours.

Under the federal Total Coliform Rule and state Total Coliform Rule, the sample volume for the four methods will be standardized at 100 mL. Results will be reported as "positive or negative" for coliforms in 100 mL of sample. The lower limit is the detection limit for reporting purposes. The MTFT, MFT, and the MMO-MUG Test methods may still be used to quantitate the presence of contamination by use of five 20 mL or ten 10 mL test tubes in lieu of a single 100 mL culture bottle.

The analyses should be conducted by a microbiologist. However, the analyses are simple enough to be conducted by a laboratory technician trained in laboratory procedures for microbiological analyses (USEPA 1990a).

The weighted average cost of analysis to meet current monitoring requirements is approximately $19 per sample. The weighted average cost of analysis to meet the proposed state Total Coliform Rule is approximately $25 per sample (CDHS 1991a).

b. Treatment Technologies

Surface Water Sources[27]

Under the federal SWTR, a treatment technique has been established for four microbial agents: *Giardia lamblia*, *Legionella*, viruses, and HPC

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[27] This includes ground water sources under the influence of surface water sources.

bacteria. Analytical methods are available for *Giardia lamblia*, *Legionella*, and viruses but are more suited for a laboratory conducting research due to certain requirements (e.g., need for special equipment and specially trained personnel to perform the analysis). As such, these methods currently are beyond the scope of most full-service, commercial and non-commercial, laboratories for routine analysis (Dufour 1991). Analytical methods exist for HPC bacteria, and are routinely performed by full-service laboratories. However, HPC bacteria is being regulated via a treatment technique to limit its growth in the distribution system.

The treatment technique under the federal and state SWTR consists of filtration with disinfection for those public water systems using surface water sources. Public water systems using these types of sources may qualify for a waiver or exemption from the federal SWTR if certain criteria are met. Under the state SWTR, no waivers or exemptions are allowed as the position has been taken that all surface sources in California are potentially subject to microbial agent contamination, and that a multi-barrier approach (i.e., filtration and disinfection) is necessary to reliably protect consumers against disease-causing organisms in their drinking water. All public water systems in California that use surface sources will be required to provide for complete treatment (i.e., coagulation, flocculation, sedimentation, filtration, and disinfection) or equivalent treatment. The federal SWTR became effective December 30, 1990, and the state SWTR became effective June 5, 1991.

Certified water treatment plant operators of the appropriate grade will be required in California for the operation of the surface water treatment plants. The certification of water treatment plant operators is a program administered by the Department.

The treatment cost to comply with the state SWTR for five "typical" community water systems is presented in Table 8.9. These costs include capital and operation and maintenance costs. Vital statistics for the five "typical" community water systems are presented in Appendix 1.

Ground Water Sources[28]

Under the federal Strawman Rule for Ground Water Disinfection (USEPA 1990b), a treatment technique is under consideration for three microbial agents: *Legionella*, viruses, and HPC bacteria. *Giardia lamblia* has been excluded as it is not typically found in ground water supplies. The

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[28] This consists of ground water sources that are not under the influence of surface water sources.

organism in its cyst form is removed during natural filtration of the water. The treatment technique consists of disinfection, with a requirement that treatment facilities be operated by qualified personnel as determined by the state. Criteria to obtain a variance from the primacy state is also under consideration by USEPA. Specific requirements will be identified when federal regulations are proposed sometime in June 1993.

The treatment cost to comply with the federal Strawman Rule for Ground Water Disinfection for those systems that do not disinfect is estimated at $474.8 million annually on a nationwide basis (Wade Miller Associates 1990).

3. Chemical Contaminants

Federal and state regulations exist for turbidity and associated parameters, inorganic chemicals, DBPs (TTHMs only), organic chemicals (VOCs and SOCs), and radiochemicals. The individual contaminants are regulated through an MCL, and their presence in drinking water is determined through analytical methods.

Federal and state regulations have been and will be proposed for inorganic chemicals, corrosion by-products, disinfectants and DBPs, organic chemicals (VOCs and SOCs), radiochemicals, and unregulated contaminants (inorganic chemicals, VOCs, and SOCs). For individual contaminants proposed prior to January 1, 1991, a majority will be regulated through an MCL, and their presence in drinking water determined through analytical methods. The exception is for two SOCs which were proposed to be federally regulated through a treatment technique. In addition, corrosion by-products have been proposed to be regulated through a combination of analytical methods and a treatment technique. Results of testing through analytical methods will be used to determine the need for treatment and the effectiveness of treatment provided to control for corrosion by-products.

a. Turbidity and Associated Parameters

<u>**Analytical Methods**</u>

Under the federal and state SWTR, analytical methods have been established for turbidity, temperature, pH, and residual disinfection (free chlorine residual, chloramines, and ozone). The analytical methods are the colorimetric method (residual disinfectants)[29], electrode method (pH), nephelometric method (turbidity), thermometer method (temperature), and titrimetric (amperometric and visual) methods (free chlorine residual and chloramines). There are two different colorimetric methods for free chlorine and chloramines each, and one colorimetric method for ozone. The nephelometric method is used to screen for the presence of suspended particles in raw and treated water, and is used as a form of process control to measure the efficiency of treatment provided at surface water treatment plants. The colorimetric, electrode, thermometer, and titrimetric methods provide for the detection and analysis of specific levels and contaminants on an individual basis. Measurement for temperature, pH, and residual disinfection are used as a form of process control for disinfection provided at surface water treatment plants.

The colorimetric method consists of a reaction between the specific chemical and a reagent, resulting in the formation of a colored complex or the formation of a colorless complex accompanied by a reagent color loss. Color formation or loss is monitored visually (ozone) or with a detector (free chlorine, chloramines, and ozone), and is proportional to chemical concentration. Preliminary treatment of the sample may be required. Analytical results are available upon conversion of instrument readings to chemical concentration by use of a calibration curve prepared for each chemical of interest. Results are reported as milligrams per liter (mg/L) of chlorine, with the range varying from 0.05 to 4 mg/L for free chlorine and chloramines determination (APHA et al. 1989), and as milligrams per liter of ozone, with the range varying from 0.01 to 0.03 mg/L for ozone determination (Bader and Hoigné 1982). The detection limits for reporting purposes will be established by the Department at a later date.

The electrode method consists of determining the hydrogen ion activity by comparing the potential developed across a hydrogen electrode submerged in a sample against a reference electrode. Preliminary treatment of the sample is not required. Analytical results are immediately available by direct readout from the instrument, and are reported as "pH units", with a range of zero to 14. The detection limit for reporting purposes is 0.1 pH unit (APHA et al. 1989).

The nephelometric method involves a comparison of the intensity of light scattered by the sample at a 90 degree angle and a standard reference suspension. Formazin and commercially prepared suspended latex

[29]The DPD (N,N-diethyl-p-phenylenediamine) colorimetric test kit may be used to analyze for free chlorine and chloramine if approved by the state.

beads are used as the standard reference suspension to calibrate the nephelometer. Preliminary treatment of the sample is not required. Results are immediately available by direct readout from the instrument, and are reported as nephelometric turbidity units, with the range dependent on instrument capability and quantity of suspension in the sample. The detection limit for reporting purposes of raw and treated water is 0.1 NTU (CDHS 1988d).

The thermometer method consists of immersing a thermometer in a sample until complete equilibration is reached. Preliminary treatment of the sample is not required. Analytical results are immediately available by direct readout from the thermometer, and are reported as degrees Celsius or degrees Fahrenheit, with the type and range dependant on type of thermometer used. The detection limit for reporting purposes is typically to the nearest degree, but may be lower depending on the need.

The titrimetric method (amperometric) consists of the incremental addition of a titrant (reagent solution of known concentration) to a sample until a response from a microammeter is no longer obtained. The titrimetric method (visual) consists of the formation of a colored complex with the specific chemical and an initial reagent. The incremental addition of a titrant (containing a second reagent) results in the formation of a colorless complex. The amount of titrant required to produce a no-response and color loss is proportional to chemical concentration. Preliminary treatment of the sample may be required for both methods. Analytical results are available upon conversion of titrant volume used to chemical concentration by use of a formula for each chemical of interest. Results are reported as milligrams per liter, with the range varying from 0.2 to 2.0 mg/L (APHA et al. 1989). The detection limits for reporting purposes will be established by the Department at a later date.

The nephelometric, thermometer, electrode, and titrimetric (visual) methods are simple enough to be conducted by a laboratory technician trained in laboratory procedures on the use of the equipment. The titrimetric (amperometric) and colorimetric methods involve a greater level of skill, but may be conducted by a laboratory technician provided specialized training and experience in the operation of the equipment is provided (USEPA 1990a).

The cost of monitoring for these levels and contaminants are included in the treatment costs, as operation and maintenance costs, under the state SWTR. These costs are presented in Table 8.9 for five "typical" community water systems. Vital statistics for the five "typical" community water systems are presented in Appendix 1

b. Inorganic Chemicals

Analytical Methods

Regulated Contaminants. A variety of analytical methods are used for the analysis of inorganic chemicals regulated in California. These methods are the atomic absorption (AA) method (aluminum, arsenic, barium, cadmium, chromium, lead, selenium, and silver), cold vapor technique (mercury), colorimetric method (aluminum, fluoride, and nitrate), electrode method (fluoride and nitrate), ion chromatography method (nitrate), inductively coupled plasma-atomic emission spectrometry (ICP-AES) method (aluminum, arsenic, barium, cadmium, chromium, lead, and silver), and spectrophotometric method (arsenic and nitrate). There are two to four, three to five, one, and one submethod(s) per chemical for the AA, colorimetric, electrode, and spectrophotometric methods, respectively. For example, barium may be analyzed using two atomic absorption submethods: flame and furnace.

Under the proposed federal Phase II and V inorganic chemical regulations, the analytical methods are the AA method (antimony, barium, beryllium, cadmium, chromium, copper, lead, nickel, selenium, and thallium); chloranilate, gravimetric, and turbidimetric methods (sulfate); colorimetric method (nitrate and nitrite); distillation-titrimetric and distillation-spectrometric methods (cyanide); electrode method (nitrate); ICP-AES method (barium, beryllium, cadmium, chromium, copper, and nickel); inductively coupled plasma-mass spectrometry (ICP-MS) method (antimony, beryllium, nickel, and thallium); cold vapor technique (mercury); ion chromatography method (nitrate, nitrite, and sulfate); spectrophotometric method (nitrite); and transmission electron microscopy (TEM) method (asbestos). There are one to two and two to three submethod(s) per chemical for the AA and colorimetric methods, respectively.

The spectrophotometric method (nitrate) provides for the screening of nitrate. The AA, cold vapor technique, chloranilate, colorimetric, distillation-spectrometric, distillation-titrimetric, electrode, gravimetric, spectrophotometric (arsenic and nitrite), TEM, and turbidimetric methods provide for the detection and analysis of specific chemicals on an individual basis. The ICP-AES and ICP-MS methods provides for the sequential or simultaneous detection and analysis of specific chemicals. The ion chromatography methods provides for the simultaneous detection and analysis of specific chemicals.

The AA method consists of atomizing a sample using a heat source (flame or furnace), and directing a light beam from a hollow, element specific, cathode lamp through the atomized sample. A detector measures the amount of energy light transmitted, which is inversely proportional to the element concentration. Preliminary treatment of the sample is required, with additional treatment required for antimony, arsenic, and selenium (hydride conversion) and low concentrations of aluminum, antimony, barium, beryllium, cadmium, chromium, copper, lead, nickel, and silver.

The chloranilate, gravimetric, and turbidimetric methods consist of a reaction between sulfate and a reagent, resulting in the formation of a precipitate or a colored product. In the chloranilate method, the reagent is converted to form a colored solution. Color formation is monitored with a detector, and is proportional to chemical concentration. In the gravimetric method, the precipitate is subject to digestion, filtration, ignition, and weighing, with the weight of the precipitate proportional to chemical concentration. In the turbidimetric method, the precipitate is subject to suspension during formation, and the turbidity level determined with a detector. The amount of light absorbed is proportional to chemical concentration. Preliminary treatment of the sample is required for the chloranilate and gravimetric methods, and may be required for the turbidimetric method.

The colorimetric method consists of a reaction between the specific chemical and a reagent, resulting in the formation of a colored complex or the formation of a colorless complex accompanied by a reagent color loss. Color formation or loss is monitored with detector, and is proportional to chemical concentration. Preliminary treatment of the sample is required for some of the specific submethods.

The cold vapor technique method consists of converting mercury to its elemental form (liquid), aerating mercury flow solution, and directing the vapor through a cell (container) which is positioned in the path of a light beam from a hollow, element specific, cathode lamp. A detector measures the amount of energy light transmitted, which is inversely proportional to the element concentration. Preliminary treatment of the sample is required.

The distillation-spectrometric and distillation-titrimetric methods consists digestion and distillation of the sample and collection of the cyanide. For the distillation-spectrometric method, formation of a colored complex occurs when a reagent is added to the distillate. Color formation is monitored with a detector, and is proportional to chemical concentration. For the distillation-titrimetric method, incremental addition of a titrant (titrimetric) is added to the distillate until a color change is observed with an indicator. The amount of titrant required to produce a color change is proportional to chemical concentration.

The electrode method consists of comparing the electrode potential developed across a chemical specific electrode submerged in a buffered sample against a reference electrode and a pH meter or a specific ion meter. Preliminary treatment of the sample is not required.

The ICP-AES and ICP-MS methods consist of nebulizing a sample and transporting the aerosol to a heat source (plasma torch). In the ICP-AES method, the ionic emission spectra produced are dispersed, and emission line intensities, which are proportional to chemical concentrations, are monitored with a detector. In the ICP-MS method, the ions produced are extracted under vacuum and separated on the basis of their mass-to-charge ratio by a mass spectrometer. Preliminary treatment of the sample is required for both methods.

The ion chromatography method consists of separating anions using an anion exchange column, suppressing the eluent's background contribution to the final result, and monitoring the concentration of the individual anions with a detector. Preliminary treatment of the sample may be required.

The spectrophotometric method for arsenic and nitrite consists of a reaction between the chemical and a reagent, resulting in the formation of a colored complex. Color formation is monitored with a detector, and is proportional to chemical concentration. The spectrophotometric method for nitrate consists of monitoring the energy absorbed or transmitted by the sample, which is proportional or inversely proportional, respectively, to the chemical concentration. Preliminary treatment of the sample is required for the three chemicals.

The TEM method consists of filtration, fixation of asbestos fibers, dissolution of the support filter, and examination of the fibers with a transmission electron microscope at a magnification of about 20,000. Preliminary treatment of the sample is required.

For the AA, chloranilate, colorimetric, cold vapor technique, distillation-spectrometric, ICP-AES, ICP-MS, spectrophotometric, and turbidimetric methods, analytical results are available upon conversion of instrumental readings to chemical concentrations by use of a calibration curve prepared for each chemical of interest. For the distillation-titrimetric, electrode, and gravimetric methods, analytical results are available upon: (1) conversion of titrant volume used to chemical concentrations by use of a formula for the chemical of interest, (2) conversion of instrumental readings to chemical concentrations by use of a calibration curve prepared for each chemical of interest (if pH meter used) or by direct readout from the instrument (if ion selection meter used), and (3) conversion of sample weight and water volume to chemical concentration, respectively. For the ion chromatography method, analytical results are available upon conversion of instrumental readings to chemical concentrations by use of a calibration curve prepared for each chemical of interest. Chemical identification is determined by comparing retention times of the sample against known standards. For the TEM method, crystal structure and elemental composition of asbestos is determined through selected area electron diffraction and energy dispersive X-ray analysis, respectively. Concentration is determined by counting the number of fibers and dividing by the volume of water filtered. Fiber length and width is also determined for each fiber.

Analytical results are reported as milligrams per liter for fluoride and nitrate and as micrograms per liter (μg/L) for aluminum, barium, cadmium, chromium, lead, selenium, and silver, with the range dependent on instrument capability and chemical concentration in the sample. The detection limits for reporting purposes varies from 0.1 to 1 mg/L for fluoride and nitrate (CDHS 1988d) and 1 to 100 μg/L for aluminum, arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver (CDHS 1990b). For the Phase II and V inorganic chemicals, analytical results are anticipated to be reported as million fibers per liter for asbestos and micrograms per liter for all other chemicals. The detection limits for reporting purposes will be established when state regulations are promulgated.

The AA, ICP-AES, ion chromatography, cold vapor technique, and TEM methods involve the use of sophisticated equipment, and are generally limited to analysts with academic training and specialized training and experience in the operation of the equipment. The chloranilate, colorimetric, distillation-titrimetric, distillation-spectrophotometric, gravimetric, spectrophotometric, and turbidimetric methods involve a lesser degree of sophistication and may be conducted by a laboratory technician provided specialized training and experience in the operation of the equipment is provided. The electrode method is simple enough to be conducted by a laboratory technician trained in laboratory procedures on the use of electrodes (USEPA 1990a).

For the general minerals[30] and inorganic chemicals currently monitored in California, a majority of laboratories have developed a group cost of analysis. The group cost of analysis for the general minerals and the inorganic chemicals is approximately $171 and $193 per sample, respectively (CDHS 1991a). The group analysis cost for inorganic chemicals and general minerals include the following Phase II and V inorganic chemicals: barium, cadmium, chromium, copper, lead, mercury, nitrate, and selenium. For those Phase II and V contaminants not already covered, the cost of analysis is estimated to be $25 per sample per metal for antimony, beryllium, nickel, and thallium; $20 per sample for cyanide (USEPA 1990c); and approximately $500 and $22 per sample for asbestos and nitrite, respectively (CDHS 1991a). Laboratories may be incorporating these individual contaminants, with the exception of asbestos, into the group analysis cost for general minerals and inorganic chemicals at a later date.

Unregulated Contaminants. The analytical methods for inorganic chemical analysis under the proposed federal special monitoring requirements for unregulated inorganic chemicals are the AA method (antimony, beryllium, nickel, and thallium), ICP-MS method (antimony, beryllium, nickel, and thallium), spectrometric method (cyanide), and colorimetric method (sulfate). The method descriptions, use and purpose, availability of results, relative technical expertise required to perform the analyses, and cost of analyses were previously summarized under Chapter VII.C.3.b-Analytical Methods-Regulated Contaminants. The detection limits for reporting purposes will be established when state regulations are promulgated.

c. Corrosion By-Products

Analytical Methods

The analytical methods for the analyses of corrosion by-products under the proposed federal Lead and Copper Rule are the AA (copper and lead), ICP-AES (lead), and electrode (pH). The method descriptions, use and purpose, availability of results, and relative technical expertise required to perform the analyses were previously summarized under Chapter VII.C.3.a and Chapter VII.C.3.b-Analytical Methods-Regulated

[30]General minerals are included here as two of the Phase II contaminants (copper and sulfate) are currently monitored as general minerals in California.

Contaminants. The detection limits for reporting purposes will be established when state regulations are promulgated. The cost of analysis for these contaminants is approximately $19 (copper), $25 (lead), and $9 (pH) per sample (CDHS 1991a).

Treatment Technology

The treatment technique under the proposed federal Lead and Copper Rule consists of: (1) minimizing lead in drinking water by optimizing corrosion control treatment, and (2) public education to inform the public as to the types of action that may be take to minimize exposure to lead. Originally, the treatment technique would have been imposed if a "no-action level" for lead, copper, or pH was exceeded. Under the supplement (USEPA 1990d) to the proposed federal Lead and Copper Rule, it has been proposed that the treatment technique be mandatory for water systems serving greater than 50,000 persons.

d. Disinfectants and Disinfection By-Products

Analytical Methods

The analytical methods available for DBP analysis (TTHMs only) are gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS). Through a combination of different instruments, sample preparation procedures, columns, and detectors, there are six specific methods available. These methods provide for the sequential detection and analysis of the four chemicals that comprise TTHMs.

The GC and GC-MS methods consist of sample extraction or purge and trap, separation of volatile DBPs using a GC column with temperature programming (except for one specific GC method), and monitoring the concentration of the individual chemicals with a detector. Preliminary treatment of the sample is not required.

For both types of methods, analytical results are available upon conversion of instrumental readings to chemical concentrations by use of a calibration curve prepared for each chemical of interest. Chemical identification is determined by comparing retention times or mass spectra of the sample against known standards.

Analytical results are reported as micrograms per liter for the DBP, with the range dependent on the type of gas chromatography column and detector used. The detection limit for reporting purposes is 0.5 ug/L for the individual chemicals (CDHS 1991c).

The analyses involve the use of sophisticated equipment, and are generally limited to analysts with academic training and specialized training and experience in the operation of the equipment (USEPA 1990a).

The cost of analysis for DBPs (TTHMs only) is approximately $102 per sample (CDHS 1991a).

Analytical Methods and Treatment Technologies

Under the federal Strawman Rule for Disinfectants and Disinfection By-Products (USEPA 1989b), analytical methods for several disinfectants and DBPs and treatment technologies or guidance for some surrogate parameters are under consideration. Overall, up to 3 disinfectants and 11 DBPs and by-product groups are under consideration by USEPA, and are summarized in Table 5.5. The surrogate parameters under consideration are MX (surrogate for mutagenicity), total oxidizing substances (surrogate for organic peroxides and epoxides), and assimilable organic carbon (surrogate for microbiological quality of oxidized waters). While analytical methods were not identified in the Strawman Rule, extensive work has been conducted (Gordon et al. 1987) to summarize and review all available disinfection residual measurement methods. Likewise, a summary and review of surrogate parameters for organic contaminants has been conducted (AWWARF and KIWA 1988). For the Disinfectants and Disinfection By-Products Rule, the specific contaminants and surrogate parameters, analytical methods, and treatment technologies will be identified when regulations are proposed sometime in June 1993. The cost of analysis for the chlorination by-products may be up to $640 per sample (USEPA 1989b).

e. Organic Chemicals

Analytical Methods

Regulated Contaminants. The analytical methods available for VOCs and SOCs regulated in California are GC, GC-MS, and high performance liquid chromatography (HPLC). Through a combination of different instruments, sample preparation procedures, columns, and detectors, there are 5 specific methods for VOC analyses, and 11 specific methods for SOC analyses by 7 chemical groups and 1 chemical. The seven chemical groups are: (1) base, neutral, and acid extractables, (2) carbamates, (3) chlorinated pesticides, (4) chlorophenoxy herbicides, (5) fumigants, (6) nitrogen and phosphorus pesticides, and (7) polychlorinated biphenyls (PCBs). The individual SOC method is for glyphosate as this contaminant does not fall under any of the seven chemical groups.

These methods provide for the sequential detection and analysis of 23 VOCs and 19 SOCs currently regulated in California, with the screening for PCBs using the chlorinated pesticides method. If PCBs are detected when using the chlorinated pesticides method, the level must be quantitated using the PCB method. The number of regulated organic chemicals that can be analyzed using a specific method varies from 1 (i.e., for glyphosate) to 11 (i.e., for base, neutral, and acid extractables). However, several contaminants may be analyzed through the use of more than one method. For example, the pesticide atrazine may be analyzed using the chlorinated pesticides; nitrogen and phosphorus pesticides; or base, neutral, and extractables method.

Under the proposed federal Phase II and V organic chemical regulations, the analytical methods for VOC analyses are GC and GC-MS, and the methods for SOC analyses are GC, GC-MS, gas chromatography-high resolution mass spectrometry (GC-HRMS), and HPLC. Through a combination of different instruments, sample preparation procedures, columns, and detectors, there are 5 specific methods for VOC analyses, and 14 specific methods for SOC analyses by 8 chemical groups and 4 chemicals. The eight chemical groups are: (1) base, neutral, and acid extractables, (2) carbamates, (3) chlorinated pesticides, (4) chlorophenoxy herbicides, (5) nitrogen and phosphorus pesticides, (6) PCBs, (7) phthlates and adiphates, and (8) polynuclear aromatic hydrocarbons (PAHs). Individual SOC methods are for: (1) diquat, (2) endothall, (3) glyphosate, and (4) 2,3,7,8-TCDD (Dioxin), as these contaminants do not fall under any of the eight chemical groups.

These methods provide for the sequential detection and analysis of 13 VOCs and 33 SOCs, with the screening for PCBs using the chlorinated pesticides method. The number of regulated organic chemicals that can be analyzed using a specific method varies from 1 (i.e., for glyphosate, diquat, endothall, and 2,3,7,8-TCDD [Dioxin]) to 13 (i.e., for chlorinated pesticides). However, several contaminants may be analyzed through the use of more than one method. For example, the pesticide endrin may be analyzed using the chlorinated pesticides or base, neutral, and extractables method.

The GC and GC-MS methods consist of sample derivitization and extraction, extraction only, or purge and trap; separation of organic chemicals using a GC column with temperature programming (for most of the chemical group methods); and monitoring the concentration of the individual components with a detector. Preliminary treatment of the sample may be required. Analytical results are available upon conversion of instrumental readings to chemical concentrations by use of a calibration curve prepared for each chemical of interest. Chemical identification is determined by comparing retention times or retention times and mass spectra of the sample against known standards.

The GC-HRMS method consists of the addition of two isotopically-labeled analyte analogs, sample extraction, addition of a recovery standard, separation of TCDD isomers using a GC column, and monitoring the concentration of the individual components with a detector. Preliminary treatment of the sample is required. Analytical results are available upon conversion of instrument readings to chemical concentrations by use of a calibration curve prepared for each chemical of interest. Chemical identification is determined by comparing retention times and mass spectra of the sample against known standards.

The HPLC method consist of sample extraction or filtration, separation of organic chemicals using a HPLC column, post-column derivitization (for methods with filtration only), and monitoring the concentration of the individual components with a detector. Preliminary treatment of the sample may be required. Analytical results are available upon conversion of instrumental readings to chemical concentrations by use of a calibration curve prepared for each chemical of interest. Chemical identification is determined by comparing retention times of the sample against known standards.

For VOCs and SOCs regulated in California, analytical results are reported as micrograms per liter, with the range dependent on the type of GC column and detector used. The detection limit for reporting purposes varies from 0.5 to 10 μg/L and 0.01 to 25 μg/L for the individual VOCs and SOCs, respectively (CDHS 1991c). For the Phase II and V contaminants, analytical results are anticipated to be reported as micrograms per liter for most of the chemicals. The chemical 2,3,7,8-TCDD (Dioxin) may be reported as nanograms per liter or picograms per liter. Detection limits for reporting purposes will be established when state regulations are promulgated.

The analyses involve the use of sophisticated equipment, and are generally limited to analysts with academic training and specialized training and experience in the operation of the equipment (USEPA 1990a).

The cost of analysis for the nine chemical groups is approximately $218 (VOCs), $415 (base, neutral, and acid extractables), $182 (carbamates), $153 (chlorinated pesticides), $175 (chlorophenoxy herbicides), $102 (fumigants), $172 (nitrogen and phosphorus pesticides), $130 (PAHs), $125 (PCBs), and $209 (phthlates and adiphates) per sample. The cost of analysis for the chemical specific SOC methods is $163 (glyphosate), $144 (endothall), $147 (diquat), and $403 (2,3,7,8-TCDD {Dioxin}) per sample (CDHS 1991a).

Unregulated Contaminants. Under the proposed federal special monitoring requirements for SOCs and the state special monitoring requirements for VOCs and SOCs, the analytical methods for VOC analyses are GC and GC-MS, and the methods for SOC analyses are GC, GC-MS, and HPLC. Through a combination of different instruments, sample preparation procedures, columns, and detectors, there are 5 specific methods for VOC analyses, and 12 specific methods for SOC analyses by 7 chemical groups and 3 chemicals. The seven chemical groups are: (1) base, neutral, and acid extractables, (2) carbamates, (3) chlorinated pesticides, (4) chlorophenoxy herbicides, (5) nitrogen and phosphorus pesticides, (6) PAHs, and (7) phthlates and adiphates. Individual SOC methods are for: (1) diquat, (2) endothall, and (3) glyphosate, as these contaminants do not fall under any of the seven chemical groups.

These methods provide for the sequential detection and analysis of 38 VOCs and 112 SOCs. The number of unregulated organic chemicals that can be analyzed using a specific method varies from 1 (i.e., for glyphosate, diquat, and endothall) to 60 (i.e., for nitrogen and phosphorus pesticides). However, several contaminants may be analyzed through the use of more than one method. For example, the herbicide simazine may be analyzed using the chlorinated pesticides or nitrogen and phosphorus pesticides method.

The method description, relative technical expertise required to perform the analyses, and the cost of the analyses were previously summarized under Chapter VII.C.3.e.-Analytical Methods-Regulated Chemicals.

For the proposed federal and state special monitoring requirements for unregulated organic chemicals, analytical results are anticipated to be reported as micrograms per liter for most of the chemicals. Detection limits for reporting purposes will be established when state regulations are promulgated.

The cost of analysis for the nine chemical groups is approximately $218 (VOCs), $415 (base, neutral, and acid extractables), $182 (carbamates), $153 (chlorinated pesticides), $175 (chlorophenoxy herbicides), $172 (nitrogen and phosphorus pesticides), $130 (PAHs), and $209 (phthlates and adiphates) per sample. The cost of analysis for the chemical specific SOC methods is approximately $163 (glyphosate), $144 (endothall), and $147 (diquat) per sample (CDHS 1991a).

Treatment Technologies

Regulated Contaminants. Under the proposed federal Phase II organic chemical regulations, two SOCs (acrylamide and epichlorohydrin) will be regulated via a treatment technique. These chemicals are typically used as coagulation or flocculation aids in the treatment of surface waters. The treatment technique consists of limiting the monomer level of the chemicals that may be introduced in drinking water during water treatment. The monomer levels for acrylamide and epichlorohydrin are 0.0005 mg/L (0.05% acrylamide in polyacrylamide dosed at 1 part per million (ppm)) and 0.002 mg/L (0.01% residual epichlorohydrin concentration dosed at 20 ppm), respectively. Compliance will be determined through a combination of monomer level in the product and the dose of product used.

f. Radiochemicals

Analytical Methods

The analytical methods available for radiochemical analysis are evaporation and counting (gross alpha and gross beta); precipitation with or without ingrowth (radium-226, radium-228, total radium, and strontium-90; one method each); radon emanation (radium-226); liquid scintillation (tritium); and fluorometric-direct, fluorometric-extraction, and radiochemical (uranium). For the federal Phase III radiochemicals, analytical methods and/or treatment technologies will be identified when requirements are proposed in mid-1991. Radiochemicals identified under the 1986 Amendments are anticipated to be regulated through an MCL due to the availability of analytical methods.

The evaporation and counting method provides for the screening of gross alpha and gross beta particle activity. This method may also be used to screen for radium-226, radium-228, and uranium if the quarterly average of four consecutive quarterly samples is >5 pCi/L. The precipitation without ingrowth methods provide for the screening of radium-226 and total radium. The method for total radium may also be used to screen for radium-226 and radium-228 if the quarterly average of four consecutive quarterly samples is >5 pCi/L. When concentrations exceed 5 pCi/L for gross alpha or total radium or exceed 50 pCi/L for gross beta, analysis for specific radiochemicals is required. The precipitation with ingrowth methods (for radium-228 and strontium-90), radon emanation, liquid scintillation, fluorometric, and radiochemical methods provide for the detection and analysis of specific radiochemicals on an individual basis.

The evaporation and counting method consists of evaporating and measuring particle activity with a counting instrument.

The precipitation without ingrowth method consists of precipitating the radiochemicals, drying the precipitate, and measuring particle activity with a counting instrument. The precipitation with ingrowth and radon emanation methods consist of precipitating the individual radiochemicals, storing the precipitate for several days to allow the ingrowth of the daughter product, and measuring the particle activity of the daughter product with a counting instrument.

The liquid scintillation method consists of distilling the sample, combining the distillate with a scintillation solution, and measuring with a counting instrument the resulting light pulses which is proportional to activity.

The fluorometric methods consists of extracting the sample (excluded for fluorometric-direct method), evaporation and fusing the extract with a flux, exposing the mixture to a ultraviolet source, and measuring the fluorescence with a detector.

The radiochemical method consists of precipitating the sample, separating the uranium through an anion exchange column, evaporating the eluent, and measuring the particle activity with a counting instrument. Preliminary treatment of the sample is required for all of the methods.

For the fluorometric-direct method, analytical results are available upon conversion of instrumental readings to chemical concentrations by use of a calibration curve. For all other methods, analytical results are available upon conversion of instrumental readings to radiometric units by calculation.

Analytical results are reported as picocuries per liter for the radiochemicals and as micrograms per liter for uranium using the fluorometric-direct method, with the range dependent on instrument capability and radiochemical concentration in the sample. The detection limit for reporting purposes consists of reporting the count of the analysis plus the counting error at a confidence level of 95%.

The analyses should be conducted by personnel with academic training and experience. However, gross alpha and gross beta analyses may be performed by a properly trained laboratory technician (USEPA 1990a).

The cost of analysis for the radiochemicals is approximately $42 (gross alpha particle activity), $45 (gross beta particle activity), $62 (radium-226), $146 (radium-228), $121 (strontium-90), $30 (tritium), and $65 (uranium) per sample. Cost of analysis data for total radium was unavailable (CDHS 1991a).

4. Issue

a. Research Needs

Microbial Agents, Turbidity, and Associated Parameters

Research is needed to develop inexpensive detection methods which could be used by small utilities and consumers to detect harmful microbial agents in drinking water.

Total Coliforms. Public water systems sample for total coliforms in the distribution system to monitor the bacteriological quality of the water delivered to consumers. Total coliforms are used as an indicator organism for the possible presence of pathogenic organisms. While several analytical methods are available for the analysis of total coliforms, all methods for total coliform analysis are limited with respect to the time required to complete the analysis. Preliminary test results are available within 24 to 48 hours, with confirmation of positive test results taking an additional 24 to 48 hours for some methods. As waterborne outbreaks may occur within this time frame, there is a need for an inexpensive, rapid, easy-to-use method that will detect and confirm the presence of an indicator organism in less than 24 hours. The goal would be to provide a greater degree of public health protection to consumers. An inexpensive, easy-to-use method would enable public water systems to sample the drinking water at frequencies greater than previously at the same overall cost. A rapid method would provide test results sooner, such that in the event of a potential public health problem, public water systems could initiate more rapidly the appropriate mitigative measures. Development of such a method could be of use to all sizes of public water systems and to consumers that have their own private water system.

For public water systems, an additional consideration with respect to the test results is its use: (1) for water quality compliance purposes under state regulations, or (2) for general information purposes. Testing for water quality compliance purposes requires additional factors to be considered, some of which are: (1) the proper sample collection, handling, and preservation procedures to be used, (2) the cost of equipment, supplies, and trained personnel to do the analyses, and (3) the annual laboratory accreditation fees ($1,349 for 1991). Items 1 and 2 are applicable to public water systems and consumers testing for general information purposes. With the current analytical methods available for total coliform analysis, the weighted average cost of analysis by accredited commercial laboratories is approximately $19 per sample for current monitoring requirements and $25 per sample for future monitoring requirements. These costs reflect items such as the cost of equipment, supplies, and personnel and a margin of profit on a per sample basis. As these considerations and costs do not make it cost-effective for many small utilities (<200 service connections) and consumers to currently perform the sampling and/or analysis themselves, small utilities and consumers should consider cost reductions as discussed in Chapter VII.D.3.a in lieu of performing sample collection and analysis themselves.

Other Microbial Agents, Turbidity, and Associated Parameters. Under the state SWTR, public water systems will be controlling the presence of *Giardia lamblia*, *Legionella*, viruses, and HPC bacteria through a treatment technique. While analytical methods are available, methods for *Giardia lamblia*, *Legionella*, viruses are generally too time consuming and complicated to be suitable for routine use. Instead, surrogate parameters, such as turbidity and residual disinfectant will be used as a form of process control for filtration and disinfection (i.e., removal and inactivation of four microbial agents) provided at surface water treatment plants. The analysis of these types of surrogate parameters is faster, easier, and less costly than the current analytical methods available for the microbial groups listed above. The technology associated with the analysis of turbidity, residual disinfectant, and pH may be complex, but the actual analysis is relatively simple. These characteristics enable water system operators to perform the analyses, and to effect immediate changes in process control during rapid changes in raw water quality.

While monitoring and analysis of surrogate parameters is an important factor in ensuring that the water produced from surface water treatment plants is pure, wholesome, and potable, the costs associated with monitoring and analysis is only a fraction of the annual operating cost. Public water systems will also be faced with the capital cost associated with the construction of new facilities or the upgrading of existing facilities to meet the treatment requirements under the state SWTR. Small utilities may need to consider alternatives in reducing their overall costs, such as consolidation of water systems. This and other alternatives for small water systems are discussed in Chapter X. The need to develop BATs suitable for use by small utilities, which may even be applicable to consumers that have their own private water system, was previously discussed under Chapter VI.

However, there is a need for research to develop and improve analytical methods for the detection of microbial agents. As discussed in Chapter V, waterborne outbreaks continue to occur, although sporadically, and the causative agents in many cases go unidentified due to the lack of suitable analytical methods. Under the federal and state SWTR, a few classes of microbial agents are anticipated to be regulated through a treatment technique. Additional microbial agents, such as *Cryptosporidium*, will need to be addressed. Development of analytical methods for microbial agents could serve to: (1) identify and monitor changes in the microbiological quality of the raw water sources and treated water, (2) refine the level of treatment required of a surface water treatment plant with respect to the raw water source quality, (3) assist in improving current BAT, and (4) further evaluate and correlate the use of existing and new surrogates (e.g., turbidity and particle counting, respectively) as screening tools, for routine use to monitor the degree of microbial agent removal and inactivation provided at surface water treatment plants.

Chemical Contaminants

Research is needed to develop inexpensive methods and instruments to ensure better screening and detection of waterborne chemicals.

Regulated Contaminants. Chemical contaminants regulated in California through an MCL consist of inorganic chemicals, DBPs (TTHMs only), organic chemicals VOCs and SOCs, and radiochemicals (CCR 1990). The detection of these inorganic chemicals, DBPs, 39 of 47 organic chemicals, and radiochemicals appears to be adequate using existing analytical methods. Detection limits for purposes of reporting (DLRs) varied from one-half to one-two hundredth of an MCL for the inorganic chemicals, DBPs and 39 of 47 organic chemicals. DLRs for the radiochemicals consisted of reporting the count of the analysis plus the counting error at the 95% confidence level.

For the remaining 8 of 47 organic chemicals, DLRs are the same as MCLs. The eight organic chemicals are: (1) carbon tetrachloride, (2) 1,2-dichloroethane, (3) total 1,3-dichloropropene, (4) vinyl chloride, (5) EDB, (6) chlordane, (7) heptachlor, and (8) heptachlor epoxide. MCLs for these organic chemicals were set at DLRs as existing analytical methods were unable to detect contaminant levels reliably below DLRs (CDHS 1988a, 1988b, 1988c, 1989). With respect to the *de minimus* risk level, which was discussed in Chapter V.B.1, DLR for EDB is at the *de minimus* risk level, whereas DLRs for the other seven organic chemicals are above the *de minimus* risk level.

In other words, MCL for EDB is set at a level that provides the same degree of public health protection as for other carcinogens (i.e., at the *de minimus* risk level). However, due to limitations in existing analytical capabilities, it is not possible to reliably monitor for the presence of EDB in drinking water until concentrations are at or above MCL. For the other seven organic chemicals, the Department was unable to establish MCLs that would have provided the same degree of public health protection as for other carcinogenic contaminants (i.e., at the *de minimus* risk level) due to limitations in existing analytical capabilities.

Development of analytical methods and instrumentations for the detection and quantitation of these eight contaminants below the *de minimus* risk level and/or current DLRs could provide a greater degree of public health protection. Such improvements could be integrated over time as drinking water standards established by USEPA and the Department are subject to review every three and five years, respectively. MCLs are amended as needed to reflect changes in technology, treatment technique, and/or health risk assessment which permit greater protection of public health.

Additional chemical contaminants to be regulated via an MCL under future federal requirements, as proposed on January 1, 1991, consist of inorganic chemicals, corrosion by-products, and organic chemicals VOCs and SOCs (USEPA 1988, 1989a, and 1990c). As these contaminants are applicable on a nationwide basis, USEPA will be responsible for validating the proposed analytical methods, identifying method detection limits and practical quantitation limits (PQLs), and establishing the appropriate MCLs. Many of the analytical methods proposed are already in use for the analysis of current, federal and state, regulated contaminants. A comparison of the proposed MCLs and PQLs show that MCLs are the same as PQLs for 5 of 16 inorganic chemicals and 20 of 48 organic chemicals.

However, conclusions regarding the adequacy of the proposed analytical methods for the detection and quantitation of these future contaminants with respect to an MCL cannot be drawn at this time as state requirements may involve lower MCLs and/or DLRs. For example, 16 of the 20 organic chemicals identified in the previous paragraph are currently monitored for in California. Of these 16 organic chemicals, 13 have DLRs lower than the federal proposal, and 5 of the 13 have MCLs lower than the federal proposal. An evaluation should be deferred until USEPA activities are completed, state regulations are adopted, and state DLRs are established.

Unregulated Contaminants. Special monitoring requirements for 47 unregulated organic chemicals VOCs and SOCs in California became effective on January 1, 1991 (CCR 1990). Additional monitoring requirements have been proposed by USEPA for 6 unregulated inorganic chemicals and 107 unregulated organic chemicals (volatiles and synthetics) (USEPA 1989a). Through monitoring for a broad number of contaminants by water systems, occurrence data will be provided to USEPA and the Department, who then will determine the need to establish regulations and at what MCL for the contaminants.

The methods used for the analysis of unregulated organic chemicals being monitored effective January 1, 1991, are currently used for the analysis of regulated organic chemicals. DLRs for the unregulated organic chemicals varies from 0.5 to 10 μg/L (CDHS 1991c), levels which are comparable to those for regulated organic chemicals, and appears to be appropriate detection levels to identify the presence or absence of the contaminant in drinking water.

Some of the methods proposed for the analysis of unregulated inorganic and organic chemicals are currently in use for the analysis of regulated contaminants, whereas other methods will be in use for future, federal and state, regulated contaminants. PQLs for these contaminants have not been proposed concurrently with the monitoring requirement. Instead, USEPA (1989a) will require analysis to be performed by laboratories that are capable of analyzing performance evaluation samples within established acceptance limits. When state regulations are adopted for the special monitoring of unregulated inorganic and organic chemicals, state DLRs will be established. It is anticipated that these PQLs and DLRs will be comparable to the range of levels used for regulated inorganic and organic chemicals.

In the event USEPA and/or the Department determines a need to regulate any of these contaminants via an MCL, a thorough evaluation of various factors (e.g., health risk, treatment technology, analytical methods, and costs) will be conducted prior to establishing a MCL. At that time, an assessment may be made concerning the adequacy of detecting the chemical with respect to the MCL.

Other Contaminants or "The Great Unknown." At the present time, there are many contaminants that are and will be monitored for in California. Current regulations are established for 82 contaminants in California, with USEPA to regulate over 133 contaminants under the 1986 Amendments. However, these contaminants only represent a fraction of what can be and will be detected and identified through existing analytical methods and instrumentations.

Due to the inability of identifying all contaminants that may be present in drinking water, a variety of analytical methods (AWWA 1985; AWWARF and KIWA 1988) have been developed to provide some gross or non-specific measure of contaminant level in drinking water. Examples of non-specific measurements are TOC and assimilable organic carbon. However, as these measurements are non-specific, the health risk associated with the actual contaminants that comprise the measurement cannot be defined.

In an evaluation of the health effects associated with ground water recharge with reclaimed municipal wastewater (SAPGRRW 1987), TOC was used to characterize the quality of the ground water. Through the use of state-of-the-art technology, only 10% of the organic chemicals that comprise TOC were identified. SAPGRRW could not conclude that the identified organic chemicals posed the greatest health concern. The health affects associated with the unidentified contaminants remained unknown. As such, these methods are appropriate for use in the absence of available analytical methods for specific contaminants. Research into developing analytical methods should continue, however, to ensure contaminants that pose a potential public concern are identified and addressed.

Future activities may involve use of existing analytical methods with some modification. An example is the development of a "Master Analytical Scheme for Organic Compounds" (USEPA 1985). In this particular scheme, a sample is subject to sequential isolation and extraction of organic compounds to yield up to 10 fractions, with each fraction subject to analysis. Overall, 6 classes of chemicals for 217 different compounds may be analyzed from one sample. The six classes of chemicals are: (1) VOCs, (2) neutral water soluble organics, (3) weak acids, bases, and neutrals, (4) extractable semivolatile strong acids, (5) volatile strong acids, and (6) strong amines. USEPA (1985) has suggested that this scheme could be used in epidemiological studies to identify the type and level of contaminants in drinking water.

Cost of Analytical Methods and Instrumentation. The cost associated with a given analytical method and instrumentation is reflected in the cost of analysis charged by laboratories to perform the analysis. The statewide average cost per sample by accredited commercial laboratories (CDHS 1991a) may be summarized as: (1) inorganic chemicals plus general minerals - $364 (combined), (2) future regulated inorganic chemicals - $20 (cyanide) to $500 (asbestos), (3) corrosion by-products - $9 (pH) to $25 (lead), (4) DBPs - $102 (TTHMs only), (5) organic chemicals (screening method) - $153 (chlorinated pesticides for PCBs); (multiple contaminant methods) - $102 (fumigants) to $415 (base, neutral extractables); (single contaminant methods) - $144 (endothall) to $403 (2,3,7,8-TCDD {Dioxin}), and (5) radiochemicals (screening methods) - $42 (gross alpha) to $45 (gross beta); (single contaminant methods) - $62 to $146 (natural radiochemicals) and $30 to $65 (man-made radiochemicals).

There are a variety of factors that influence the cost of analysis. Some factors with respect to a given method and instrumentation are: (1) concentration of contaminant that must be detected, (2) number of contaminants that can be analyzed, (3) level of technical expertise required to perform the analysis and operate the equipment, (4) sample throughput (i.e., the number of samples that can be analyzed per unit time), (5) demand from clients for the analyses, and (6) level of quality control and quality assurance activities. The need for low detection levels, trained persons with an appropriate academic background, and increased quality control/quality assurance activities tends to drive up the cost of analysis on a per sample or per analyte basis. On the other hand, automation to increase sample throughout, increased demand for the analysis, and an increase in the number of contaminants that can be analyzed with a given method will generally drive down the cost of analysis on a per sample or per analyte basis. All of these factors are compounded by the economic competitiveness of businesses involved with environmental analyses in California.

In the development of inexpensive analytical methods and instrumentation, these and other factors must be taken into consideration in order for the cost of analysis to become "inexpensive." However, it must not be overlooked that the goal of monitoring and the need for certain "expensive" analytical methods and instrumentation is for public health protection. Through improved analytical capabilities, contaminants may be detected at concentrations that were previously unattainable. This in turn has allowed drinking water standards to be established at levels that are more protective of public health. As discussed later in Chapter VIII, the public must understand the need and importance of activities relating to drinking water in order to accept the expense associated with receiving a water supply that is pure, wholesome, and potable. Some activities public water systems themselves may take to reduce the cost of monitoring and analysis are discussed in Chapter VII.D.3.a. Financing with respect to the total cost of water is discussed in Chapter VIII. For those communities with specific financial difficulties, especially small water systems, some alternatives in reducing the total cost of water are discussed in Chapter X.

In addition to the development of new analytical methods and instrumentation, existing analytical methods and instrumentation should be evaluated with respect to their use in the detection and screening of newly regulated and unregulated contaminants, either for quantitating the contaminant or for screening purposes. Examples are the use of the chlorinated pesticides method to analyze for PCBs, and the gross alpha analysis for radium-226, radium-228, and uranium. In the event PCBs are detected, the amount is quantitated using the PCB method. When gross alpha levels exceed certain limits, the specific radiochemical must be analyzed for. It is important to note that chemical specific methods are available for the regulated or unregulated contaminants, but that screening methods may be used in lieu of the chemical specific methods provided certain limits are not exceeded.

Until additional inexpensive analytical methods and instrumentation are developed, an alternative is the use of field test kits. Field test kits are available from product manufacturers for contaminants such as microbial agent (total coliforms), nitrate, and organic chemicals (triazines). On a per sample basis, the cost of analysis is generally lower through a field test kit. However, the cost of the kit itself may be comparable to a single analysis by an accredited laboratory as the kit may be packaged for a minimum of 20 to 100 samples. An additional consideration in the use of the field test kits is the purpose of the test results. Analyses of samples must be conducted by accredited drinking water laboratories using specific analytical methods, pursuant to the federal and California SDWA. Unless a field test kit has received federal approval for use in drinking water, the results cannot be used for water compliance purposes and are not recognized by the Department. However, the results could be used for general information purposes, and to identify the need for additional testing by an accredited laboratory.

Proposal

Research needs have been identified based on a review of current and proposed analytical methods and treatment technologies for microbial agents and chemical contaminants. These needs include: (1) an inexpensive, easy-to-use method that will detect and confirm the presence of an indicator organism in less than 24 hours, (2) methods to detect and identify specific microbial agents such as *Giardia lamblia, Legionella*, and viruses, (3) methods for the detection of several organic chemicals below the *de minimus* level and/or current DLRs, and (4) methods to identify the chemicals that make up non-specific measurements to ensure contaminants that pose a potential public concern are identified and addressed. These needs are anticipated to increase in the future if unregulated contaminants monitored under special monitoring requirements become regulated via an MCL.

The California SDWA, Section 4021(b), HSC provides the Department with the responsibility to conduct research and studies relating to the provision of a dependable, safe supply of drinking water which may include: "(1)(A) Improved methods to identify and measure the existence of contaminants in drinking water..."

The Department should establish a research and development unit that is given the responsibility of carrying out Section 4021(b), HSC. The responsibilities of this unit could include, but not be limited, to:

- Identifying and prioritizing those contaminants of greatest concern in California where research is needed to develop suitable analytical methods and instrumentation.

- Developing new or revising existing methods for those contaminant found in California public water supplies for which approved or acceptable methods do not exist.

- Evaluating existing methods for screening and/or detection of contaminants to be monitored for solely in California.

- Coordinating research efforts with other research-oriented organizations, such as, USEPA's Environmental Monitoring and Systems Laboratory and AWWARF. The Department could focus efforts on those completed works by USEPA and/or AWWARF where additional work is needed for promising methods that would be most beneficial to consumers and purveyors in California. The latter approach particularly avoids duplication of effort.

Support for this research and development unit could be funded through a variety of funding mechanisms, such as:

- State wide fees on public water systems and accredited laboratories as they would be the beneficiaries of methods development.
- Outside funding for all or a portion of a specific research project. For example, the AWWARF provides 75% funding for research projects of common interest through a request for proposal and competitive bids process as well as for unsolicited proposals (AWWA 1991).
- Funding for specific research projects as eligible costs under a future long-term state financial assistance program.

D. FINANCIAL IMPACT OF CURRENT AND FUTURE MONITORING REQUIREMENTS

The cost associated with water quality monitoring has generally been of limited concern. When compared to other public water system costs to comply with regulations, the cost of monitoring represented a small percentage. In a recent report prepared for USEPA (Wade Miller Associates 1990), the cost of monitoring was roughly 10% of the annual total cost to comply with the 1986 Amendments[31] on a nationwide basis. However, a question has been raised under Section 4022(b)(2)(A), HSC for SDWP as to the cost of monitoring for primary drinking water standards at the consumer level. To address this question, a determination was made of the cost of current and future monitoring requirements.

1. Scope and Limitations

The financial impact of current and future monitoring requirements was estimated for five "typical" community water systems. This classification was selected as a majority of the permanent residential population are

[31] The subject report considered the: (1) final rule on fluoride, VOC, SWTR, and Total Coliform Rule, (2) proposed regulations for Phase II SOC, Phase II inorganic chemicals, and the Lead and Copper Rule, and (3) prospective regulations for radiochemicals, sulfate, arsenic, and disinfection of all public water supplies.

served by public water systems of this classification. Vital statistics for these systems are presented in Appendix 1.

In order to identify those current and future monitoring requirements that would be included for consideration, it was necessary to establish a cutoff date. Current monitoring requirements were limited to those state requirements in effect prior to January 1, 1991 (CCR 1990). These requirements considered microbial agent (total coliform), general physical, general mineral, inorganic chemicals, organic chemicals (VOCs and SOCs), DBPs, and radiochemicals. General physical and general mineral were included to account for all contaminants monitored for in California, not just those with established primary drinking water standards. Future monitoring requirements were limited to those federal and state requirements proposed as of January 1, 1991, some which became effective on or after January 1, 1991. Federal proposals considered the Lead and Copper Rule, Phase II and V inorganic chemicals, Phase II and V organic chemicals (VOCs and SOCs), and special monitoring requirements for unregulated chemicals (inorganic chemicals and SOCs) (USEPA 1988, 1989a, and 1990c). State proposals considered the Total Coliform Rule and special monitoring requirements for unregulated organic chemicals (VOCs and SOCs) (CDHS 1991b and CCR 1990). Unregulated chemicals were included to account for all contaminants with proposed monitoring requirements, not just those with proposed primary drinking water standards. Although not proposed to date, future monitoring requirements for radon (a Phase III radiochemical) and TTHM (a Phase IV DBP) were projected for the five typical community water systems, based on current state monitoring requirements (CCR 1990).

The impact of monitoring requirements associated with the state SWTR, Phase VI drinking water priority list, and disinfection of public water supplies using ground water sources were excluded from consideration. Turbidity and the contaminants associated with the state SWTR were excluded as monitoring costs are operation and maintenance costs for process control. Capital and annual costs for the state SWTR are provided in Table 8.9. Requirements for Phase VI contaminants and disinfection requirements were excluded as: (1) the regulations have not been proposed to date, (2) the contaminants were covered under other current or future monitoring requirements, and (3) for contaminants not covered under current or future monitoring requirements, there was a lack of cost of analyses data or comparable contaminants groups under current requirements that proposed monitoring schedules could be based upon.

The current and future monitoring requirements were also limited to routine monitoring requirements, with routine monitoring distinguished between "initial" and "continuing" monitoring requirements. For contaminants where a vulnerability assessment was to be made, all systems and sources were assumed to be "vulnerable" to contamination. This would therefore represent the "worst case scenario" for such contaminants. To avoid "double counting" of monitoring requirements and costs as a result of overlap in the monitoring requirements, current monitoring requirements were cross-checked against future monitoring requirements, and monitoring of regulated contaminants was cross-checked against monitoring of unregulated contaminants.

In developing the cost to comply with current and future monitoring requirements, costs were limited to the cost of analyses (i.e., cost charged by laboratories). The cost of analyses information was obtained through a survey of commercial laboratories accredited by ELAP for drinking water analyses (CDHS 1991a). The cost of follow-up monitoring when initial test results exceed a drinking water standard, sampling for routine (initial and continuing) and follow-up monitoring, and maintaining an in-house laboratory (if applicable) are additional monitoring costs that have not been included. These costs, which may be significant, will need to be addressed by public water systems.

2. Findings

The cost to comply with current and future monitoring requirements for the five "typical" water systems are summarized in Table 7.1 Cost breakdown by contaminant group for current and future monitoring requirements are presented in Tables 7.2 and 7.3, respectively. All costs are shown in 1990 dollar costs on a dollar per service connection per year basis. Initial costs are associated with the initial monitoring requirements, and are expressed as a one-time cost distributed over one year. Continuing costs are associated with the continuing monitoring requirements and are annualized over the monitoring cycle.

The costs and percentages that are discussed in the following paragraphs only apply to the "typical" community water systems as described in Appendix 1. Costs for an actual public water system must be determined on an individual basis due to differences in actual monitoring requirements and statewide differences in the cost of analyses.

CHAPTER VII

WATER QUALITY MONITORING

Table 7.1 Annual Cost of Current and Future Monitoring Requirements for Five "Typical" Community Water Systems ($/service connection/year) [1]

	Type of "Typical" Water System [2]				
	Very Small	Small	Intermediate	Medium	Large
Current Monitoring Costs [3]					
Initial Annual Cost [5]	$346	$104	$42	$12	$5
Continuing Annual Cost	$67	$21	$8	$3	$2
Future Monitoring Costs [4]					
Initial Annual Cost [5]	$956	$282	$112	$33	$11
Continuing Annual Cost	$135	$61	$20	$9	$3
Total Monitoring Costs					
Initial Annual Cost [5]	$1,302	$386	$154	$45	$16
Continuing Annual Cost	$202	$82	$28	$12	$5

1 Costs presented are in 1990 dollars.
2 Vital statistics for "typical" water systems are presented in Appendix 1.
3 Monitoring costs were associated with contaminants monitored in California prior to January 1, 1991.
4 Monitoring costs were associated with future federal and state contaminants that have been proposed as of January 1, 1991.
5 Initial cost involves an intensified, one-time monitoring schedule, with costs distributed over one year.

Table 7.2. Annual Cost of Current Monitoring Requirements for Five "Typical" Community Water Systems by Contaminant Group ($/service connection/year) [1]

	Type of "Typical" Water System [2]				
Contaminant	Very Small	Small	Intermediate	Medium	Large
Microbial Agent					
(Total Coliform)	$15.20	$2.28	$0.99	$0.85	$0.86
Turbidity [3]	------	------	------	------	------
General Physical	$0.84	$0.51	$0.15	$0.04	$0.01
General Mineral	$3.80	$2.28	$0.68	$0.16	$0.05
Inorganic Chemicals	$4.29	$2.57	$0.77	$0.18	$0.06
Disinfection By-Products					
(Total Trihalomethanes)	N/R[4]	N/R	N/R	$0.47	$0.10
Organic Chemicals					
Initial [5]	$334.67	$100.40	$40.16	$11.47	$3.90
Repeat	$41.83	$12.55	$5.02	$1.43	$0.49
Radiochemicals					
Natural					
Initial [5]	$11.20	$3.36	$1.34	$0.38	$0.13
Repeat	$0.70	$0.42	$0.17	$0.05	$0.02
Man-made					
Initial [5]	N/R	N/R	N/R	N/R	$0.61
Repeat	N/R	N/R	N/R	N/R	$0.04
Total					
Initial Annual Cost [5]	$345.87	$103.76	$41.50	$11.85	$4.64
Continuing Annual Cost	$66.66	$20.61	$7.78	$3.18	$1.63

[1] Costs presented are in 1990 dollars.
[2] Vital statistics for "typical" water systems are presented in Appendix 1.
[3] Cost for turbidity excluded as monitoring is conducted at the surface water treatment plant for operational process control. Future costs have been incorporated into the state SWTR water treatment costs in Table 8.9.
[4] Monitoring not required for this particular "typical" water system.
[5] Initial cost involves an intensified, one-time monitoring schedule, with costs distributed over one year.

Table 7.3. Annual Cost of Future Monitoring Requirements for Five "Typical" Community Water Systems by Contaminant Group/Regulation ($/service connection/year) [1]

Contaminant/Regulation	Very Small	Small	Intermediate	Medium	Large
	Type of "Typical" Water System [2]				
Microbial Agent (Total Coliform) [3]	$4.80	$0.72	$0.31	$0.36	$0.28
Turbidity, Temperature, pH, and Residual Disinfectant [4]	------	------	------	------	------
Inorganic Chemicals					
Phase II					
Asbestos					
Initial [5]	$33.33	$10.00	$4.00	$1.14	$0.39
Repeat	$11.11	$6.67	$2.00	$0.48	$0.15
Nitrate/Nitrite	$2.87	$2.15	$0.60	$0.14	$0.04
Barium, Cadmium, Chromium, Mercury, and Selenium; and Copper and Lead	------ [6]	------ [6]	------ [6]	------ [6]	------ [6]
Phase V					
Antimony, Beryllium, Nickel, and Thallium	$2.22	$1.33	$0.40	$0.10	$0.03
Cyanide	$0.44	$0.27	$0.08	$0.02	$0.01
Sulfate	------ [6]	------ [6]	------ [6]	------ [6]	------ [6]
Corrosion By-Products					
Initial [5]	$35.33	$5.30	$1.06	$1.82	$0.32
Repeat	$7.07	$1.06	$0.53	$1.82	$0.32
Disinfectants and Disinfection By-Products: Total Trihalomethanes	N/R [7]	$16.32	$3.26	------ [6]	------ [6]
Organic Chemicals					
Volatile Organic Chemicals (Phase II and V)					
Initial/Repeat	------ [6]	------ [6]	------ [6]	------ [6]	------ [6]
Synthetic Organic Chemicals (Phase II and V)					
Initial [5]	$472.80	$141.84	$56.74	$16.21	$5.50
Repeat	$94.56	$28.37	$11.35	$5.40	$1.83

Table 7.3 (con't). Annual Cost of Future Monitoring Requirements for Four "Typical" Community Water Systems by Contaminant Group/Regulation ($/service connection/year) [1]

	Type of "Typical" Water System [2]				
Contaminant/Regulation	Very Small	Small	Intermediate	Medium	Large
Special Monitoring for Unregulated Chemicals					
Inorganic Chemicals					
Initial	------ [8]	------ [8]	------ [8]	------ [8]	------ [8]
Repeat [9]	------	------	------	------	------
Synthetic Organic Chemicals					
Initial [5]	$265.07	$79.52	$31.81	$9.09	$3.09
Repeat [9]	------	------	------	------	------
Volatile and Synthetic Organic Chemicals					
Initial/Repeat (VOC)	------ [6]	------ [6]	------ [6]	------ [6]	------ [6]
Initial (SOC) [5]	$135.20	$40.56	$16.22	$4.64	$1.57
Repeat (SOC)	$11.27	$4.23	$1.52	$0.41	$0.14
Radiochemical					
Radon					
Initial [5]	$14.40	$4.32	$1.73	$0.49	$0.17
Repeat	$0.90	$0.27	$0.11	$0.03	$0.01
Total					
Initial Annual Cost [5]	$956.13	$282.04	$111.56	$33.39	$11.04
Continuing Annual Cost	$135.24	$61.39	$19.85	$8.76	$2.81

1 Costs presented are in 1990 dollars.
2 Vital statistics for "typical" water systems are presented in Appendix 1.
3 Costs represent the <u>incremental</u> cost increase to comply with the state proposed Total Coliform Rule.
4 Costs for turbidity, temperature, pH, and residual disinfectant excluded as monitoring is conducted at the surface water treatment plant for operational process control. Costs have been incorporated into the state SWTR water treatment costs in Table 8.9.
5 Initial cost involves an intensified, one-time monitoring schedule, with costs distributed over one year.
6 Costs have been incorporated under current monitoring requirements for this "typical" water system.
7 Monitoring not required for this particular "typical" water system.
8 Costs have been incorporated under current and future monitoring requirements for this "typical" water system.
9 No repeat monitoring requirements proposed for these contaminants.

a. General Cost Trends

For the five "typical" community water systems, the cost per service connection decreased as the size of the water system increased, for total, current and future, and initial and continuing monitoring requirements. Even through the larger water systems had a greater number of sources and were subject to increased sampling for some of the current and future monitoring requirements, the overriding factor in reducing costs was the number of service connections. Larger water systems had a greater number of service connections to distribute the costs over as compared to the smaller water systems. Consumers served by smaller water systems could therefore be expected to pay the most, with consumers served by larger water systems paying the least, for their portion of the monitoring costs.

The cost to the five "typical" community water systems also decreased as the size of the water system increased, for each type of contaminant group under the current and future monitoring requirements. Again, the overriding factor for this trend was the greater number of service connections for the larger water systems. The exception to this trend was with the microbial agent (total coliform) for current and future monitoring requirements and corrosion by-products (Lead and Copper Rule) under future monitoring requirements. The decreasing trend was not observed for these contaminants due to: (1) the number of samples required for a given size water system, and (2) the number of services connections used for the "typical" systems.

With respect to current and future costs for a given "typical" community water system, future costs were higher than current costs. Future costs were higher due to the greater number and type of contaminants to be monitored. Many of the contaminants are associated with analytical methods that are performed by trained analysts using sophisticated analytical equipment, which was reflected in the cost of analyses. As the future costs only reflected a portion of expected federal and state requirements, these costs will likely be greater once all future federal and state requirements are promulgated.

For initial and continuing costs for a given "typical" community water system, initial costs were higher than continuing costs. Initial costs were higher as initial monitoring is generally conducted at a greater frequency as compared to continuing monitoring for some contaminants. However, the overriding factor was that the initial costs were only distributed over one year. While the initial cost for some contaminants (i.e., those with continuing monitoring requirements) could have been distributed over a monitoring cycle, other contaminants (i.e., federal special monitoring requirements for unregulated chemicals (SOCs)) only involved one-time monitoring. Therefore, all initial costs were distributed over one year to show the impact of the initial monitoring requirements over a common time line, and the "total" one-time surcharge to consumers if the initial monitoring costs are not planned and budgeted for.

b. Initial Costs and Continuing Costs

The total initial cost for current and future monitoring requirements combined varied from $16 to $1,302 per service connection per year. These combined total costs are about 19 and 8 times higher than the continuing cost to meet current monitoring requirements for the very small and large water systems, respectively. Monitoring for primary and secondary drinking water standards and unregulated contaminants accounted for 69%, zero%, and 31% of the costs, respectively. About 92% to 97% of the total costs are associated with contaminants where a vulnerability assessment is required. These contaminants consisted of organic chemicals under the current monitoring requirements, and contaminants from the following future monitoring requirements: (1) Phase II inorganic chemical (asbestos), (2) Phase II and V SOCs, and (3) special monitoring requirements for unregulated chemicals (VOCs and SOCs). Overall, the initial monitoring for one of the two contaminant groups (i.e., the organic chemicals- SOCs and VOCs) accounted for the majority (84% to 97%) of the current initial costs. The monitoring for two of the five future contaminant groups/regulations accounted for the majority (90% to 94%) of the future initial costs: (1) Phase II and V SOCs and (2) special monitoring requirements for unregulated chemicals (SOCs).

The total continuing cost for current and future monitoring requirements combined varied from $5 to $202 per service connection per year. These combined total costs are about three times higher than the continuing cost to meet current monitoring requirements for the very small and large water systems. Monitoring for primary and secondary drinking water standards and unregulated contaminants accounted for 91% to 96%, 1% to 3%, and 3% to 6% of the costs, respectively. About 59% to 79% of the total costs are associated with contaminants where a vulnerability assessment is required. These contaminants are the same as those identified in the previous paragraph. Overall, the monitoring for two of the seven current contaminant groups/regulations accounted for the majority (72% to 86%) of the current continuing costs: (1) microbial agent (total coliform) and (2) organic chemicals. With respect to future continuing costs, the monitoring for two of the seven future contaminant groups accounted for the majority (63% to 82%): (1) Phase II and V inorganic chemicals and (2) Phase II and V SOCs.

3. Issue

a. Reducing the Cost of Monitoring

Monitoring costs can be expected to increase as drinking water regulations are established for new contaminants detected in California public water supplies and to meet the requirements of the 1986 Amendments. Based on the example of five "typical" community water systems, the cost of routine monitoring may triple for consumers served by all sizes of public water systems. Consumers served by smaller water systems will experience the greatest impact due to a lack of economy of scale. Although the cost of current and future routine monitoring accounts for a small portion or will have a small impact on the total cost of water, as presented later in Chapter VIII, public water systems will still need to plan and budget for these costs. This is especially true of the costs associated with the initial monitoring requirements. These initial costs may be significant and must be considered in order to avoid sharp increases or "one-time surcharges" to the consumers water bill.

Throughout this chapter, several proposals have been presented that could be used to reduce the cost of monitoring. These proposal are: (1) an evaluation of a state-instituted sampling program that would be targeted for small water systems (Chapter VII.A.1.b), (2) an evaluation of alternatives to provide for flexibility in the monitoring requirements while maintaining the same level of public health protection and consumer acceptance of the water (Chapter VII.A.1.c), (3) the consolidation or sharing of in-house laboratory capability of public water systems with other public water systems (Chapter VII.B.1.c), and (4) the development of inexpensive methods for drinking water analyses (Chapter VII.C.1).

In addition, there are activities public water systems could consider to reduce their cost of monitoring. For most public water systems, the cost of monitoring involves two costs: (1) implementation of a drinking water monitoring program and (2) cost of analyses. Both costs could be addressed through the consolidation of monitoring programs by joint sample collection and analyses. Through sharing of resources and conducting monitoring activities as a group, associated costs are spread out over a larger group of participants than if conducted through an individual effort.

Sample collection could be conducted through the use of a circuit-rider, by arrangement with noncommercial laboratories, or through a contract with commercial laboratories. A group of samples could then be submitted to noncommercial or commercial laboratories for analyses. In a survey of accredited drinking water laboratories (CDHS 1991a), commercial and noncommercial laboratories reported the availability of discounts. These discounts, which may vary between laboratories, were based on a variety of factors, such as the number of samples submitted at one time, the total dollar value of the analyses, or by establishing a contract with the laboratory. As an example, commercial laboratories on average offered a volume discount of 10%, 14%, and 15% for >4-5, >9-10, and >19-20 samples, respectively, when submitted at one time for the same analyses.

However, in the selection of a laboratory, it is not the intent of this discussion to encourage public water systems to seek out a laboratory that will conduct the analyses at the least expense. The cost of analyses is only one of many factors public water systems need to consider in the selection of a laboratory, whether the laboratory is non-commercial or commercial (Wade Miller Associates 1989; Koorse 1990). Additional factors to consider are laboratory certification, degree of instrumentation, technical expertise of key employees, accuracy of data, quality assurance and quality control, reputation of the laboratory, responsiveness and turnaround time, geographic proximity, types of services provided by the laboratory, and continuity of management.

CONCLUSIONS AND RECOMMENDATIONS

The potential for intentional data falsification and unintentional data error is present in the drinking water quality monitoring program in California. While not believed to be extensive, both have been detected in California and other states. As part of it's regulatory program, ODW should conduct routine drinking water verification check sampling to substantiate drinking water test results submitted by all public water systems.

Recommendation: The Office of Drinking Water should be authorized and funded to implement a verification check sampling program of public water systems in California and legislation should be considered to require direct reporting from laboratories to the Office of Drinking Water of test results from analyses conducted pursuant to the California SDWA.

Water quality monitoring requirements in California have historically been more stringent than federal monitoring requirements. With the passage of the 1986 Amendments and its forthcoming increased monitoring requirements, there is a need to identify means by which current monitoring requirements in California can be revised to provide for flexibility in monitoring and yet maintain the same level of public health protection and consumer acceptance of the water. At the same time, there is a need to consider whether compliance with secondary drinking water standards should be treated the same as primary drinking water standards.

Recommendation: The Office of Drinking Water should evaluate the current source and distribution system monitoring requirements with respect to the factors used in determining the monitoring requirements and the frequencies of monitoring. The evaluation should include identifying means by which monitoring can be made more flexible while still maintaining the same level of public health protection and consumer acceptance of the water. The evaluation should include, but not be limited to, developing and evaluating vulnerability assessment criteria for contaminant groups other than organic chemicals, and the use of statistical design and mathematical modeling.

Vulnerability assessment determination is anticipated to play a greater role with respect to future monitoring requirements. Information concerning sources of potential hazards to a public water system and its sources is needed by ODW to make the determination. Public water systems may benefit from documenting land use practices within the system and in the vicinity of the sources. Potential hazards beyond the service area may also be of importance. Establishment of a wellhead protection program would serve to provide this information, in addition to protecting ground water supplies by identifying wellhead protection areas.

Recommendation: The Office of Drinking Water should develop a guidance document for public water systems on the criteria used and information needed by the Office of Drinking Water to determine the vulnerability assessment of a public water system and ground and surface water sources.

Small water systems will be faced with the task of meeting current and ever increasing, complex, future monitoring and reporting requirements with inadequate resources. From a regulatory perspective, small water systems represent an area in which substantial resources will be needed. Efforts by ODW and small water systems should be coordinated to make the best use of existing resources to achieve public health protection in a cost effective manner. A careful evaluation should be made regarding a state-instituted sampling program for small water systems, comparable to existing programs in other states and some counties in California. The evaluation should identify the scope, cost, benefits, and potential problems of a state-instituted sampling program.

Recommendation: A thorough study should be conducted by an independent contractor to determine the feasibility of a state-instituted drinking water sampling program for small water systems.

Laboratory accreditation activities are expected to increase with the promulgation of monitoring requirements for regulated and unregulated contaminants under the 1986 Amendments. Department oversight of laboratories and public water systems will be greater than what has historically been required. Greater enforcement and support for ODW activities may be needed as public water systems begin to implement the monitoring requirements.

Recommendation: The Department should coordinate and synchronize the drinking water regulatory and laboratory accreditation process.

Federal and state regulations provide for field analysis of general physical (color, odor, and turbidity), free chlorine residual, pH, and temperature. However, state statutory authority is in reference to a laboratory and not an individual. As several contaminants are and will be used to determine compliance with primary drinking water regulations, a quality assurance program should be established for these contaminants to assure the validity of the data. This program should include analyses of these contaminants in a laboratory as recommended by USEPA.

Recommendation: Statutory authority requiring analyses conducted pursuant to the California SDWA to be performed by an accredited laboratory should be revised to expressly provide for flexibility needed in performing field analyses conducted pursuant to the California SDWA.

Recommendation: The Department should establish a quality assurance program for field and laboratory analyses of general physical (color, odor, and turbidity), free chlorine residual, pH, and temperature that are conducted pursuant to the California SDWA by public water systems and laboratories.

Public water systems in remote locations with in-house laboratories may need to re-evaluate the costs and benefits associated with maintaining an in-house laboratory, due to annual laboratory accreditation fees mandated under the fee-supported ELAP. These public water systems should consider alternatives by which monitoring and analyses in compliance with drinking water regulations may be conducted at a reduced cost and to address the laboratory accessibility problem in certain areas with respect to microbial agent (total coliform) analysis.

Recommendation: Public water systems with in-house laboratories should consider sharing or consolidation of resources to reduce costs and provide for laboratory accessibility for microbial agent (total coliform) analysis.

A drinking water laboratory plays an important role in public health protection. Actions taken by public water systems to avoid a potential public health problem are dependant upon receipt of verbal and written test results. While many laboratories recognize the importance of their role, there have been instances where verbal and written test results have not been provided to public water systems in a timely manner. Communication, both verbal and written, between public water systems and laboratories needs to be improved to enable public water systems to meet the mandates of the California SDWA -- protection of public health and compliance with monitoring and reporting requirements.

Recommendation: The Department should review and revise as needed the current verbal and written communication requirements specified in regulations for public water systems and laboratories.

A review of current and proposed analytical methods and treatment technologies has identified the need to improve upon existing methods to provide a greater degree of public health protection. Research is also needed to evaluate and correlate the use of surrogate parameters at surface water treatment plants, and surrogate parameters for ground water recharge to identify and address contaminants that pose the greatest health concern. These needs are in addition to methods for unregulated contaminants may be regulated via an MCL at the federal and/or state level. The California SDWA, Section 4021(b), HSC provides the Department with the authority to conduct research relating to the provision of a dependable, safe supply of drinking water, including, but not limited to improved methods to identify and measure the existence of contaminants in drinking water.

Recommendation: The Department should establish and fund a research and development unit to conduct research on new methods and to improve upon existing methods that could be used to identify and measure the existence of contaminants in California drinking water supplies.

The cost of monitoring to meet current and future, continuing and initial monitoring requirements will increase for all public water systems. Consumers served by smaller water systems will experience the greatest impact due to the lack of economy of scale. Although the cost of monitoring accounts for a small portion or will have a small impact on the total cost of water, public water systems will still need to plan and budget for these costs. Public water systems should consider alternatives by which monitoring and analyses in compliance with drinking water regulations may be conducted at a reduced cost.

Recommendation: Public water systems should consider consolidation of monitoring programs for sample collection and/or analyses to reduce sampling costs and/or to take advantage of discounts offered by laboratories.

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CHAPTER VIII

FINANCIAL ASPECTS

A. COST OF DRINKING WATER

Consumers typically have maintained an attitude that plentiful water of the highest quality is their right, but have not always willing to pay the cost associated with that right. Water has traditionally been undervalued because of its abundance. Although water covers nearly three quarters of the earth's surface, only 0.033% of the world's total supply is freshwater available for human use (AWWA 1989). Water is essential to every form of life, but is often taken for granted by consumers (ASDWA 1990). Because of these attitudes, there have been substantial controversies in California communities regarding water rate increases and metering of service connections in unmetered water systems.

The era of inexpensive water, however, is coming to an end. Not only has the public become concerned about reports of water contamination, but the current five-year drought in California has also contributed to changing the attitude of "abundant, cheap water," and brought to the forefront the problems faced by the state in balancing water quality with water quantity at an affordable price to the drinking water consumer.

It is true that an adequate, reliable supply of pure, wholesome, and potable water is the "right" of consumers served by public water systems; hence the many laws and drinking water standards adopted by the state and federal governments applicable to public water systems. However, as the public demands more stringent drinking water standards, there must be a realization that with the greater assurance of the safety of the water and reduced risks, there will be associated increases in the cost to provide that assurance, through the use of high-cost analytical methodology and treatment techniques, as well as increased regulatory controls and oversight.

In many water utilities, water rates have been kept artificially low by deferring expenditures for needed maintenance and replacement of water treatment facilities and distribution systems (ASDWA 1990). This has resulted in deficient operation and maintenance programs, with many systems now facing the need to replace outdated or severely aged infrastructure such as leaking mains and deficient storage capacity.

Other programs, such as routine water main flushing and valve maintenance, which would improve the water system efficiency, have not been implemented because of cost considerations.

The increased cost of providing drinking water has resulted from the need to provide increased treatment to the water, as sources become contaminated due to increased population densities, urbanization, and pollution from industries and waste facilities. Regulatory controls by both the state and USEPA have required increased monitoring for detection of chemical and microbial contaminants. Improved analytical methodologies, to detect minute concentrations of chemicals and previously unidentified viruses and bacteria, have also become somewhat expensive. There is a vast amount of monitoring required of public water systems to provide a valid database to characterize water quality and determine compliance with drinking water standards.

The health benefits of monitoring and treatment will be manifested in a decreased number of illnesses related to drinking water. Since the first use of chlorine as a means to disinfect drinking water for consumption in the early 1900s, cases of waterborne illness have dramatically decreased. In the case of reducing chemical contamination, the benefits may not be readily apparent to consumers, since these benefits will be spread over many generations as a result of the reduction in the risk of chronic health effects, such as cancer, which sometimes take a lifetime to develop.

Only if consumers understand the benefits associated with these increasing costs of providing a reliable supply of safe, wholesome, and potable water will they come to accept them. Public education will be the cornerstone in facilitating this understanding

1. Cost of Water Survey

To determine the current cost of drinking water in California, as required in Section 4022(b)(9) HSC, ODW conducted a survey to collect information, such as water rates, water usage, and average water bills from large, medium, intermediate, and small community water systems. The *Survey of Community Water Systems in California* was mailed to all public water systems in California in early 1990.

The information from responses to the Department's *Survey of Community Water Systems in California* was summarized by Morgan and Mercer (1991). Additional summary and analysis is provided below. The information herein represents the price charged to customers in community water systems as opposed to the cost to the water utility to produce water. The cost of water in non-community water systems could not be assessed because there are typically no water rates charged to consumers of the water in these systems.

Of the many survey responses received, information from 1,083 surveys was used in the detailed analysis prepared by Morgan and Mercer. Of these, 559 were from metered utilities and 524 were from unmetered utilities. The survey information was analyzed to present cost figures for drinking waters in California based on types of utility ownership, size of water system, regional variations, and type of water source and treatment provided. Although water rate information was requested and received on the survey form for all types of customer classifications, only information for single-family residential customers was analyzed by Morgan and Mercer.

The survey results show that the statewide average cost for drinking water for single family residential customers was $21.30 per month in metered systems and $19.31 in unmetered systems.

a. Type of Ownership

The three ownership classifications analyzed are publicly-owned, investor-owned, and mutual water companies. Morgan and Mercer reported that the average monthly water bill for single-family residents in metered water systems was the lowest for publicly-owned systems at $20.57, with investor-owned systems averaging slightly higher at $20.68 per month. Mutual water companies had the highest average monthly bill for metered systems at $28.20, which was 37% greater than in publicly-owned water systems. Mutuals represented the smallest percentage of respondents and had the largest statewide variation in average bill paid by consumers.

The fact that the water bills in publicly-owned systems are the lowest is not surprising. Publicly-owned systems have other resources from which to generate revenues, as is discussed in Section B - Sources of Revenue, that are not available to the investor-owned and mutual water companies, such as taxation and special assessments and other user charges. The investor-owned and mutual water companies must generate all or most of their revenues through the water rates.

Figure 8.1 illustrates the relationship for unmetered systems. The relationship between the monthly bill in publicly- and investor-owned systems is reversed, with customers in investor-owned unmetered systems paying on average $13.67 per month, where as those in publicly-owned systems averaged $17.87 per month, a 31% difference.

Again, mutual water companies had the highest average monthly bill, at $19.73.

The average monthly bill for customers in unmetered water systems was significantly less than that for metered customers in all ownership categories. The publicly-owned systems had the closest association, with unmetered bills 13% less than metered average monthly water bills. Investor-owned utilities had a 34% difference, and the mutuals a 30% difference.

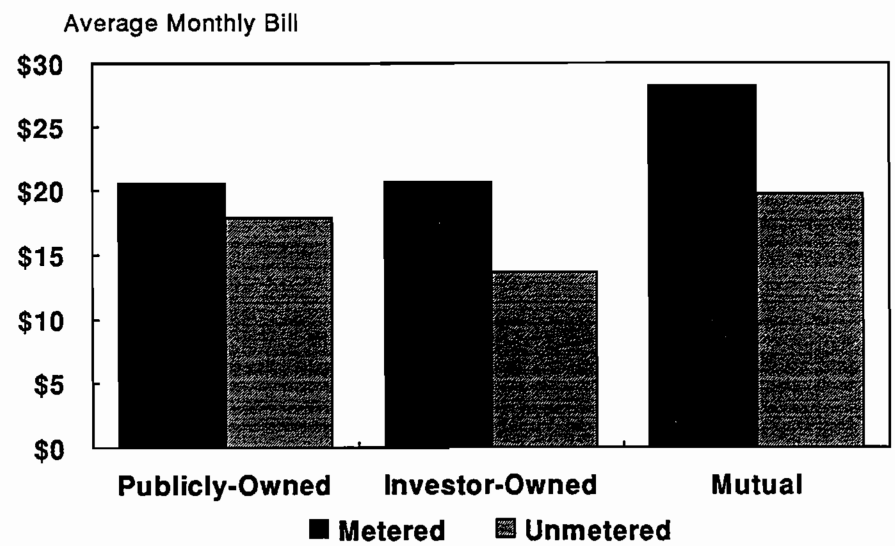

Figure 8.1. Average Monthly Bill by Type of Utility Ownership

b. Utility Size

The monthly costs were analyzed using the following size classifications: small (15 to 199 service connections), intermediate (200 to 999 service connections), medium (1,000 to 9,999 service connections), and large (10,000 or more service connections). The classifications were identified to provide breakdown of cost by size of system, and do not correspond to the regulatory definitions for large and small water systems. Morgan and Mercer reported the average monthly bill and total charge for consumption of 1,500 cubic feet (cf) and 3,000 cf of water. This information is presented in Table 8.1 and Figure 8.2.

On average, customers in the small systems in both the metered and unmetered categories pay about 40% more for drinking water than customers in the large water systems. The greatest difference in average monthly bills in metered systems occurs between the small and intermediate sizes, with the small systems paying 19% more than intermediate. The difference between intermediate and medium size systems is 3%, and 2% between medium and large. Costs per service connection escalate when the system size is less than 200 service connections. The most significant reason for this is a lack of economy of scale in all phases of operation of a small water system. It can also be determined that customers in unmetered systems pay between 20% and 36% less for drinking water, depending on size, than customers in metered systems.

Table 8.1 Average Cost of Drinking Water by Utility Size[a]

	Metered			Unmetered
Size (No. of service connections)	**Average Monthly Bill**	**Average Charge at 1500 cf**	**Average Charge at 3000 cf**	**Average Monthly Bill**
Small (15-199)	$26.03	$25.01	$45.95	$18.76
Intermediate (200-999)	$21.91	$21.44	$40.45	$17.44
Medium (1,000-9,999)	$21.27	$17.61	$30.67	$13.60
Large (>/=10,000)	$20.87	$16.28	$28.80	$15.20

[a]Data from Morgan and Mercer 1991, Table 6

At a usage level of 1,500 cf per month, customers in small systems pay over 50% more for this volume of water than do customers in large water systems. This comparison shows what the cost to customers would be in each size system if the same volume of water were consumed by each. The cost per unit of volume is much greater in smaller systems, but is not reflected in the monthly bill. The conclusion is that customers in smaller systems use less water than those in large water systems. This may be partly due to the general rural location of many of the small water systems, where less importance in placed on landscape maintenance.

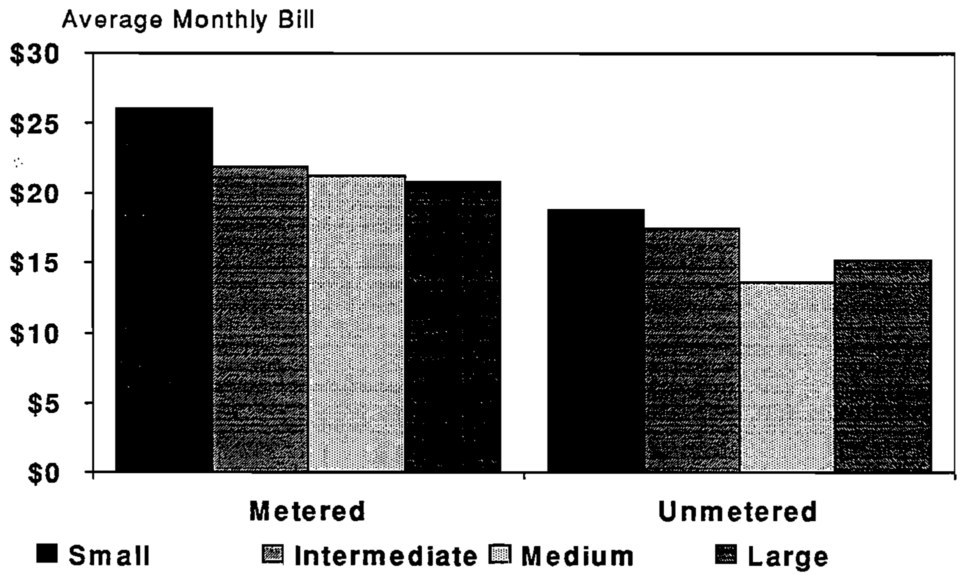

Figure 8.2. Average Monthly Bill by Utility Size

c. Water Source and Treatment

Three classifications of drinking water sources were identified by Morgan and Mercer: ground water, surface water, and combined (those utilities that use both surface and ground water, or purchase water from others). The survey also asked if the water was treated prior to distribution. Table 8.2 reports the average charge for water at 1,500 and 3,000 cf per month for metered water systems. The average charge is presented for treated and untreated drinking water for each type of source. In the survey, chlorination was classified as a treatment process. Due to the limited information provided, a similar comparison cannot be made for the unmetered water systems.

Overall, treated surface water is the most expensive source of supply for California consumers. The cost to provide treatment to ground water is very similar, at only 2% to 3% lower. This is due to the high capital cost to construct water treatment facilities and the high on-going costs to operate and maintain these facilities. With surface water, all water delivered to customers must be treated, whereas for ground water, if treatment is provided due to chemical or microbiological contamination, it is usually on a source by source basis; few utilities that use ground water are required to provide treatment on all wells serving their system. Of the utilities using surface water, almost all will also have ground water sources that are used as emergency sources or to buffer seasonal or peak day demands.

The survey results show that treated surface water is about 2% to 3% more expensive that treated ground water, and 23% to 27% more expensive than untreated ground water.

Table 8.2 Average Charge for Treated and Untreated Drinking Water

	Average Monthly Charge at 1,500 cf	**Average Monthly Charge at 3,000 cf**
Ground Water		
Treated	$21.04	$35.03
Untreated	$17.60	$28.12
Surface Water		
Treated	$21.58	$35.77
Untreated	$21.44	$34.07

d. Regional Variations

A significant regional variation occurs in the cost of drinking water. To show this, the state was divided into six areas which conform roughly to similar watershed, climatic, or wholesale service areas. The purpose was to set boundaries to include similar water sources, water use, and consumption characteristics within the same regions. These regions have been identified in Figure 8.3 as the Bay Area, Central Coast, Central Valley/Agricultural (includes Imperial County), Foothill, Mountain/Desert, and Southern California. Table 8.3 shows the average monthly charge and average monthly bill by region. The lowest average monthly bill was found in the Mountain/Desert region at $16.00 and $15.98 for metered and unmetered systems, respectively; whereas the lowest monthly charge for water at 1,500 cf and 3,000 cf was in the Central Valley/Agricultural region.

Interestingly, of the utilities providing information from the Central Valley/Agricultural region, over 65% were unmetered water systems.

Central Coastal customers have the highest average monthly bills for both metered and unmetered systems at $28.22 and $23.69, respectively. These comparisons can be seen in Figure 8.4. Bay Area water utilities were found to have the highest monthly charges for water for usage of 1,500 cf and 3,000 cf.

There are several reasons why water costs vary so significantly throughout California. One reason, as was discussed previously, is the variation in the source of the water and the type of treatment that may be required. For example, surface water, which is the major source of supply for drinking water in the Bay Area and Southern California, is more expensive due to the high level of treatment required to make it potable. Concerns about water quantity as a result of the on-going drought, which had been in its third year at the time of the survey, may have impacted water rates, especially in some Bay Area and Central Coastal communities. These communities may have increased rates as consumption increases as a means to induce water conservation; hence the significantly higher cost for 3,000 cf of consumption over the 1,500 cf rate in these regions.

2. Comparison to National Water Rates

It is difficult to compare the results of the *Survey of Community Water Systems in California* to national water rates. Two national water rate surveys have been conducted recently, one by the Ernst & Young National Environmental Consulting Group, the other by the AWWA. The difficulty lies in the type of utilities that were included in these two national surveys, which were typically large municipal water systems. The results of these surveys may reflect the average cost to the majority of customers in public water systems. However, they do not even hint at the much higher cost for water in smaller communities. Therefore, these two national surveys will be used only to compare the results for California and the nation. As a comparison to these two surveys, USEPA has estimated that the nationwide average annual household water bill is about $250, or $20 per month.

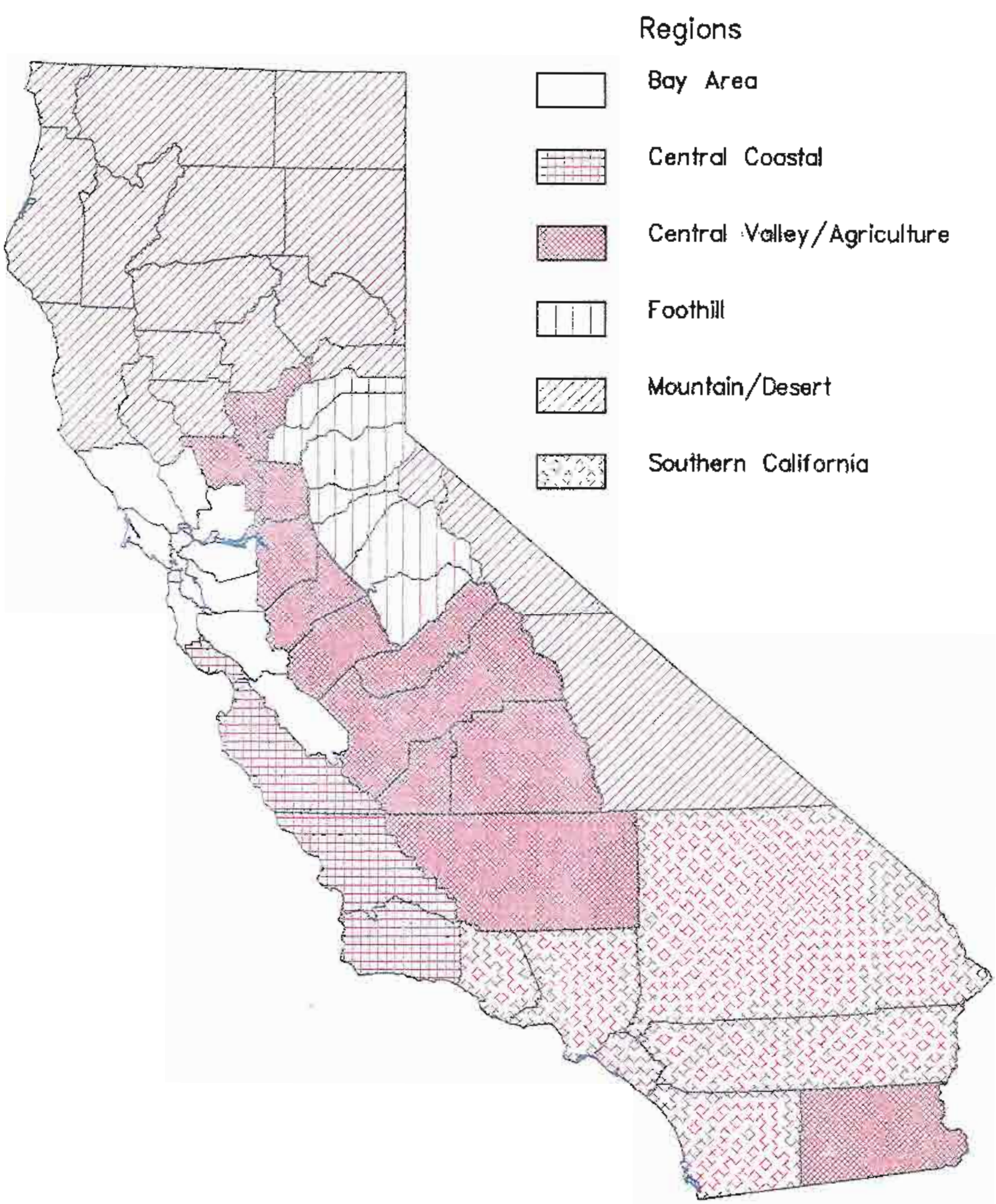

Figure 8.3
California Regions for Cost Comparisons

Table 8.3 Average Cost of Drinking Water by Region[a]

Region	Metered: Average Monthly Bill	Metered: Average Charge at 1,500 cf	Metered: Average Charge at 3,000 cf	Unmetered: Average Monthly Bill
Bay Area	$21.85	$24.97	$51.49	$19.06
Central Coast	$28.22	$24.45	$42.87	$23.69
Central Valley /Agricultural	$17.96	$15.54	$23.54	$16.10
Mountain/Desert	$16.00	$16.96	$26.65	$15.98
Foothill	$17.15	$20.53	$32.15	$18.19
Southern California	$24.84	$19.32	$33.99	$19.51

[a]Data from Morgan and Mercer 1991, Table 9.

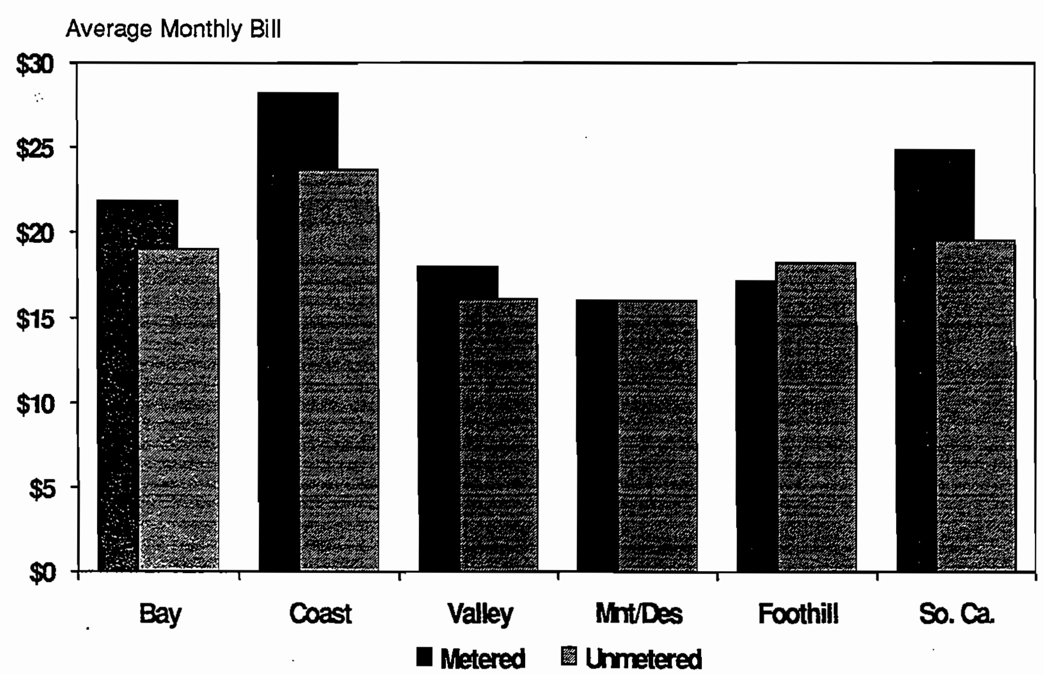

Figure 8.4. Average Monthly Bill by Region

Ernst & Young National Water and Wastewater Rate Survey. The 1990 Ernst & Young National Water and Wastewater Rate Survey (Ernst & Young 1990) was conducted in the 120 largest communities throughout the United States. A total of 150 utilities provided rate information from which the monthly charges for water at various usage levels were calculated. In Table 8.4, information is summarized for monthly water rates for the 12 California cities responding, for cities in five western states, and for the United States as a whole. The Ernst & Young survey found that wastewater rates were higher than water rates in California, ranging from 10% to 20% higher, depending on usage.

Table 8.4 Ernst & Young National Water and Wastewater Rate Survey Results

	Monthly Water Charges			
	0 cf	500 cf	1,000 cf	3,000 cf
United States Average	$3.67	$6.78	$11.16	$29.14
Western Cities Average[a]	$4.83	$7.94	$11.27	$26.12
California Cities Average[b]	$4.37	$6.94	$10.07	$23.08

[a]Includes cities responding to the Ernst & Young survey from CA, NV, WA, OR, and AR.
[b]Includes 12 California cities.

American Water Works Association Water Utility Survey. The AWWA survey conducted in 1990 (AWWA 1991) to establish a water industry database included 612 large water systems serving 50,000 or more people. The results for the average cost per 1,000 gallons were reported for the USEPA regions. Region IX, which includes California, had a cost of $1.35 per 1,000 gallons. This information for all regions has been converted to cost per cubic foot and is shown in Table 8.5. Interestingly, the AWWA survey has shown that the five western USEPA regions (Regions VI, VII, VIII, IX, and X) have lower water costs than the eastern USEPA regions, yet have the highest rate of residential water consumption. Region IX ranked the eighth lowest for the cost per 1,000 gallons, while ranking the second highest for water consumption nation-wide.

The results from the AWWA survey appear to be comparable to results shown by Ernst & Young for consumption of 1,000 cf. These two surveys show that California water rates are lower than those in most other areas of the nation.

USEPA Region	Cost per 1000 cf	USEPA Region	Cost per 1000 cf
I	$13.69	VI	$11.97
II	$12.87	VII	$12.11
III	$17.50	VIII	$9.42
IV	$12.27	**IX**	**$10.10**
V	$12.19	X	$9.95

Table 8.5 AWWA Water Industry Database Survey Results

3. Other Water-Related Costs Paid by Consumers

In addition to the price of water, there are additional costs or charges to the customer for being provided a potable water supply through a public water supply system. These costs have not been determined for California consumers, but can be significant. These include connection fees, assessments, and property taxes, from which revenues are used by the utility to pay annual operation and maintenance and to repay some debt service when the latter cost is relatively high. Connection fees charged by some California water systems range from no fee to fees as high as $3,250 for a new single-family residential connection (Ernst & Young 1990).

Other costs to the consumer are more difficult to assess because they are "hidden" or intangible costs. As an example, if a water utility serving a residence is not in compliance with all regulations, including drinking water standards, the Department of Housing and Urban Development (HUD) may deny private mortgage insurance to the potential borrowers. All customers served by that system would be ineligible to receive private mortgage insurance through HUD for a Federal Housing Authority (FHA) home loan until the water system comes into compliance with drinking water standards. What does the denial by HUD for private mortgage insurance mean to the potential borrower? Customers may be ineligible for the benefits of FHA financing (which typically requires less down payment and has lower interest costs than conventional financing), and this may result in the inability to obtain financing through other programs, as these agencies exchange information on problem areas.

One example of this is a water system in Fresno County which exceeded the state primary drinking water standards for fluoride and arsenic. The Farmers Home Administration (FmHA) directed a memorandum to that water system advising that a building moratorium on all FmHA financed housing would be effective in the community within 120 days of the date of the letter if certain actions were not taken by the water utility. This building moratorium would have immediately impacted two proposed farm labor housing projects for a local dairy.

a. Bottled Water Costs

One survey conducted for ACWA reported that nearly one-half of all Californians use a water filter or purifier, or purchase bottled water for everyday drinking water (ACWA 1990). It was estimated that over one-third of state residents purchase bottled water for aesthetic reasons or due to a lack of confidence in the quality of the public water supply. USEPA has estimated that bottled water costs of about $400 per year is a cost many families throughout the nation are willing to pay on an increasingly frequent basis (USEPA 1990a).

Morgan and Mercer presented representative costs for bottled water. The three average prices reported include: (1) the average price of all available bottled water including imports and exotics (non-sparkling), (2) the average price of domestic house and local brands only, and (3) the average price of water delivered to the home or business. Using the average cost per gallon presented by Morgan and Mercer, the estimated annual bottled water cost per person is shown in Table 8.6. The average cost per person and per household was calculated using the annual bottled water consumption rate of 654 million gallons in California for 1989 (Fresno Bee 1991) and assuming 3.9 persons per household[32].

Table 8.6 Estimated Annual Bottled Water Costs[a]

Type of Bottle Water	Average Price per Gallon	Average Annual Cost Per Person	Average Annual Cost Per Household
All Bottled Water[b]	$1.91	$140	$546
Domestic Brands	$1.01	$74	$289
Delivered	$1.42	$104	$406

[a]Data from Morgan and Mercer 1991, Table 12
[b]The bottled water prices in this category may be higher than in the other categories because of the inclusion of imported and exotic bottles waters.

[32]Determined by, Morgan and Mercer 1991, Table 4.

It is significant that bottled water is much more expensive than tap water. On a volume basis, Californians pay an average of one-tenth of a cent ($0.001) per gallon of tap water, based on the statewide average of $21.30 per month for metered systems, and using a consumption rate of 125 gallons per capita per day[33]. One-third of all Californians are willing to pay about 700 to 1,400 times more for bottled water than for tap water.

4. Financial Impact of Regulations

The current cost of drinking water has been shown using a variety of comparisons. These costs represent the cost to the consumer for the water utility to provide drinking water in compliance with all regulations as of January 1, 1990. The cost of providing treatment and monitoring in compliance with current and future regulations has been presented in Chapters VI and VII of this report, respectively. To understand the financial problems being faced by water utilities, it is critical to explain the total financial impact of these regulations.

To present the financial impact on consumers, five "typical" community water systems have been selected as examples of the incremental and total cost to meet existing and proposed regulations. These systems have been designated as: very small, small, intermediate, medium, and large. The costs to consumers in the "typical" systems provides a means for examining the magnitude of costs, and does not reflect the actual cost that may be incurred by all consumers. A brief discussion of the individual costs is presented below. The characteristics of the "typical" systems are provided in Appendix 1.

a. Adjusted Current Cost of Drinking Water

Baseline Costs

The analysis of the *Survey of Community Water Systems in California* showed that the average monthly cost per metered residential single family service connection was $26.03, $21.91, $21.27, and $20.87, respectively, for the small, intermediate, medium and large water systems. These current costs were assumed for the five "typical" water systems, and annualized as shown in Table 8.7, with both very small and

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[33]From *Aspects of Financing, Revenues, and Costs for California Water Utilities*, CDHS 1991, Table 3.

small having a current cost of $26.03 per month, since they are each in the small water system category.

Table 8.7 Current Cost of Drinking Water for a "Typical" Water System ($/service connection/year)

	Very Small	Small	Intermediate	Medium	Large
Average Monthly Bill	$26.03	$26.03	$21.91	$21.27	$20.87
Average Annual Bill	$312	$312	$263	$255	$250

Additional Costs to Meet Current Regulations

The current cost of water was adjusted to include regulations for which the total cost of compliance was not reflected in the survey. These include the costs to meet 36 MCLs adopted by the Department in 1989 and 1990 (CDHS 1988a-i and 1989a), most of which were for organic chemicals. The large water systems had begun the required quarterly monitoring for those adopted January 1, 1989, and it was assumed that the cost for the quarterly monitoring is reflected in the intermediate, medium, and large water system water rates reported in the survey.

Historically. when new MCLs are promulgated, these regulations have not been immediately enforced by LEHJs on the small water systems. At the time of the survey, the 36 new MCLs were not enforced on the small water systems. Monitoring had not been initiated, and, therefore, the associated costs were not reflected in the survey responses from small water systems. Therefore, the current cost of water for the "typical" very small and small water systems must be adjusted for this monitoring. The monitoring costs include the initial quarterly monitoring for organic chemicals to determine system and source vulnerability, and the on-going routine monitoring costs based on the results of vulnerability assessments. Table 7.2 presents the costs for the organic chemical monitoring for the "typical" systems. Additional monitoring for very small systems costs $130 per service connection. Additional monitoring for small systems costs $39 per service connection. In both estimates it is assumed that the initial, one-time, monitoring costs are spread over five years and that the annually recurring monitoring costs are fully recovered each year.

The treatment costs to meet these MCLs must also be considered in adjusting the cost obtained from the 1990 survey. Although the initial quarterly monitoring may have been completed by the large water systems at the time of the survey, treatment for those with confirmed positive results in excess of an MCL would not have been in place due to the time required to plan, design, and construct treatment facilities. Therefore, the current cost of water must be adjusted for each "typical" system to reflect these treatment costs.

The statewide estimated one-time capital treatment costs for water utilities to meet 24 of the 36 MCLs is about $51 million, with ongoing average annual operating and maintenance and monitoring costs of $3.1 million. Assuming capital costs are financed for 20 years at 10% interest, and adding the annual operation and maintenance costs results in an annual cost of $7.48 million for California water utilities. The treatment cost for the remaining 12 MCLs was minor since little contamination by these has occurred in California drinking water.

To determine the cost impact to the "typical" systems if treatment was required, the annual cost per service connection per source for the treatment processes considered BAT for organics removal have been provided in Table 6.5. These costs were applied to the number of contaminated ground water sources in the "typical" systems (25% of ground water sources were assumed contaminated in excess of the MCLs), resulting in the annual per service connection treatment cost figures shown in Table 8.8. The range of annual treatment costs presented reflects the minimum and maximum cost associated with the various treatment processes.

Table 8.8 Additional Costs for a "Typical" Water System to Meet Current Regulations ($/service connection/year)

	Very Small	Small	Intermediate	Medium	Large
Monitoring	$130	$39	----[a]	----[a]	----[a]
Treatment	$57-92	$57-92	$20-27	$9-23	$1-31
TOTAL	$187-222	$96-131	$20-27	$9-23	$1-31

[a]No additional costs over existing monitoring cost will be incurred by the Intermediate, Medium, and Large "typical" water systems since these costs are already reflected in the average cost to consumers.

The Department has determined that small water systems have a high rate of noncompliance with the existing regulations, as is discussed in Chapters IV and X. Information regarding the noncompliance rate of the small water systems was presented in Table 4.4. The costs to consumers in small water systems to bring these systems into compliance with all existing regulations has not been included in the summary of costs shown in Table 8.8. However, these costs will be significant for the small water systems.

b. Future Cost of Drinking Water

Cost Impacts of Proposed California Regulations and Fees

There are regulations currently being developed that will also increase the cost of drinking water in California. In response to the promulgation of new regulations by USEPA, the Department has developed proposed regulations for surface water treatment for the control of waterborne pathogens, and new regulations for monitoring the microbiological quality of distribution system water. Regulations are also being developed to meet the Legislative requirements of AB 21 with regards to the promulgation of RPHLs.

Surface Water Treatment Regulation. The economic impact of California's implementation of the California SWTR has been estimated by the Department to be $448.6 million in initial capital equipment costs and $46.9 million annually for operation and maintenance of these facilities (CDHS 1989). The total annualized capital and operation and maintenance cost is $85.4 million for California water utilities. The average annual cost has been estimated to be $50 per capita for smaller systems and over $4.40 per capita for larger systems. Prorating these costs to each size "typical" system resulted in the annual cost per household shown in Table 8.9. California water utilities must be in compliance with the SWTR by June 1993.

Total Coliform Regulation. The significant cost impact of the state Total Coliform Regulation stems from the increased monitoring requirements for all public water systems. The monitoring costs under the proposed regulation will increase as a result of increased laboratory and analysis costs and increased routine and repeat monitoring frequency. The Department has estimated the increased cost over current bacteriological monitoring costs to be in excess of $6 million annually for water utilities. Table 7.3 shows the incremental cost increase for the proposed Total Coliform Regulation for the "typical" community water systems. These values have been presented in Table 8.9, and range from about $5 per service connection per year for a system with 15 connections to less than $1 for a system with 33,500 connections. These costs are to be phased in between 1992 and 1994 as various requirements of the Total Coliform Regulation become effective.

Recommended Public Health Levels. Chapter VI of this report discusses the economic impact of compliance with the proposed RPHLs for water systems with greater than 10,000 service connections. AB 21 also requested an evaluation of the economic impact if these recommended levels were to be imposed on public water systems with 15 to 10,000 service connections. Table 6.6 presents the annual cost impact per service connection per source for water systems to meet the proposed RPHLs.

To present an example of the treatment cost impacts to meet the currently proposed RPHLs on a "typical" water system with 10,000 or more service connections, Table 8.9 presents the range of costs for organic and inorganic treatment processes that could be anticipated for a system with 33,500 service connections. These costs include the initial capital equipment costs only, financed over 20 years at an interest rate of 10%, and do not include the annual cost for on-going operation and maintenance of the treatment facilities. For the purposes of discussion of the total cost impact to the water systems with less than 10,000 service connections, the cost impact of the proposed RPHLs, in addition to all other current and proposed regulations, has been estimated for the "typical" water systems with less than 10,000 service connections.

AB 2158 Fees. An aspect of AB 2158 that directly impacts large and small water systems is the requirement that the state drinking water program continue to be fee-supported, as was initially mandated in AB 1806. AB 1806 required public water systems with at least 200 service connections to pay the Department an annual fee of 50 cents per service connection. AB 2158 repealed the provisions of AB 1806 and established instead a Small Water System Account and a Large Water System Account in the state General Fund, effective on July 1, 1992 and July 1, 1991, respectively.

All public water systems will be required to pay annual operating fees into these accounts sufficient to cover the reasonable and necessary costs of the Department to carry out its activities for public water systems. These activities include the issuance of permits, annual inspections and surveillance activities, enforcement actions taken, and the cost of administering any contracts with local health officers. The amount of the fee paid by each water system is to reflect the actual costs of the Department in conducting these activities for that water system. AB 2158 allows the water utility to recover the cost of these fees from its customers, but does not specify the amount of the fees. The Department must establish a fee schedule for large and small water systems based on the cost of program activities. The only limitations are that the state drinking water program must meet expenses for conducting the program through the fees imposed on water utilities, and cannot collect in excess of $4.25 million annually from large water systems, and $8.25 million annually from small water systems.

The estimated fees to be paid by consumers in the "typical" water systems to support the drinking water program in California are presented in Table 8.9. The Department has initially estimated that the fee impact on small community water systems could range from $1,000 to $1,800 per system. For very small and small systems with 15 and 100 service connections, this results in annual fees of $67 and $14 per service connection, respectively. For the "typical" intermediate, medium, and large water systems, annual fees have been estimated to range from $2,100 to $3,675, $4,200 to $5,775, and $7,350 to $9,975, respectively. The maximum annual fee per service connection, as shown in Table 8.9, would be $7, $2, and less than $1 for the intermediate, medium, and large "typical" water systems.

Table 8.9 Costs for a "Typical" Water System to Meet Proposed Regulations ($/service connection/year)

	Very Small	Small	Intermediate	Medium	Large
Costs to Meet Proposed California Regulations					
Surface Water Treatment Regulation	----	$175	$37	$36	$15
Coliform Regulation	$5	<$1	<$1	<$1	<$1
Recommended Public Health Levels	----	----	----	----	$1-185
Est. Fees: AB 2158	$67	$14	$7	$2	<$1
Estimated Monitoring Costs to Meet Proposed USEPA Regulations					
Lead and Copper Rule; other organic and inorganic MCLs	$378	$117	$45	$17	$5
TOTAL	$450	$307	$90	$56	$23-207

Cost Impacts of Proposed Federal Regulations

USEPA has proposed regulations, in compliance with the 1986 SDWA Amendments, for lead and copper and other organic and inorganic chemicals. The nationwide cost impact for these proposed regulations has been estimated by USEPA. However, an evaluation of how these costs may be applied in California has not been conducted due to a lack of knowing what the final MCLs will be and lack of monitoring information to determine the number of water systems that may exceed the proposed standards. Therefore, treatment costs can not be estimated. Monitoring costs, though, can be estimated since all systems will be required to conduct routine monitoring in compliance with the frequency established by the proposed regulations. These monitoring costs have been shown in Table 8.9.

c. Summary of Cost Impacts

The incremental costs discussed above may appear insignificant when considered independently of the total costs. However, when the total costs are considered the current cost of water will increase as a result of proposed state and federal regulations, in addition to the cost for water utilities to come into compliance with the existing standards and regulations.

Table 8.10 and Figure 8.5 provide a summary of total annual costs that will be seen by consumers in each of the "typical" water systems as a result of the existing and proposed regulations. These exhibits show that, whereas customers in the small and very small water systems are currently paying only 25% more for drinking water than are customers in large water systems, by the mid-1990s they will be paying over 90% to 150% more for water. The greatest cost impact for all water systems is attributable to the implementation of the new SWTR. Costs to meet new drinking water standards to be implemented by USEPA every three years will be significant in the very small and small water systems. Since treatment costs for these future regulations could not be estimated, the cost impact is not shown, and may be much greater that estimated for monitoring alone.

Overall, the cost increases will be substantial. Customers in the very small water system can anticipate increases up to three times the current water bill, or a 210% increase. Customers in the small system may see a 135% increase; in the intermediate, a 43% increase; in the medium, a 28% increase; and in the large, a 52% increase. The Large water system will experience a greater increase due to the implementation of the RPHLs on the systems with greater than 10,000 service connections.

In this example of the total cost impact of regulations, it was assumed that all costs would be recovered through the water bills paid by customers. If current prevailing rate procedures continue, these costs for customers in the publicly-owned systems would be paid through both increases in the water rates and through increased taxation, special assessments, or other user charges.

Table 8.10 Total Costs for a "Typical" Water System to Provide Safe Drinking Water ($/service connection/year)

	Very Small	Small	Intermediate	Medium	Large
Current Cost of Drinking Water[a]	$312	$312	$263	$255	$250
Additional Costs to Meet Current Regulations[b]	$205	$114	$24	$16	$16
Additional Costs to Meet Proposed Regulations[c]	$450	$307	$90	$56	$115[d]
Estimated Total Cost to Provide Safe Drinking Water	$967	$733	$377	$327	$381

[a]Data from Table 8.7
[b]Average Figures from Table 8.8
[c]Average Figures from Table 8.9
[d]Includes costs to meet proposed RPHLs for water systems with greater than 10,000 service connections.

Table 8.11 and Figure 8.6 present the estimated cost impact on water systems with 15 to 10,000 service connections if the RPHLs are applied to this group of utilities. The cost to treat for RPHLs increased the future total cost presented in Table 8.10 by 19% to 27%, depending on the "typical" system. Without taking into account any other new or proposed regulations, RPHL implementation alone would increase the current cost of water from 25% to 60%.[34] The total annual water bill reflected in Table 8.11 is more than triple the current cost of water in the very small water systems. Similar increases would be experienced in the small, intermediate, and medium systems, with the total future cost increases if RPHLs are imposed ranging from almost 275% to 40%, respectively, over current water costs and could result in monthly charges of about $100 for some smaller system customers. The additional cost of regulations that will be proposed in the future, such as for radon and TTHMs that

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[34]The costs to meet the RPHLs must be compared with the health benefits of lowered concentrations of contaminants in drinking water. The health benefits of the draft RPHLs are discussed in Chapter V.

will result in a significant reduction in the risks to which the population is exposed, must be weighed along with the additional cost if RPHLs were imposed on the very small to medium size water systems.

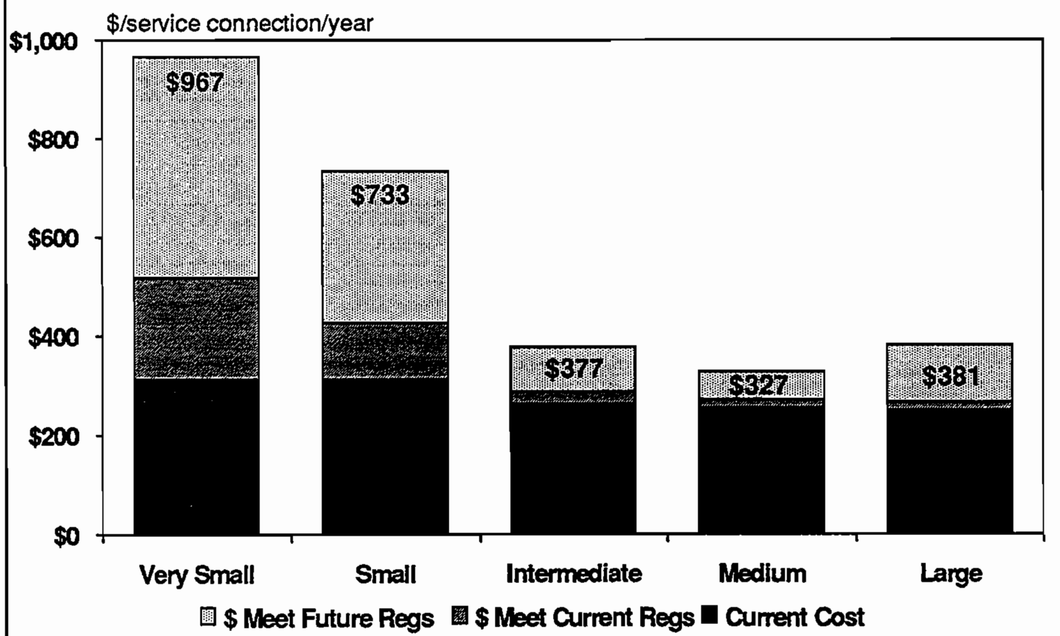

Figure 8.5. Costs For a "Typical" Water System to Provide Safe Drinking Water

Table 8.11 RPHL Cost Impacts on "Typical" Systems With 15 to 10,000 Service Connections ($/service connection/year)

	Very Small	Small	Intermediate	Medium
Minimum Future Cost[a]	$967	$733	$377	$327
Average Cost to Meet Proposed RPHLs	$196	$196	$74	$62
(range of costs)[b]	($57-335)	($57-335)	($40-256)	($9-114)
Future Cost if RPHLs Imposed	$1163	$929	$451	$389

[a]Figures from Table 8.10
[b]Minimum and maximum costs for inorganic and organic treatment, based on number of sources which would exceed RPHL level.

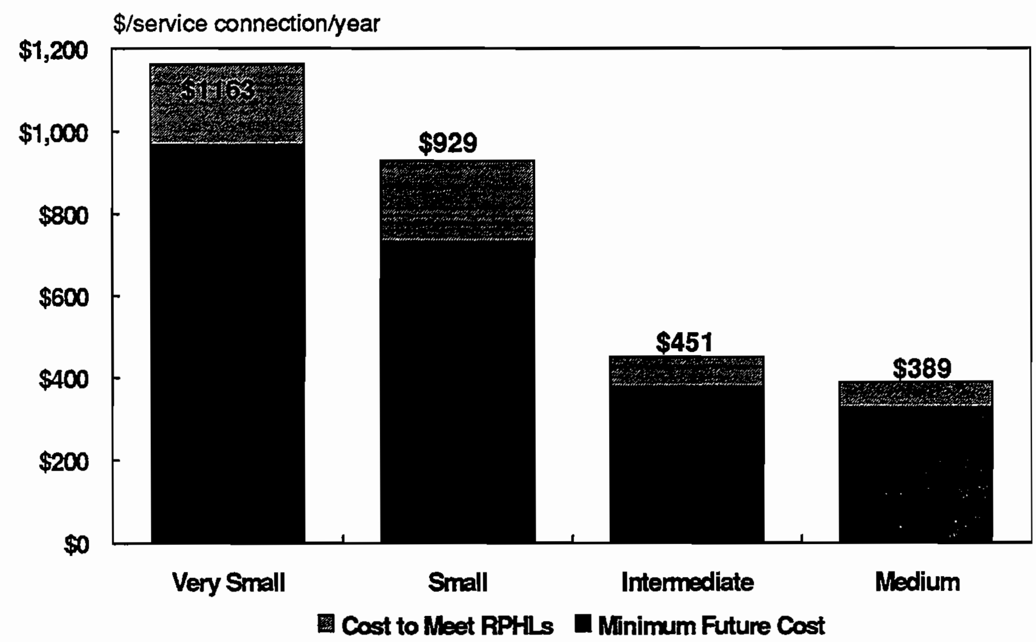

Figure 8.6. RPHL Cost Impacts on "Typical" Systems With 15 to 10,000 Service Connections

5. Financial Hardship Indicators

Customers will pay only so much for water service. Whereas how much differs from utility to utility, as was previously shown in the discussion of the *Survey of Community Water Systems in California*, most customers feel that they are hard pressed to commit to rate increases for improved water service, needed infrastructure replacements, and upgrades in treatment, not to mention protection of their water sources from potential contamination.

USEPA has recognized that waterworks projects that cause user charges to exceed 1% to 2% of median household income should be reevaluated. USEPAs experience with such projects indicated that the potential for economic hardship exists above this threshold.

In the USEPAs *Draft Policy on the Use of Variance in the Public Water System Program* (USEPA 1990a), it is stated that the "EPA believes that, as a very rough rule of thumb, a total annual household water bill becomes unaffordable when [the water bill is] greater than 2 percent of the median household income, or about $650/household/year if calculated based on median national income"... and "that in cases where local median income is very low, a total annual household water bill as small as $450 may be unaffordable." Total annual bills below that amount are deemed affordable by the USEPA.

a. How Much More Can the Consumer Bear?

These financial hardship indicators may reflect what many people consider affordable for good quality drinking water. Therefore, using 2% of median household income as the basis for customer affordability, the cost of water in California can be examined relative to ability and willingness to pay.

The California median household income for 1987 was $30,200 (California State Census Data Center 1988); 2% of this is roughly $604 per year, slightly less than the USEPA figure derived from the national median income. This comes to about $50 per month per household. If one applies the 1987 federal poverty level income, the 2% rule of thumb yields an "affordable" monthly bill of about $20. Therefore, a range in monthly water bill of $20 to $50 would be the maximum that a consumer could be expected to pay for water in California, based on the 2% of income standard.

Data from the *Survey of Community Water Systems in California* has shown that statewide water bills averaged $21.30 per month, or $255 per year for metered single family residents (1990 dollars) and averaged $26.03, $21.91, $21.27, and $20.87 per month in small, intermediate, medium, and large water systems. This shows that monthly costs in all water systems already exceed the lower limit of $20. When considering the cost impact of existing and future regulations, as summarized in Table 8.10, the water bills paid by customers in smaller water systems will exceed the upper limit by the mid-1990s, with monthly water bills ranging from $80 for the very small to $60 for the small water system customers.

The last word in what is affordable, however, must come from the customer. If the customer perceives a definite benefit which results from rate increases, his or her willingness to pay may not be at issue. In a survey conducted in California to determine public attitudes regarding water issues (ACWA 1990), the question of the consumer's willingness to pay higher costs for stricter water quality standards was explored. The study found that 54% of the survey respondents were willing to pay an additional $10 for stricter water standards, but there was also substantial opposition to such a proposition. A cost increase of $25 per month was clearly rejected by the vast majority of California residents, with only 15% of respondents indicating that they would be wiling to pay this much more to meet stricter standards.

The results of this survey can be compared to the estimated cost impact of existing and future regulations presented in Table 8.10. It shows that the smallest cost increase will be experienced by the medium size "typical" water system, at $72 per year or $6 per month, based on treatment and monitoring costs for regulations that either have been or will be enforced in California. The large water systems will experience a slightly higher cost increase of $130 per year, or $11 per month, due to RPHL treatment costs and other current and proposed standards. The very small systems will experience increases of as much as $650 per year, or $55 per month. These estimated increases in monthly water bills in the very small and large water systems exceed the $10 increase that was deemed acceptable by a bare majority of respondents to the ACWA survey. Most customers will experience increases that are far beyond that which they indicated was acceptable. The basic conclusion is that Californians have already stated a general opposition to major cost increases that are demonstrably necessary to meet more stringent drinking water standards.

B. SOURCES OF REVENUE

Utility costs that must be recovered through revenues include operating costs and debt service. Operating costs are those that are required for the ongoing operation and maintenance of the water system. These include salaries, electricity, treatment chemicals, materials, and other recurring costs. Debt service cost is paid out annually to repay long-term borrowing that funds capital costs. Fees to support the regulation of drinking water in California (i.e. those required under AB 2158) must be met from revenues.

Revenues for investor-owned water utilities must also be sufficient to pay an annual user fee of 1.5% of gross operating revenues to PUC. Mutual water companies must pay an annual franchise tax, as well as maintain a sinking fund or reserve for the repair and replacement of water system facilities, as required by DOC.

The major sources of revenue for publicly-owned water systems include the water rates charged to customers, on either a flat rate or a metered rate basis; property taxes (though use has been severely limited by Proposition 13); and benefit assessments levied through special improvement districts. As a result of the voter opposition to tax increases, local governments have turned to other methods of raising additional revenues, while maintaining lower increases in water rates, such as development impact fees for new construction, standby fees, and fees for special services. These alternatives are typically feasible only for the larger water utilities because of their larger service areas and rate base, and steady growth within the service area, so that income from these fees may be significant and provide a reliable revenue.

1. Summary and Issues

The sources available to water utilities to generate a significant portion of the revenues necessary to meet the continuing operation, maintenance, and debt service payments are summarized in Tables 8.12 and 8.13. Table 8.12 shows the revenue sources available categorized by the type of utility ownership. Table 8.13 provides a summary of revenues that are feasible based on utility size. Each of these sources of revenue is described in detail in *Aspects Of Financing, Revenues, And Costs For California Water Utilities* (CDHS 1991). The determination that these revenue sources are feasible for specific utility sizes or types of ownership does not necessarily mean that they are commonly used by these classifications, nor does it mean that there are no other sources available.

Table 8.12 Significant Sources Of Revenue For Water Utilities Categorized by Type Of Utility Ownership[a]

Revenue Source	Publicly-Owned	Investor-Owned	Mutual
Water Rates	✘	✘	✘
Property Taxes	✘		
Special Improvement District Assessments	✘		
Development Impact Fees	✘		
Customer Hookup Fees	✘		
Special Service Fees	✘	✘[b]	

[a]Refer to *Aspects of Financing, Revenues, and Costs for California Water Utilities* (CDHS 1991) for details on each of these sources of revenue.
[b]Special fees can be charged by investor owned utilities only under very specific criteria established by the PUC, and are not commonly used.

As can be seen from Table 8.12, publicly-owned systems have a much broader range of options from which they can generate revenues. Investor-owned and mutual water companies are almost exclusively restricted to generating the necessary revenue from water rates. In addition, Morgan and Mercer indicate that interest income may be significant for some of the larger utilities that maintain substantial reserve accounts.

Table 8.13 Significant Sources Of Revenue for Water Utilities Categorized by Utility Size[a]

Revenue Sources	**Small**	**Intermediate**	**Medium**	**Large**
Water Rates	✘	✘	✘	✘
Property Taxes		✘	✘	✘
Special Improvement District Assessments		✘	✘	✘
Developer Impact Fees				✘
Customer Hookup Fees				✘
Special Service Fees				✘

[a]Refer to *Aspects of Financing, Revenues, and Costs for California Water Utilities* (CDHS 1991) for details on each of these sources of revenue.

For small to medium size systems there are limitations in generating revenues as well, as shown in Table 8.13. Property taxes and special improvement district assessments (where there is voter approval) may be feasible for some smaller utilities for repaying debt service. Although not discussed as a financing tool, special improvement district assessments can generate sufficient funds to repay the debt service for high-cost capital improvement projects.

a. Inadequate Water Rates

Even though the smaller water systems currently have the highest water rates for drinking water in the state, the small systems generally have an inadequate rate structure to provide for system replacement needs and improvements to meet new drinking water standards. Although the current cost of water is higher in smaller water systems than in the larger water system, this does not reflect the poor physical condition of many small water systems, which results in a higher rate of noncompliance in small water systems relative to the large water systems. In other words, smaller water system customers in general are paying more and receiving less than customers in large water systems.

If small to medium size systems continue to plan rate structure requirements poorly, noncompliance will increase due to a failure to plan for and implement rate structure changes to meet the monitoring and treatment requirements for new drinking water standards and other future regulations. Without a rapid reassessment of the adequacy of existing water rates, almost all water systems in California will be faced with inadequate means to fund compliance with proposed regulations.

C. METHODS OF FINANCING

Financing needs arise as a result of the requirement to construct new facilities. This requirement for capital improvements can result from a variety of causes. Regulatory requirements are and will continue to be the greatest cause for most water utilities to need financing.

Morgan and Mercer (1991) state that "the ability of water suppliers to raise funds for new raw water sources and treatment facilities to meet new and future regulations depends on conditions in the credit markets and the financial condition of the suppliers including their previously incurred indebtedness. Various legal constraints in financial instruments and the tax policies of the federal and state governments are important factors in financing choices." The effect of tax policies can be seen by the overall impact of the federal Tax Reform Acts of 1986 and California's Proposition 13 on public works financing. The Tax Reform Act of 1986 and the federal Deficit Reduction Act of 1987 were passed in an attempt to generate additional federal tax revenues and reduce the federal deficit. These acts made tax-exempt bonds much more difficult to issue by changing the tax laws related to tax-exempt bonds in a way that restricted how the proceeds of tax-exempt bonds could be used. At least partially as a result of these changes, the nationwide value of new issues of municipal debt decreased by one-half of the 1985 level, with even more dramatic reductions in the issuance of "private activity bonds". Private activity bonds are tax-exempt bonds issued to fund a privately-owned project that has a public purpose that is recognized in the federal tax code. Private activity bonds are subject to a strict quantity rationing formula in each state.

Although there was a significant drop in municipal borrowing between 1986 and 1987 nationwide, the impact of the tax reform acts on traditional public-use infrastructure projects may not have been significant in the long-term. Debt financing of traditional public works appears to be at a higher level now than before the passage of the 1986 Act. This is in part due to increasing regulatory requirements in the water and wastewater areas. However, the reforms have had a significant effect on a wide range of activities financed by state and local governments, especially those undertaken in cooperation with the private sector. The provisions of the Tax Reform Acts, which have raised the greatest concern to public utilities, includes stricter criteria for tax-exempt bonds (OTA 1990). Tax code revisions have restricted the use of tax-exempt private activity bonds to projects in which no more than 10% of the facility is used for private purposes, and no more than 10% of the debt service is derived from payments from private parties, down from a previous private activity bond threshold of 25% for both use and debt service coverage. This reduction in permissible level of private sector involvement has limited tax-exempt borrowing, and raised costs for some forms of public works such as water treatment plants that are owned or operated by private firms.

In California, Morgan and Mercer (1991) report that the passage of Proposition 13 in 1976 virtually destroyed the capability of issuing general obligation (GO) bonds by eliminating the *ad valorem* taxing authority previously used as security on GO bonds. Between fiscal years 1969-70 and 1977-78, the number of GO bonds issued in California dropped by half, decreasing from 67.2% of all bond issues to 32%.

Capital improvement projects may be financed through traditional forms of financing such as revenue bonds, general obligation bonds, special taxes and self-financing. Less traditional means of funding improvement projects include the use of Certificates of Participation (COPs), bond-pooling, and public/private partnerships. These are discussed briefly below and summarized in Tables 8.14 and 8.15. Complete discussions are provided in *Aspects Of Financing, Revenues, And Costs For California Water Utilities* (CDHS 1991).

1. Self-Financing

Self-financing, commonly termed pay-as-you-go, is a form of non-debt financing. A water system can use reserves generated from accumulated revenues and other income to pay for system improvements in lieu of incurring debt. The benefit is the avoidance of interest costs associated with obtaining debt financing; however, interest income from these reserves will be lost when the funds are used to create new capital (Morgan and Mercer 1991).

The ability of water utilities to use reserves depends upon their maintenance of a reserve account with a positive balance. One investment strategy may involve increasing revenue for several years prior to project construction, through increases in water rates or other charges, in order to generate some or all of the project capital funding. Very few utilities are able to generate this reserve based on accumulated revenues. The Department's *Survey of Community Water Systems in California* requested information regarding reserve accounts. The responses indicate that roughly half of the community water systems maintain a reserve account with a positive balance. This ranged from about 45% of small systems to 65% of the large systems with greater than 10,000 service connections that maintain a reserve account.

Table 8.14 Financing Alternatives Available to Water Utilities Categorized by Type of Utility Ownership[a]

Financing Options	Publicly-Owned	Investor-Owned	Mutual
Self-Financing	✘	✘	✘
Short-Term Financing			
Fixed Rate Notes (Bond-, Tax-, Grant-, and Revenue Anticipation Notes)	✘	✘[b]	✘[b]
Commercial Paper	✘	✘[b]	✘[b]
Floating (or Variable) Rate Demand Notes	✘	✘[b]	✘[b]
Long-Term Financing			
Equity Shares or Stock		✘	✘
Bonds (GO, LO, and Revenue)	✘	✘[b]	✘[b]
Lease Revenue Bonds (Certificates of Participation or COPs)	✘		
Bond Pools	✘		
CSDA Pooled Bonds	✘		
CRWA Pooled Bonds	✘		
Other Financing Options			
Privatization (Public/Private Partnerships)	✘		✘

[a]Refer to *Aspects Of Financing And Revenues For California Water Utilities* (CDHS 1991) and Morgan and Mercer (1991) for details on each of these financing alternatives.
[b]Taxable instruments

However, the size of the reserves held by the small systems is generally insignificant in comparison to capital project funding requirements. Because of the low reserves held by the smaller systems and the limited number of systems that generally maintain a reserve account, self financing may not be a viable option except under certain circumstances. Self financing may be viable for capital expenditures if the project may be broken into several phases and constructed individually over time. This may be acceptable for some public works projects when there is no urgency for completion, such as a freeway expansion project, storm drainage project, or even the expansion of a water system for proposed development and growth. However, due to the health risks associated with most of the regulated contaminants, phasing in a new water treatment facility to meet an MCL or other regulations is not acceptable. These are not projects that can be postponed while revenue is generated, nor can they be constructed in phases. Therefore, most water utilities will be required to look to other sources to obtain capital to construct needed facilities. These will include debt financing and, for a very few systems, state and federal financial assistance.

Table 8.15 Financing Alternatives Available to Water Utilities Categorized by Utility Size[a]

Financing Options	Small	Intermediate	Medium	Large
Self-Financing			✘	✘
Short-Term Financing				
Fixed Rate Notes (Bond-, Tax-, Grant-, and Revenue Anticipation Notes)				✘
Tax-Exempt Commercial Paper				✘
Floating (or Variable) Rate Demand Notes				✘
Long-Term Financing				
Equity Shares or Stock			✘	✘
Bonds (GO, LO, and Revenue bonds)				✘
Lease Revenue Bonds (Certificates of Participation or COPs)				✘
Bond Pools	✘	✘	✘	✘
CSDA Pooled Bonds	✘	✘	✘	✘
CRWA Pooled Bonds	✘	✘	✘	
Other Financing Options				
Privatization (Public/Private Partnerships)	✘	✘	✘	✘

[a]Refer to *Aspects Of Financing And Revenues For California Water Utilities* (CDHS 1991) and Morgan and Mercer (1991) for details on each of these financing alternatives.

2. Short-Term Debt Financing

Short-term debt financing typically includes short-term borrowing instruments with maturities of less than one year, including bond-, tax-, grant-, and revenue-anticipation notes, which are notes with a fixed interest rate; tax-exempt commercial paper, which is a short-term, unsecured promissory note backed by a line of credit or a letter of credit from one or more banks; and tax-exempt variable rate (or floating-rate) monthly demand notes. The security for these short-term financing instruments ranges from anticipated tax revenues to lines or letters of credit. Short-term financing has been common with investor-owned utilities, but historically has seen limited use by municipal (publicly-owned) water systems (AWWA 1988). Short-term financing instruments for a capital improvement projects are commonly used to fund construction costs, followed by a permanent long-term financing package.

3. Long-Term Debt Financing

Capital improvements may be financed through long-term debt so that the cost of the project is spread out over its useful life. There are a myriad of long-term financing instruments currently available. Conventional methods are those that have been used and proven effective over the years. The uncertain market and high long-term interest rates in the early 1980s resulted in the development of innovative financing mechanisms, which were structured on a long-term basis but possess certain characteristics of short-term debt.

a. Conventional Long-Term Financing

Conventional long-term financing methods include the issuance of GO bonds, revenue bonds, limited obligation bonds, which are typically limited to use by publicly-owned agencies. Raftelis (1989) has pointed out that conventional financing with short-term fixed rate demand notes, followed by long-term bonds once operation commences, is not the automatic choice it once was. This combination, however, still remains the prevalent financing method in the tax-exempt market. While all resources are unconditionally pledged for GO bonds, the power to levy property taxes provides the basic security for payment of interest and principal. With revenue bonds, the debt service requirements are payable exclusively from the earnings of a public entity, such as water service. During the last decade, revenue bonds have predominated over GO bonds and now comprise almost two-thirds of the total annual volume of long-term tax-exempt bond issues (Moody 1989). Because revenue bonds do not require voter approval for issuance, there is greater emphasis on user charges to support public services such as public water systems, which explains the expanded use of revenue bonds. In addition, taxpayer resistance and state statutes (specifically Proposition 13) have limited the taxing and borrowing authority, thus reducing the use of GO bonds.

Also as a result of the difficulty in issuing GO bonds, lease revenue bond issuance has become quite common in California, particularly in the form of a COP. Under a COP, facilities are built or acquired by an agency of the city, and leased to the city, for which the city makes lease payments equal to the principal repayment plus interest. Either a city non-profit corporation or a community redevelopment agency is necessary as an intermediary leasing entity, but that agency mandatorily must give the facilities to the city free and clear without added expense when the indebtedness is paid off. The underwriter sells certificates to investors, which signify a proportionate share in the lease payments. Interest is exempt from both federal and state income taxation.

The costs associated with bond issuance must be considered in determining the feasibility of this mechanism for financing. Fees of 2% of principal are common for large issues, and may be higher for small issues.

b.. Innovative Long-Term Financing

Newer, innovative methods of financing have developed in response to high, long-term interest rates and an uncertain market in the 1980s. These methods, which transfer some of the benefits of short-term borrowing to the long-term market, include tender-option bonds, floating-rate bonds, zero-coupon bonds, to name a few. These and others are detailed in *Aspects of Financing, Revenues, and Costs for California Water Utilities* (CDHS 1991).

<u>Bond Pools</u>

One financing alternative that provides the benefits of bond issuance to smaller utilities, and minimize the cost of issuance for smaller borrowers, is the bond pool. The California Legislature enacted the Marks-Roos Local Bond Pooling Act of 1985 for this purpose. To qualify for participation in a local bond pooling program, a local agency must participate in an agreement creating a Joint Powers Authority which can issue assessment bonds, redevelopment agency bonds, government issued mortgage bonds, industrial development bonds, short-term notes, commercial paper, and other forms of indebtedness, including COPs and lease-purchase agreements.

Two bond pooling programs have been developed that benefit publicly-owned water companies. The California Special Districts Association has developed a pooled tax-exempt lease-purchase financing vehicle for California special districts. The California Rural Water Association(CRWA) is putting together the first of an annual $5 million revenue bond issue specifically for water utilities with less than 10,000 service connections for infrastructure needs. Utilities are to be identified for a $3 million dedicated pool. The remaining $2 million will be placed into a blind pool to be used on a first-come-first-serve basis. The bond issue should be finalized by mid-1991.

Privatization

Privatization can be defined as private sector involvement in the design, financing, construction, ownership, and/or operation of a facility that will provide services to the public sector (Raftelis 1989). Privatization of water facilities is a way for local governments to work with the private sector in obtaining financing and/or construction for needed facilities. Privatization is also a possible solution to the increasingly difficult task of managing water systems, which are faced with increasingly complex and more stringent regulations that require the implementation of advanced treatment technologies and complex monitoring schedules. Depending on the project and the type of private participation involved, privatization can offer several important advantages. Financing of privately run projects, for example, may be cheaper or more available than other forms of conventional financing, even after the most recent changes in the tax code. Prior to the Tax Reform Act of 1986, tax benefits could make privately-financed projects 20% to 40% less costly than publicly-financed projects as a result of tax benefits available to a private sector firm for which a public agency is not eligible. Under the Tax Reform Act of 1986, that advantage was cut by more than half, but in some cases privatization may still have an edge. Where the publicly-owned utility's access to the finance market is diminished or non-existent, such as is the case for many smaller utilities, privately arranged or enhanced financing may be an attractive option.

4. Credit Substitution and Credit Enhancement

Credit substitution refers to an issuer's purchase of outside support that substitutes for the issuer's own credit on a particular bond or note issue (Moody 1989). These can include commercial bank or thrift institution letters of credit, bond insurance, and guarantees. Through credit substitution, the issuer can improve the credit quality of its bonds, or provide support for some portion of a financing for which its own resources may be inadequate. As a result, the issue generally carries a lower interest cost, which may offset the cost of purchasing the form of credit substitution used.

Guarantees have been employed by several states as public credit enhancements, which support debt issued by local governments (Standard & Poor 1989). This form of enhancement is a very low cost and effective way for states to assist localities within their jurisdictions to reduce borrowing costs. The programs use state aid entitlements as a form of guarantee that debt service obligations will be met. If a local agency cannot meet its repayment obligation on a qualified bond, the state withholds sufficient aid to meet debt service. As a result of the credit enhancing value of these programs, local governments can achieve substantial interest savings, and the programs are virtually cost-free for the state governments that administer them.

In California, Standard & Poor assigns the state's AAA GO rating to participants in the California Health Facility Construction Loan Insurance Program. The program is managed by the Office of Statewide Health Planning and Development. Other states use bond guarantees as a form of state aid for school districts. It could also be applicable to the drinking water program in California for publicly-owned water utilities able to finance capital projects through bond issuance that could be additionally secured by the state's AAA rating.

5. Summary and Issues

Feasible financing mechanisms vary by the type of ownership and size of the water system. The aspects of feasibility and availability of financing are summarized in Tables 8.14 and 8.15 for those financing mechanisms that have been identified in this report and in *Aspects Of Financing And Revenues For California Water Utilities* (CDHS 1991). Specific benefits or limitations associated with ownership and size are discussed below.

a. Publicly-Owned Water System Financing

In general, the publicly-owned systems such as municipal, district, or government water systems have a greater availability of financing options than do the investor-owned and mutual water companies. Many long- and short-term financing instruments will be tax-exempt for publicly-owned agencies. Publicly-owned systems of sufficient size can issue tax-exempt notes and bonds, assess property taxes, issue special assessment bonds, and enter into public/private partnerships to finance water system capital improvements. There are many types of bonds that publicly-owned agencies can issue, each with its own structure, advantages and disadvantages. The ability of a publicly-owned system to finance a capital improvement project through these means is largely dependent upon the size and type of publicly-owned water system. In the case of water systems operated by a school, state park, or state correction facility (classified as non-transient, non-community water systems under the regulatory definition), there are no "paying" water customers. Publicly-owned water systems falling into the non-transient, non-community regulatory classification often rely upon the financing powers of their larger governing body, such as the school district, county, or state (in the case of government-owned systems) for financing large capital improvement projects.

Local, state and federally-owned systems have unique problems in attempting to comply with the California SDWA, in that budgets for major improvements are controlled by the governing body, and must be prioritized along with other expenditures. Therefore, it is not certain that financing or the necessary funds will even be made available for even mandatory projects to meet California SDWA requirements.

Water District Financing

Local special-purpose districts may provide a reasonable solution to some financial constraints. Municipalities can be restricted by debt limitations and tax base limitations as a result of Proposition 13, as well as restrictions based on political boundaries. However, a special purpose district can establish boundaries to surround the geographic area of need, and has the availability of a variety of financing mechanisms such as bond issuance, special assessments, fees, and special charges.

Privately-owned water systems in California, including both investor-owned and mutual water companies, have been looking to the formation of special districts to resolve financial problems. For these systems, the formation of a publicly-owned special district provides the benefits such as eligibility to participate in state and federal loan and grant financial assistance programs and to issue special assessments.

There are eight types of special districts that can be formed to provide water service. In all cases, these organizations are created by action of LAFCO and the county boards of supervisors as a result of a petition from either the customers or the water utility owners. Not all counties in the state, however, readily approve the formation of new entities, making it somewhat difficult to convert into a publicly-owned utility.

b. Investor-Owned Water System Financing

Investor-owned water utilities have the capability of issuing equity stock (common and preferred stock) and to sell taxable bonds of their company. PUC must give authorization prior to the issuance of any stocks or bonds of an investor-owned water company. This method of financing capital improvement projects is limited primarily to the large PUC-regulated investor water systems that have stock. The smaller investor-owned systems, which are generally owned by families or individuals, do not issue stock and, like smaller publicly-owned systems, lack the rate base to make other financing options usable. PUC-regulated investor-owned water systems are not able to accumulate reserves. Investor-owned utilities may use both short- and long-term financial instruments such as taxable notes and bonds.

c. Mutual Water System Financing

Mutual water companies have the ability to assess members to raise capital. This does not require the approval by members, nor by any outside agency. The amount of this assessment may be limited, however, by the ability of the member to pay. As a requirement of formation of a mutual water company, a sinking fund must be established that provides for capital replacement of water facilities at the end of their useful life. This sinking fund, or reserve, is a means to maintain the integrity of the system's existing infrastructure, but may not be available or adequate to fund the high costs necessary to meet new regulations adopted after the formation of the mutual water company. Mutual water companies of sufficient size may also use short- and long-term financing instruments such as taxable bonds and notes.

d. Small System Financing

A smaller publicly-owned water system may be unable to secure financing because either the cost of that method (such as the cost of issuing bonds) or the amount of funds needed to make the improvement exceeds the ability of the customers to repay the debt. Because of the limited availability and economic feasibility of most traditional financing mechanisms for the smaller water systems, many look to state and federal financial assistance programs to finance necessary capital improvement projects to assure a safe and potable water supply.

D. FINANCIAL ASSISTANCE PROGRAMS

There are numerous state and federal financial assistance programs available to water utilities. Few of these programs, however, are strictly for the purpose of assistance to domestic water supply systems. Typically, water utilities must compete for funding with other public works projects, such as wastewater disposal or reclamation, low income housing, and water conservation. Few of these programs have sufficient funding to address a significant portion of the needs, let alone to make a significant contribution to addressing the needs of drinking water systems in California. For example, FmHA, offers loans and grants through the Water and Wastewater Disposal Loan and Grant Program. During the 1990 fiscal year, a total of $15.2 million was disbursed for loans and grants in California. Of this, $13.4 million was directed toward wastewater disposal projects, while only $1.8 million was for drinking water projects.

In contrast, two state programs are available for financial assistance for the correction of deficiencies for drinking water systems. The California Safe Drinking Water Bond Law Program has provided low interest loans and grants to correct primary drinking water standard deficiencies. Since 1976, it has provided $425 million for California water systems. The Emergency Clean Water Grant(ECWG) Program, established in 1985, was given a one-time allocation of $4 million to address emergency needs for drinking water systems. Both programs are discussed in detail below. The inability of these two programs to meet the needs of water utilities in California, based on the funds allocated is addressed, and the direction these programs should take in the future is outlined in the Conclusions and Recommendations at the end of this chapter.

1. Safe Drinking Water Bond Law Program

In 1975, USEPA published the National Interim Primary Drinking Water Regulations(NIPDWR), mandated by the 1974 federal SDWA, which included the adoption of the NIPDWRs. These standards were adopted by California under the SDWA of 1976. Under the NIPDWRs, unlike the Clean Water Act for wastewater treatment systems, USEPA did not provide financial resources to water utilities for meeting these new standards. In California, legislation was introduced to provide a source of financing of the capital improvements mandated by these new drinking water standards. The legislation (SB 1327, Chapter 1008, Statutes of 1975) was placed on the June 1976 ballot as Proposition 3, and received approval by 62.6% of the voters. This legislation, known as the Safe Drinking Water Bond Law (SDWBL) of 1976, provided $175 million from the sale of state GO bonds for loans and, in certain situations, grants for capital improvements required to meet the Department's drinking water standards mandated under the California SDWA.

The people of California have supported, by overwhelming majority vote in subsequent general elections, the continued funding of the SDWBL program. Four bond acts, approved in 1976, 1984, 1986, and 1988, have provided a total of $425 million in grants and loans to correct domestic water system deficiencies.

The primary responsibility for the administration of the SDWBL program, as well as accountability to the Legislature, was assigned to DWR, with significant input and assistance from ODW. ODW responsibilities included establishment of a priority list of water systems based on public health threats through an application process. ODW was responsible for evaluating the technical engineering and related aspects of the projects, and for determining eligibility of specific project items for funding. Once projects were approved for engineering feasibility, ODW certified the project over to DWR.

DWR was responsible for evaluation of the financial capabilities of the water system whose project had been certified by ODW. Either a loan, grant, or combination of the two would be awarded to the applicant based on DWRs evaluation of the utility's ability to repay a loan. Negotiation and execution of grant and loan contracts, administration of contracts including disbursement of SDWBL funds, collection of loan repayments, and other financial aspects of contract administration and other activities were carried out by DWR.

In the Water Resources Bond Act of 1990 (AB 1312, Chapter 919, Statutes of 1990) the Legislature provided an additional $60 million in funds to continue the SDWBL program as well as to provide continued funding for a variety of other water-related financial assistance programs. This proposal, called Proposition 148, requested approval of a total of $380 million in state GO bonds. Proposition 148 was rejected by the voters on the November 1990 ballot. As a result, ODW staff are preparing to close down SDWBL program activities at the end of the 1991 calendar year. A completion plan for all existing projects, which are in various stages of the application process, will be established by ODW in 1991. Funds remaining from the four SDWBLs will be pooled and disbursed in 1991, using the last priority list. Once ODW approves the projects and certifies them over to DWR, the ODW Financial Assistance Unit will be abolished. This is anticipated to occur in late 1991.SDWBL program statistics are provided in Table 8.16.

Table 8.16 Safe Drinking Water Bond Law Program Summary[a]

	1976	1984	1986	1988
Available Funds	**$175,000,000**	**$75,000,000**	**$100,000,000**	**$75,000,000**
Loan Allocation	$145,000,000	$50,000,000	$75,000,000	$50,000,000
Grant Allocation	$30,000,000	$25,000,000	$25,000,000	$25,000,000
Maximum Funds Per Utility				
Loan	$1,500,000	$5,000,000	$5,000,000	$5,000,000[b]
Grant	$400,000	$4000,000	$400,000	$400,000
Number of Water Systems on Priority Lists	640+	839	1,359	651[c]
Number of Invited Applicants	335	128	151	117
Number of Projects Committed	281	86	70	13
Average Cost Per Project	$622,775	$862,068	$1,010,101	$595,238
Net Remaining Available for Commitment	$12,776,094	$519,024	$9,204,721	$12,364,370

[a]Data as of December 31, 1990 (DWR 1991).
[b]Up to $25,000 for engineering and feasibility studies were eligible under the SDWBL of 1988.
[c]The 1988 SDWBL priority list is limited to systems with primary drinking water standard failures only. Prior lists accepted all applicants regardless of the type of failure.

a. SDWBL Program Issues

Inadequate Funding

The SDWBL program has provided about 70% of government assistance (state and federal) directed toward public water system improvements in California. However, as shown in Figure 8.7, the funds provided by each of the four SDWBLs has not met the demand for financing of water system improvements to meet the primary drinking water standards adopted by the state and federal governments. A total of 450 systems have received a commitment for funds, as shown in Table 8.16, from the four SDWBLs. Only a small percentage of the systems on the priority list have received funding. Because the funds requested were always much greater than the funds available, projects were prioritized and limited to correction of the most critical problems. For this reason, a set of criteria to rank projects was established by ODW to address primary drinking water standard failures only. Systems low on the priority list have not received an invitation from ODW to submit a full application to finance the needed project. At the same time, ODW and LEHJs are requiring water systems to make the necessary improvements to correct primary drinking water standard violations.

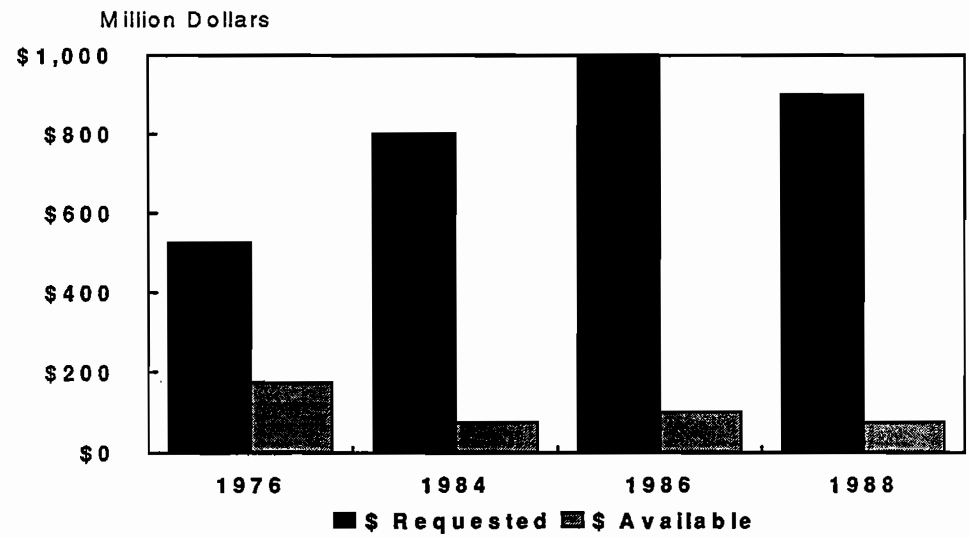

Figure 8.7. Water System Needs Compared to SDWBL Funding

As outlined previously in this chapter, there are a limited number of other funding mechanisms that are financially feasible for small to medium size water systems. With the failure of Proposition 148 for additional SDWBL program funding in the 1990 general election, most systems that are failing to meet primary drinking water standards will need to use one of these other sources of financing (which are more expensive) or be faced with continued noncompliance. ODW anticipates additional increases in noncompliance of the smaller water systems as new and more stringent drinking water standards and additional regulations are passed.

There are about 83 primary and secondary drinking water standards currently regulated in California. With the federal SDWA mandate that USEPA promulgate drinking water standards for 25 contaminants every three years, water systems will be required to monitor for and comply with numerous existing and new standards. Just as the Legislature developed the original SDWBL of 1976 to help water systems meet the NIPDWR, there must be a continuing state financial assistance program to assist water systems to comply with the lengthening list of drinking water standards.

Partial Compliance With Standards

Recognition of the limited funds available, the SDWBL program has restricted eligibility of projects to only those that correct a primary drinking water standard failure. Other system elements, such as new or replacement mains, new storage facilities, or standby equipment, may be funded as part of the project only if necessary to correct the primary drinking water standard deficiency. Thus, limited funding of the SDWBL program does not allow the use of funds for violations of the California Waterworks Standards. Secondary drinking water standard failures are also currently not eligible for SDWBL funding, although, in some cases, these have a significant impact on public perception of water quality.

Small Water System Problems

The typical small water system that has applied for funding under the SDWBL program has a variety of system problems, which include deteriorated water distribution mains, failing storage tanks, and water quality problems. Many of these small water systems have been kept operating by "passing the hat" to pay for minor improvements. Once a system has deteriorated to the point that "passing the hat" is no longer is a viable option, the search for financing or financial assistance to fund the needed improvements begins. Most cannot afford the cost of financing the improvements outside of the SDWBL program; with a smaller utility, the cost to the individual customer is often too great. Even with the low-interest loans and grant options offered by the SDWBL program, some projects may still exceed the ability of the customer to pay in a small water system.

Over 80% of all systems that have requested SDWBL funding were small water systems with less than 200 connections. Even with this high percentage of small water system preapplicants on the priority list, the number of commitments for small water systems is approximately equal to the number of commitments for large systems. Of those systems invited to submit a full application, as many as 85% of large water systems received a commitment of funds, whereas only 67% of small water systems received a commitment. There are several reasons for this. When a small water system does submit an application, it takes a longer time for DWR to decide whether to commit funds and in what form (grant or loan). This is due primarily to a failure of the small water system to maintain complete accounting records, poor operational record keeping, few or no permanent employees to follow through with requests for further information, and the inability of the part-time staff/board members to effectively communicate among themselves or with the government entities involved in the process. These problems result in a high "drop-out" rate of small water system applicants.

The problem does not limit itself to the inability to complete the application process. It extends also to the inability to finish the project within a reasonable time frame. Typically, small water systems have problems in the bid process and in dealing with contractors. Of the systems that have received an initial commitment of SDWBL funds, over 64% of the projects for large water system were completed, where as only 33% have been completed for small water systems.

In addition, engineering costs for small water system projects are a significant part of the entire construction project. It is the Department's policy that all recipients of SDWBL funds must have plans and specifications prepared by an engineer licensed in California. This requirement can increase the overall cost of a project by 10% to 20% for engineering design, not including contingencies.

If construction of a treatment plant is part of the project, the utility must obtain the services of a certified treatment plant operator. This cost is not an eligible cost for SDWBL funding. The cost for employing a certified operator, as well as the ongoing operation and maintenance of the new facilities, is borne by the water utility from the water revenues. Small water systems, especially, do not have the rate base to absorb these additional costs associated with maintaining the new facilities.

<u>Consolidation</u>

Consolidation of water systems is highly recommended by ODW whenever it is feasible. The benefits from consolidation include: (1) resolution of primary drinking water standard problems for one or more systems through one project, (2) realization of economies of scale, and (3) reduction in the number of water systems which must be tracked by the regulatory agencies, which decreases the cost of conducting the drinking water program.

When a proposed SDWBL project is reviewed to determine if the project will bring the system into compliance with all primary drinking water standards, consideration is given to the possibility of consolidation with neighboring water suppliers, whether large or small. Under the 1988 SDWBL, water systems were eligible to apply for up to $25,000 to study the engineering feasibility of proposed projects, including consolidation with other local systems to resolve regional water quality problems. The $5 million maximum loan was applied to each applicant if a consolidation project was proposed with multiple applicants. No aggregate limits were established by law for consolidation projects. However, the failed Proposition 148 had proposed a maximum aggregate loan of $10 million for consolidation projects.

2. Emergency Clean Water Grant Program

The ECWG Fund was authorized by SB 1063 (Chapter 1428, Statutes of 1985). This statute defined the purposes and requirements of the program and appropriated $4 million to the fund. In 1987, this authority was amended by AB 1285 (Chapter 885, Statutes of 1987) which specified that $400,000 be used to design, purchase, and install a water filtration system for nitrate removal for the McFarland Mutual Water Company. ODW is responsible for administration of the ECWG funds. Currently only $1.5 million remains in the fund. With the continuing drought, these funds are anticipated to be exhausted to resolve water outage and water shortage emergencies during Summer 1991.

Because these funds had been made available in the form of grants under SB 1063, only publicly-owned water supply systems could originally request emergency assistance. However, methods for repayment have been established so that a privately-owned or mutual water company may now request use of these funds to resolve an emergency situation.

The ECWG funds are to be used strictly for the purpose of correcting or preventing an emergency or imminent threat to public health due to the contamination of a public water supply or due to water outages. Funds are to be disbursed upon ODWs determination that the situation would not be adequately addressed through funding from other sources, typically for expediency in resolving the problem. Table 8.17 provides some information regarding the disbursement of the ECWG funds.

The funds are used primarily to carry a water system through the emergency until a long-term solution can be arranged. Typical solutions to resolve short term problems include temporary interties with adjacent water systems; temporary treatment systems; rented, borrowed, or purchased equipment replacements; and the distribution of bottled water or the use of water trucks to haul water. Solutions for long-term problems that must be resolved quickly include permanent interties with adjacent water systems, alternate water supplies, and the use of consultants to solve operational problems.

An oral contract may be awarded for up to $5,000, and may be executed as quickly as within 24 hours. The oral contract would normally be used to provide financial assistance for a public health emergency, which can be resolved for $5,000 or less. The oral contract may be used to provide an interim solution (such as bottled water or a temporary intertie) in order to allow sufficient time to process a standard written contract for disbursing ECWG funds.

Table 8.17 Emergency Clean Water Grant Program Summary[a]

Program Funds Allocated	**$4,000,000**	
Funds Remaining	**$1,500,000**	
	Formal Contract	**Oral Contract**
Maximum Grant Per Utility	No Maximum	$5,000
Total Contracts	26	12
Average Cost Per Project	$80,970	$2,950
Number of Schools Receiving Funds	17 (45% of total contracts)	

[a]Data as of December 1990.

a. ECWG Program Issues

There are no staff positions identified for the administration of the ECWG program. Currently, staff are assigned from the ODW Certification Unit to work on ECWG projects as they arise.

As previously mentioned, the remaining funds in the ECWG fund is inadequate. The $1.5 million remaining in the fund may be consumed by continuing drought conditions in some water systems during the Summer 1991.

The ECWG program is now allowing loans to privately-owned utilities. The ODW Certification Unit has no mechanism to determine the ability of a water system to repay a loan. This function is carried out for the SDWBL program by DWR, not by ODW staff.

3. Summary of Financial Assistance Programs

As discussed in the introduction to Section D - Financial Assistance Programs, there are several financial assistance programs available to water utilities. Each program has established criteria to determine project eligibility for funding. Most of the state and federal programs do not provide funding to investor-owned and mutual water companies, since this is often seen as adding value to a privately-owned business. The exceptions to this are the state SDWBL and ECWG programs, and the federal FmHA and Small Business Administration programs. The programs available to finance drinking water projects are summarized in Tables 8.18 and 8.19, categorized by system size and type of ownership.

Table 8.18 Financial Assistance Programs Available to Water Utilities Categorized by Type of Utility Ownership[a]

Financial Assistance Programs	Publicly-Owned	Investor-Owned	Mutual
STATE			
Safe Drinking Water Bond Laws	✘	✘[b]	✘[b]
Emergency Clean Water Grants	✘	✘[c]	✘[c]
Water Conservation Bond Laws	✘		
Water Reclamation Loans	✘		
Rural Community Facilities Technical Assistance	✘		
Agricultural Drainage Water Management Loans	✘		
Community Development Block Grants	✘		
FEDERAL			
Water and Waste Disposal Loans and Grants (FmHA)	✘		✘
Community Facilities Loans (FmHA)	✘		✘
Small Business Administration Loans		✘	
Community Development Block Grants	✘		

[a]Refer to *Aspects Of Financing And Revenues For California Water Utilities* (CDHS 1991) and Morgan and Mercer (1991) for details on each of these financing alternatives.
[b]Loans only, grants not provided to privately-owned water systems
[c]Grants that would result in a permanent improvement in the system (i.e., a new well) are not allowable. A loan repayment schedule must be established for such emergency projects.

Table 8.19 Financial Assistance Programs Available to Water Utilities Categorized by Utility Size[a]

Financial Assistance Programs	Small	Intermediate	Medium	Large
STATE				
Safe Drinking Water Bond Laws	✘	✘	✘	✘
Emergency Clean Water Grants	✘	✘	✘	✘
Water Conservation Bond Laws	✘	✘	✘	✘
Water Reclamation Loans	✘	✘	✘	✘
Rural Community Facilities Technical Assistance	✘	✘	✘	
Agricultural Drainage Water Management Loans	✘	✘	✘	✘
Community Development Block Grants	✘	✘	✘	
FEDERAL				
Water and Waste Disposal Loans and Grants (FmHA)	✘	✘	✘	
Community Facilities Loans (FmHA)	✘	✘	✘	
Small Business Administration Loans	✘	✘	✘	
Community Development Block Grants				✘

[a]Refer to *Aspects Of Financing And Revenues For California Water Utilities* (CDHS 1991) and Morgan and Mercer (1991) for details on each of these financing alternatives.

4. Evaluation of Alternative Programs

State GO bonds have been used to fund the SDWBL program since its inception in 1976. This program has helped over 450 water systems to finance water system projects. There is no additional funding in this program to continue financial assistance.

Funding for drinking water financial assistance should not be something that needs to be reaffirmed again and again by the voters. Although a significant percentage of voters approved the four bond acts which have funded the SDWBL program till now, the most recent attempt to continue this funding (Proposition 148) failed. Proposition 148 was presented to the public at a time of concern over budget deficits at the state and local levels.

It is clear that water utilities need a source of assistance that will finance water system improvements required by existing and proposed regulations. Compliance with these regulations will be very costly, as was shown earlier in this chapter. Voters have approved past requests for funding of a financial assistance program for drinking water, which shows support for such a program.

It is time, however, to look to alternatives which would make a significant amount of funding available, since over $1 billion in needs in the public water systems have been identified. Any alternative to the previous SDWBLs should provide long-term funding for a financial assistance program, rather than small sums that are quickly allocated. With these requirements in mind, several alterative financing mechanisms are discussed below.

There are numerous alternative revenue sources that can be implemented to fund a state drinking water financial assistance program. One report by the National Governors' Association(1989), identified several alternative revenue sources, such as user fees, permit fees, pollution discharge fees and taxes, taxes devoted to environmental programs, bonds, and compliance penalties and fines. The feasible alternative mechanisms to fund a drinking water financial assistance program include fees, dedicated taxes, and bonds. The most advantageous means to extend the life of funds from any single or combined revenue sources is to pool them into a revolving loan fund.

a. Fees

Fees are a means of charging the beneficiaries or users to recover part or all of the costs associated with pollution-causing activities. There are many fee programs already in existence in California, such as the NPDES waste discharge fees, wastewater operator fees, fees on applications for water rights, and newly established fees on water utilities. Since water contamination is generally a result of a discharge, the dedication of a portion of the NPDES waste discharge or other fees already being collected in the state would be appropriate to provide a portion of the funding for a financial assistance program for drinking water systems. Many of the surface waters in the state are subject to waste discharges. The upgrading of surface water treatment plants to meet the requirements of the new SWTR will be costly, especially for the smaller systems.

b. Dedicated Taxes

Most tax revenues raised by state governments flow directly into their general funds, rather than being dedicated or "earmarked" for specific purposes. The most widely earmarked taxes are those on motor fuels, motor vehicle registrations fees, alcoholic beverages, general sales taxes, and tobacco (USEPA 1990b). One of the most successful revenue programs to support environmental activity is the State of Washington's cigarette tax, which helps finance the state's water pollution control program. In this case, no clear connection exists between the activity taxed (sale of tobacco) and the use for which the revenue is collected (the water program). Nevertheless, the use of "sin taxes" typically elicits little public opposition, particularly when the revenues are used for activities receiving widespread public support.

Washington's Centennial Clean Water Act, enacted in 1985, established an eight cent tax on each pack of cigarettes sold at the retail level, a 16.75% tax on tobacco sales at the wholesale level, and a sales tax on all materials used in building wastewater facilities. The funds are loaned primarily to municipalities to finance point source contamination, ground water protection projects, and related water pollution control activities (NGA 1989).

One of the advantages of earmarked taxes is that the tax burden is spread over a broad base. Also, use of existing tax collection mechanisms reduces the administrative burden. Greater public approval may often be achieved for new proposed taxes for environmental programs if such taxes are levied on the sale or purchase of products that contribute to pollution. However, for the most part, revenues from earmarked taxes are used to supplement appropriations from general revenues and they do not provide the major source of revenue for water programs.

c. Bonds

A government bond is a written promise to repay borrowed money on a definite schedule, usually at a fixed rate of interest over the life of the bond. State and local governments repay this debt by levying taxes on citizens or charging fees to users. Bond proceeds are traditionally used as a source of loan funds for bond banks or direct loan programs. They also have been used for capitalizing revolving loan funds or providing grants. Because of their small size or lack of good credit rating, many communities do not have access to the national capital markets at reasonable prices. As a result, states, including California, have created bond banks to provide market access to some communities. California currently has a AAA rating from Standard and Poor's, a bond rating firm. California's high bond rating facilitates the issuance of bonds for this purpose.

The major advantage of state-issued bonds is that they offer lower interest rates than the rates that could be obtained by many communities in the tax-exempt bond market. GO bonds carry the lowest available interest rate of any state bond because they are backed by the state's general treasury. The primary disadvantage of GO bonds is that they require two-thirds voter approval in California. Therefore, the state risks disapproval of a proposed bond issue by the citizens due to the possibility of increased taxes. Revenue bonds, on the other hand, do not require voter approval, since they are backed solely by project revenues. Revenue bonds generally have a higher interest rate than GO bonds.

California's bonding capacity is decreasing due to the current general fund deficit. With the state general fund in a deficit position, there is a risk that the state's credit rating may deteriorate. If the state's credit rating is lowered, the interest cost of state GO debt will increase. Revenue bonds may be a solution in that they do not rely on tax revenues for repayment. Therefore, revenue bonds may be useful in a situation that requires the state to conserve its GO debt capacity.

d. Revolving Loan Programs

A revolving loan fund is essentially a bank operated by the state. The fund is established by an infusion of seed capital, which may come from any combination of funding, including general appropriations, fees, bond proceeds, and/or dedicated taxes. Once the fund is established, it serves as a source of long-term, low-interest loans. Loan repayments maintain the solvency of the bank. The greatest advantage to establishing a revolving loan fund is its potential for long-term self-sufficiency. Since loan repayments are cycled back into the fund, a pool of capital is available for future projects. Although there are benefits to establishing and operating a revolving loan fund, the financial management of a state-operated bank is complex. Tracking money over long periods of time often requires sophisticated and expensive resources. California already has developed the necessary system to track repayment of SDWBL funds through DWR.

Although revolving loan funds are used primarily to finance sewage treatment plants, through the federal Clean Water Act of 1987, states are increasingly using the revolving loan concept to finance a variety of public projects. NGA (1989) reported that 13 states maintained 19 revolving loan programs.

e. Examples of Other State Financial Assistance Programs

California's State Revolving Fund for Wastewater

The State Revolving Fund (SRF) Loan Program, authorized by Congress under the Clean Water Act of 1987, assists communities that need financing for wastewater treatment projects. Prior to 1987, the wastewater industry had access to the USEPA financial assistance program, called the Wastewater Treatment Construction Grants Program. In 1987, the United States Congress established the State Revolving Funds as a method of phasing the United States government out of the financial assistance picture altogether.

The Clean Water Act authorized a total of $7.2 billion to be granted over a five year period (1989-1994) to states as capitalization grants for the establishment of state loan programs to finance wastewater facilities. The state must deposit 20% matching funds into the account to start the SRF. The federal capitalization grants can be used for establishing state banks, to purchase credit enhancement purposes, or to fund loans directly.

California's SRF replaced the Clean Water Grant Program. Under SRF, fundable projects include those for wastewater treatment, agricultural drainage problems, non-point source contamination, estuary enhancement, storm drainage, and water reclamation. Between $150 to $200 million is available annually from the federal capitalization grants, totaling $757 million by 1994. Loans are available for up to 20 year terms with an interest rate of one-half the rate of the most recent sale of state GO bonds. The types of assistance include low-interest loans, insurance for local debt obligations, guarantees for local debt obligations, and the purchase or refinancing of local debt obligations where construction was initiated after October 1, 1988.

State of Washington

The Washington State Public Works Trust Fund (PWTF) is an example of a successful multipurpose infrastructure funding program. It emphasizes project self-sufficiency, comprehensive planning, and allocation according to ability to pay as well as severity of need. The PWTF grew out of a 1982-83 statewide survey of Washington State infrastructure needs, that found a total of $4.3 billion in projected needs for all publics works, while only 53% of this could be met by local resources.

PWTF offers a number of programs that provide low interest loans to help local governments finance needed public works projects or planning. A 13-member Public Works Board directs the offering of loans from this state revolving fund. Staff support for policy development, technical assistance, and loan issuance is delivered through the Washington State Department of Community Development's Public Works Unit. Special consideration is given to public health and safety and to sound public works capital programming at the local level. There are three financial assistance programs offered: General Construction, Capital Improvement Planning, and Emergency.

PWTF is capitalized with dedicated revenues from taxes on water, sewer, garbage utilities, and a portion of the real estate excise tax. These taxes are collected and deposited in the Public Works Assistance Account that is managed by the State Treasurer. Repayments of past Trust Fund loans are placed in a revolving fund. Future revenues are expected to provide over $30 million annually. There are currently over $36 million available in the General Construction program; $1 million in the Emergency program; and $400,000 in the Capital Improvement Planning program.

To be eligible, an applicant must be a local government or special purpose district and have a long-term capital improvement plan for financing its public works needs. If the applicant is a county or city, the optional 0.25% real estate excise tax dedicated to capital purposes must be imposed.

Eligible public works projects include bridges, roads, domestic water, sanitary sewer, storm sewer, and capital improvement planning projects. Loans are presently offered only for purposes of repair, replacement, rehabilitation, reconstruction, or improvement of existing eligible public works systems to meet current standards, and to adequately serve the needs of the existing service users.

State of Pennsylvania

The Pennsylvania Infrastructure Investment Authority (PENNVEST) is an independent state agency that finances improvements to drinking water and sewage treatment facilities in Pennsylvania. Authorizing legislation (shown in Appendix 3) was passed in February 1988, and signed into law on March 1, 1988. Because of prior lack of state financial assistance and regulatory authority requiring facility upgrades to meet the federal

SDWA, Pennsylvania drinking water and sewage treatment facilities were estimated to need over $4 billion in improvements. Funded by nearly $1 billion, it is the most ambitious water and sewer infrastructure funding program in the United States. The funding for PENNVEST has been obtained from the following sources:

- $310 million in federal wastewater capitalization grants[35]
- $215 million in unused Water Facilities Loan Board funds
- $300 million from a voter approved bond referendum
- $150 million from site development capital budget projects
- $25 million in direct appropriations from the general fund

The monies have been used to create revolving and non-revolving low-interest loan funds. The PENNVEST funds will be expanded by additional general fund appropriations, loan repayments, interest on invested funds, and funding from authority-backed revenue bonds. This will allow the original funding to be leveraged to finance hundreds of new projects for the next 25 years.

Most PENNVEST assistance is in the form of low-interest loans, which range from 1% to 6% interest. Some grant money is available for economically distressed communities that would face unreasonably high user rates even with low-interest loans. Financing is for up to 100% of eligible project costs with a project cap of $11 million for single-system projects. The cap is increased if multiple systems benefit from the project.

In addition to loans for construction, PENNVEST also gives advance funding for design, engineering, and feasibility studies for drinking water projects, and design and engineering studies for sewage projects. Advance funding is available to small communities to plan the design of a project prior to applying for a construction loan.

Projects are prioritized and selected based on an evaluation of project applications on the basis of the criteria outlined in the PENNVEST legislation. The PENNVEST Board of Directors, chaired by the Governor, meets quarterly to decide on funding for projects submitted for consideration by the staff. In addition to the Governor, the Board of Directors includes four legislators; secretaries from five state agencies; and and three members representing the water and wastewater industry,

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[35]Capitalization grants from the federal Clean Water Act of 1987 are provided to states thru 1994 to establish state revolving fund programs for wastewater treatment.

the engineering community, and local government, each of whom is appointed by the Governor.

This law was signed in March 1988. By June 1988, the Board of Directors had approved 42 loans totaling $62 million. By April 1990, 346 projects had been approved for funding, totalling over $516.4 million, which consisted of $490.8 in loans and $25.6 million in grants.

The PENNVEST program administration includes a computer database that tracks over 130 pieces of information on projects and applicants; a general financial advisor to assist with revenue bond issues; and six firms hired to provide financial advice to applicants.

CONCLUSIONS AND RECOMMENDATIONS

Cost of Water

Many consumers believe that plentiful, inexpensive, potable water is a right, but they are not always willing to pay the cost associated with that right. This has been demonstrated by national water surveys that have shown that Californians pay the lowest water bills while having the highest water consumption rate in the United States. Because of this, there has been substantial controversy in California communities regarding water rate increases and metering of unmetered water systems. The current drought has contributed to changing this attitude by bringing to the forefront the problems faced by the state in balancing water quality with water quantity at an affordable price. People living in areas served by public water systems that possess a domestic water supply permit have a right of an adequate supply of potable water. However, as the public demands more stringent drinking water standards, they must realize that with these greater assurances of the safety of the water, there will be increases in the cost to provide that assurance, due to the high-cost of monitoring and treatment techniques and expanded regulatory controls and oversight.

In many smaller water utilities, water rates have not kept up with the increasing costs of complying with the regulations. This has caused deficient operation and maintenance programs. Many systems need to replace outdated or severely aged infrastructure (such as leaking water mains and deficient storage tanks). Also, standard operation and maintenance programs such as routine water main flushing, valve maintenance, and repainting facilities to prevent rust, have not been implemented.

An analysis of the responses to the *Survey of Community Water Systems in California* conducted by the Department for this report shows that the current average cost of drinking water in California is $21.30 per month for metered single family customers and $19.30 for unmetered customers. The average monthly water bill for metered customers increases as the water system size decreases. Overall, single family residents in small water systems have average monthly water bills that are about 40% higher than those for single family residents in large water systems with greater than 10,000 service connections. The average water rate, which is the cost for each unit of volume used, is more than 50% greater in the small systems than in the large.

The price of water has been shown to vary by size of water system, geographic location, type of source, and treatment provided. The San

Joaquin Valley counties have the lowest overall average water rates; the predominant source of drinking water in these counties is ground water. The survey has shown that treated surface water is about 23% more expensive than untreated ground water.

The analysis of the cost of water has shown that water treatment practices and regulatory requirements for treatment, as of December 1989, increased the unit cost of water (at 1500 cf) by up to 20% over the cost of untreated water for both surface and ground water.

Based on an analysis of the monitoring costs, treatment costs, and fees imposed on water systems to meet current and proposed regulations, it has been estimated that providing drinking water that is in compliance with all standards and regulations will cost $283 million per year statewide or increase an average water bill from $6 to $55 per month per service connection for the large and very small water systems, respectively, by the mid 1990s. The customers in most water systems will see a substantial increase in the cost of water, with the smaller water systems experiencing the greatest overall percentage increase and paying the highest price for water. In addition to the approximately $283 million per year paid to public water systems, surveys indicate that Californians voluntarily pay in excess of $1 billion per year for bottled water and home treatment devices. The reported purpose of this use of bottled water and home treatment devices is to improve the aesthetic quality of the water or to eliminate perceived health risks.

Using a financial hardship indicator of 2% of median household income as a basis to determine affordability for drinking water, it has been estimated that Californians may be able to afford water charges in the range of $20 to $50 per month. On average, it appears that the cost of water has already exceeded the lower end of this range. When considering the cost impact of future regulations, the water bills paid by customers in small and large water systems will exceed the upper limit in the mid-1990s.

The imposition of RPHLs on water systems with 15 to 10,000 service connections would result in the cost of drinking water served by these systems to increase an additional 19% to 27% over the future total costs necessary to meet the existing and proposed regulations. This would increase the current cost of water by 60% for the smaller systems and 25% for the medium systems. Although the cost to meet the RPHLs, by itself, does not appear to be substantial, this cost must be evaluated with the health benefits obtained and the minimal reduction in population exposed. Figure 8.8 illustrates the comparison of the "Typical" system costs to provide safe water and costs to meet the RPHLs versus the reduction in population exposure due to the implementation of the RPHLs.

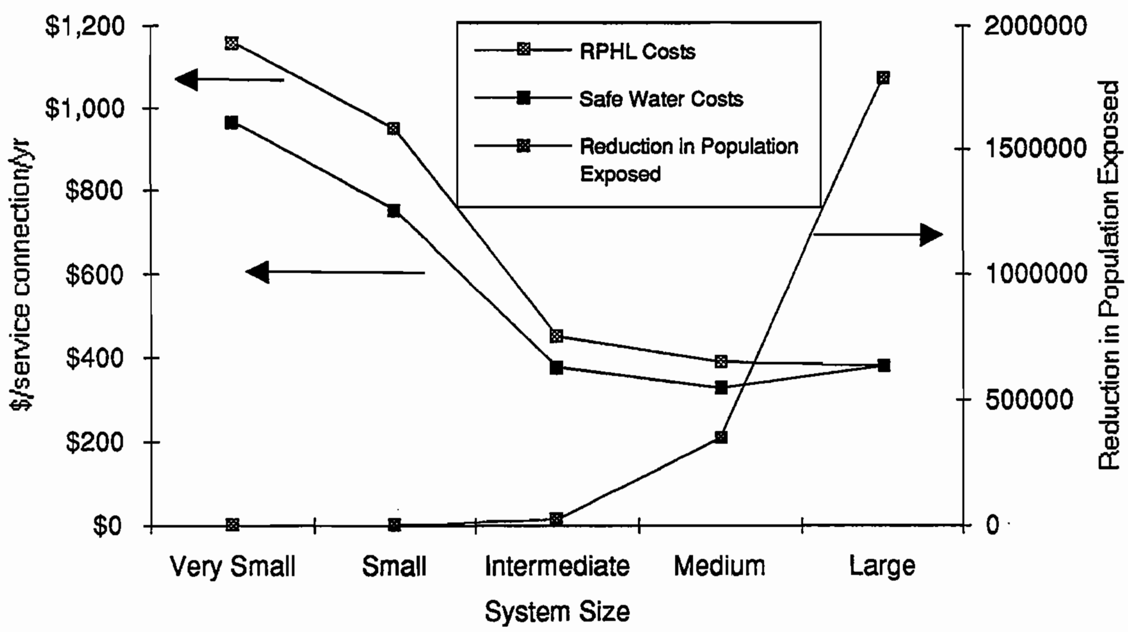

Figure 8.8. "Typical" System Costs Versus Population Reduction Due to Implementation of RPHLs

Recommendation: When the costs of mandatory compliance with the numerous new MCLs, the costs of more monitoring and treatment, and the actual incremental health benefits are considered, it is not recommended that the RPHL requirement be extended to the smaller systems.

The cost of water will definitely increase. If consumers can understand the benefits associated with these increasing costs, they will have an easier time accepting these costs. Public education is essential to help the public understand the benefits of more stringent drinking water standards and regulations. But, despite a desire by the consumers for better water quality, many systems will become financially nonviable due to the inability of customers to pay the additional costs.

Recommendation: An active, visible public education and information program should be implemented by the Office of Drinking Water to provide water customers with up-to-date

information regarding: water quality; the needs of local the water programs; the benefits of providing ongoing water quality monitoring, system maintenance, disinfection and treatment (if needed) to meet increasingly stringent regulations; and the costs involved. Funding for such a program may be obtained either through fees on water systems or through a new state financial assistance program for drinking water.

Sources of Revenue

The cost to the water utility to provide drinking water must be recovered through revenues. These costs include operating costs, repayment of debt service, and imposed fees to support the regulation of drinking water in California. Revenues may be derived from the water rates charged to customers, either on a flat rate or a metered rate basis; property taxes; and special improvement district assessments. Publicly-owned water systems have traditionally paid for high-cost water system improvements through broad-based taxes plus some user fees on direct beneficiaries of the service. Due to voter opposition to tax increases in California, utilities have turned to raising additional revenues through special charges and fees, such as development impact fees, connection fees, and standby fees.

Many smaller water utilities have not kept water rates at a level to provide the revenue necessary for needed program or system improvements required by new regulations. Although the current cost of water is higher in smaller water systems than in the larger water systems, this does not reflect the same level of service received by customers in the larger systems, nor does it reflect the physical condition of the water system. In other words, small water system customers in general are paying more and receiving less than large water system customers.

Methods of Financing

The methods of financing that can be used for large capital improvement projects have been found to be limited by both the type of water utility ownership and the size of the water system. The small- to medium-sized water utilities have limited access to adequate capital financing due to the associated costs of obtaining financing and the lack of financial expertise of the utility management. The investor-owned systems have limited access also, due to the fact that these are for-profit utilities, with certain regulatory limitations imposed.

Self-financing, or pay-as-you-go, is a feasible method to finance projects when the utility has maintained a reserve of sufficient size. However, it was found that smaller water systems do not maintain reserves large enough to pay for the high capital costs of water treatment. Conventional long-term debt instruments, such as the issuance of GO bonds (secured through property taxes) and revenue bonds (secured through revenues of the agency), continue to be the prevalent financing method in the tax-exempt market. The use of revenue bonds has predominated over GO bonds in the past decade as a result of limitations in issuing debt secured by property taxation. COPs were developed in the 1980s as a financing instrument in California due to Proposition 13 limitations in issuing tax-backed debt, and use is increasing in California and nation-wide. Other innovative methods of financing have developed in response to high long-term interest rates in the 1980s and changing tax policies. There are disadvantages to these new methods, which potentially increase the overall cost of financing a project, such as higher interest rates, requirements for establishing a sinking fund reserve, or obtaining a letter of credit.

Bond pools have become a feasible method for smaller systems to take advantage of the bond market, which is typically available only to larger water utilities due to the high costs of bond issuance. Privatization, specifically the use of private financing, construction, and/or operation (termed public/private partnerships), could provide additional options to smaller systems as well as larger water systems for financing and operating high cost and high technology water treatment facilities. The tax benefits of private participation in public ventures, however, has been limited by state and federal tax reforms. Whereas privatization occurs elsewhere in the United States, there is limited use by California water utilities.

Recommendation: The Legislature should consider identifying and making changes in the state tax laws that would encourage privatization, such as public-private partnerships. The legislature should take steps to improve the availability and reduce the costs of financing for public and private agencies.

State Financial Assistance

Although there are several state and federal financial assistance programs available to water utilities, few of these programs are strictly for the purposes of assistance to public water systems. This creates competition for the funds available through these programs for projects which include drinking water, wastewater, low-income housing, and water conservation, to name a few. The state's SDWBL program has historically funded only those projects that resolved a primary drinking water standard failure, thereby providing a direct reduction in risk to the water consumer. Projects funded under other programs, such as the

Agricultural Drainage Water Management Loan program and the Water Conservation Bond Law program, follow priorities established by those programs that are not based on health benefits. Therefore, projects to reslove any health threat may not receive priority under these programs.

Two issues arise from this, specifically with regards to the drinking water program. One is the need to maintain a drinking water financial assistance program that is clearly established to meet the needs of water utilities that provide drinking water to Californians, as opposed to a joint program, such as those offered is some states, where financial assistance for drinking water is lumped with other public works infrastructure assistance, thus creating competition within the financing program for different needs. The other issue is the need to coordinate the activities and priorities of the various financial assistance programs within the state to assure that the funds are utilized to meet the needs that address the greatest health threat.

Both of the financial assistance programs for drinking water systems (i.e., SDWBL and ECWG programs) are administered through a variety of agencies and units. For example, the SDWBL was administered through DWR, with assistance from the ODW Financial Assistance Unit. The ECWG program is administered through the ODW Certification Unit. The ODW Certification Unit does not have the capacity to adequately review the ability of investor-owned and mutual water companies to repay emergency loans. Overall, greater coordination of activities should be provided for under any new state financial assistance programs for drinking water.

Recommendation: Coordination of future state and federal financial assistance programs available to public water systems in California should be implemented to ensure that government financial assistance programs prioritize and resolve the greatest public health threats.

Recommendation: To provide greater coordination of financial assistance activities specifically within the drinking water program, the administrative activities for any future financial assistance programs within the Office of Drinking Water should be combined into one program under the Financial Assistance Unit. This would include any future long-term financial assistance program and the existing Emergency Clean Water Grant program.

Long-Term State Financial Assistance

Water purveyors in California have already requested over $1 billion from the SDWBL program, which has provided financial assistance through low-interest loans and grants to bring domestic water systems into compliance with primary drinking water standards. Many millions of additional dollars will be needed as new and more stringent drinking water standards are adopted and treatment regulations presently under development by USEPA and ODW come into effect. The state's SDWBL program has been the major source of financial assistance to smaller water systems.

The SDWBL program is being discontinued due to a lack of continued funding for the program. Yet, based upon the need for financial assistance and the fact that the small to medium size utilities have greater difficulty in obtaining other sources of financing, either due to their type of ownership or the cost of using that financing vehicle, there is a substantial demand for a state financial assistance program for domestic water systems.

It is time, however, to examine alternatives that would make a significant amount of funding available, as over $1 billion in needs has been identified. Any alternative to the previous Safe Drinking Water Bond Laws should provide a stable, long-term sources of funding to the financial assistance program, rather than small sums that are quickly allocated. There are several alternative revenue sources that can be used to fund a state drinking water financial assistance program including dedicated taxes, bonds, and revolving loan funds. One example of a successful revolving loan fund program is the Pennsylvania Infrastructure Investment Authority (PENNVEST) which finances improvements to drinking water and sewage treatment facilities in the State of Pennsylvania.

Recommendation: The Legislature should consider authorizing an independent in-depth review of alternative methods for providing state financial assistance, and should determine the most applicable program to meet California's growing needs in financing drinking water improvements. Types of alternative financing programs to consider should include the establishment of a revolving loan fund using any one or combination of the following revenue sources: general obligation or revenue bonds; fees; and dedicated taxes. Specifically, the State of Pennsylvania's PENNVEST program should be examined as a potential model state financial assistance program.

Recommendations for the continuation of long-term financial assistance for the drinking water include:

Program/Policy Issues

- **Funding to target the systems with the greatest need, such as the smaller water systems with 15 to 1,000 service connections, where the greatest cost increases are anticipated.**

- **Systems receiving funds should be required to establish and maintain a sinking fund to maintain the funded improvements and pay for replacements at the end of their useful life.**

- **Technical assistance should be provided to utilities for guidance in obtaining financing; both in applying for state financial assistance and other financing mechanisms.**

- **The maximum grant should be increased from $400,000 to offset the decreased purchasing power of the dollar since the establishment of the grant limit in 1976.**

Eligible Project Costs

- **Consolidation (regional solutions) should be encouraged by 1) allowing connection fees and charges to be eligible project costs; 2) increasing the amount of funding available for consolidations; and 3) funding county studies to determine where consolidation should take place.**

- **Funds should be provided for preliminary feasibility studies for both single system projects and consolidation. Provide advance funding to approved small water system projects for design and engineering studies.**

- **The authorization to use funds for letters or lines of credit; bond insurance; bond guarantees; and loan guarantees. These means of enhancing utility creditworthiness will allow utilities to become eligible for outside sources of long-term financing or enable them to obtain better interest rates on bond issues and loans.**

- **To expedite repayment of contractors, eligible costs for a funded project should include the costs for a utility to obtain a line of credit at a local bank in order to pay contractors for work completed. The bank loan would be repaid by the state funds as these funds are disbursed to the utility.**

- **Funding should be provided to counties to plan regional solutions for water systems through the development of county drinking water master plans[36].**

Emergency Assistance

The ECWG funds have been used typically to resolve emergencies for smaller water systems, which have little or no reserves for such situations. With the continuing drought and increased monitoring requirements that the small water systems are just now beginning to implement, water outages and newly identified primary drinking water standard failures can be expected. Due to this need, and recognizing that the existing allocation is soon to be depleted, additional allocations are necessary if the ECWG program is to continue.

The ODW Certification Unit, which currently administers the ECWG funds, is not able to properly determine the ability of investor-owned and mutual water companiesto repay a loan. Although emergency loans can now be approved for these systems, the institutional mechanism for credit review of these applicants is lacking.

Many of the publicly-owned small water systems requesting ECWG funds may not have a reserve to get through an emergency, but may be able to repay state emergency assistance through their existing water rates.

Recommendation: The Legislature should consider additional allocations to maintain the Emergency Clean Water Grant Fund. A revolving loan fund for emergencies should also be established for use by investor-owned and mutual water companies.

Recommendation: Public water systems with the ability to repay the emergency loan, to be determined based upon the customer's average annual income level, should also be required to repay emergency funds.

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[36]Refer to Chapter X for details.

Recommendation: The administration of the Emergency Clean Water Grant program should be combined with the administration of Office of Drinking Water duties in any new long-term state financial assistance program under the Office of Drinking Water Financial Assistance Unit. This would resolve both the financial ability determination issue and the staffing needs to conduct the emergency program.

Technical Assistance

Many smaller utilities lack the technical expertise to determine economical and feasible means to finance capital improvement projects. In applying for funding through the SDWBL program, it has been ODW's experience that many small systems "drop out" from the application process due to this lack of expertise.

The smaller investor-owned water systems lack an understanding of the PUC application process, for obtaining rate increases to recover the costs of implementing required monitoring and water works construction standards. As a result, operation and maintenance suffers and systems fail to comply with the SDWA monitoring requirements.

Recommendation: It is recommended that any new California financial assistance program contain authority and funding to allow the development and implementation of a financial technical assistance program that would be aimed primarily at the small-to-medium size water utilities. This technical assistance program would provide utilities with updated information regarding methods of financing, available state and federal financial assistance, and would provide aid to utilities in determining the feasible means to finance projects and in applying for financial assistance.

Recommendation: As part of a financial technical assistance program, training should be provided through a third-party contract for investor-owned utilities on procedures to applying for rate increases to meet the cost requirements of new regulations, and the need to plan for infrastructure maintenance and replacement.

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CHAPTER IX

INFORMATION SYSTEMS

Timely and accurate information is critical to any successful regulatory program. The drinking water program also reflects this critical need for timely and accurate information to adequately protect the public health.

Prior to 1980, the drinking water program was a relatively simple program with concerns only for bacteriological quality and a few inorganic chemicals. The technological revolution provided instruments and methods to detect more chemicals at much lower levels and previously unknown microbial agents, such as *Giardia lamblia* and *cryptosporidium*. This has led to the finding of chemicals and microbial agents in drinking water that are of health concern. The findings of these constituents has led USEPA and California to establish a substantial number of new drinking water standards and regulations over the past 15 years. This in turn has led to an increased amount of required monitoring that has generated an overwhelming amount of water quality data. The new regulations and standards, with the increased amount of monitoring, has also greatly increased the amount of compliance information on all water systems.

The requirement for the drinking water program to manage this changing and increasing amount of information is and will be a significant issue at both the federal and state level. The federal government itself has been under considerable pressure to improve the information management capabilities of the drinking water program nationwide. One recommendation from the National Wildlife Federation report (1988) on the national drinking water program stated, "EPA must adopt rules and implement a computer tracking system and record keeping practice that allows it to bring prompt and effective enforcement cases against those public water systems that break the law."

The United States General Accounting Office (1990) recently found that states were underreporting violations to USEPA. The USGAO found that "...the percentage of total errors identified from state to state varied widely, the percentage of errors found to involve the underreporting of violations was consistently high."

These findings have led USEPA to implement stricter and additional reporting requirements under the Federal Data Reporting System (FRDS-II) for states retaining primacy for the drinking water program. USEPA has established the reporting of data as a key element for each state to retain primacy for the drinking water program. In addition, USEPA has also tied specific data reporting to federal grants that fund the drinking water program.

For California to effectively regulate public water systems, handle the increased amount of water quality data and information, and retain primacy with continued federal grant funding, an efficient information management system is needed. The current information systems and efforts to improve these systems to meet these needs are presented in this report.

A. STATE PROGRAM IN DRINKING WATER

The provisions of the California SDWA initially established a separation of the responsibilities for regulating public water systems. ODW was given responsibility for large water systems (systems with at least 200 service connections), whereas LEHJs were responsible for small water systems (systems with less than 200 service connections) within their respective counties. Because of this split jurisdiction, two separate information systems were developed to meet the requirements set forth in the federal SDWA and USEPA regulations.

1. Office of Drinking Water

The ODW information system is currently made up of several individual components lacking integration or consistency. The statewide inventory was set up on the Health and Welfare Data Center mainframe computer, where it still resides, and is regularly updated. ODW's fourteen district offices also maintain the inventory information on all large water systems within their boundaries. In addition, each district office also manually collects information on compliance, enforcement, permitting, inspection, and water quality data. Information specific to public water systems is stored in paper files, and is manually compiled and submitted to ODW headquarters where it is again manually compiled and reported quarterly to USEPA. Water quality data is stored in paper files in the district offices, but it is also entered into an electronic information management system, Water Quality Management (WQM) at ODW headquarters.

This paper-oriented, labor-intensive, dual tracking and reporting system does not effectively and efficiently track drinking water program information. It has become a major resource problem, significantly affecting the drinking water program. Over 25% of staff time is being used to routinely handle the information, taking away valuable staff resources that could be used to manage other portions of the program. Any request for data becomes a major resource demand far beyond what a simple information request should be. Any data request reports to the Legislature, public, or press requires a redirection of resources to accomplish that task, again taking resources away from program functions.

Recognizing this problem and the need to address information management issues, ODW established a Data Management Committee in March 1988, to evaluate the options and alternatives for the use of electronic-data processing and collection to meet the needs of ODW. As part of this evaluation the ODW - Data Management Committee was to also assess what would be needed to meet the USEPA information reporting requirements for maintaining primacy and retaining grant funding for the program. Based on the recommendations from the committee and the Department's Data Systems Branch, an information management work plan to begin to address ODW's problems and needs was developed and implemented. This work plan has been approved by the Department of Finance, Office of Information Technology(CDF 1990).

This work plan for improved information management moves ODW toward a better information system for large water systems only with the limited resources available. This plan is only a beginning; there are still many areas that need to be addressed to develop and implement a comprehensive, effective, and efficient information system. The work plan has established three integrated software data programs installed on the Health and Welfare Data Center mainframe computer, accessible through dedicated telephone lines via a wide area network tied to personal computers.

a. PICME

PICME is the acronym for a comprehensive information management system to track and maintain information on permits, inspections, compliance, monitoring, and enforcement (PICME) for public water systems in each district office. PICME is the major building block for ODW's computerization to provide support to district office engineers and technicians to conduct day-to-day business. PICME will help assure the safety of the drinking water by enabling ODW field staff to perform more effectively and efficiently by providing timely and up-to-date information on public water systems including the compliance status with monitoring requirements and MCLs. The PICME system will also produce timely and accurate reports to USEPA that will meet the FRDS-II reporting requirements for California to continue to maintain primacy and continued grant funding.

b. Water Quality Management

WQM is a program that has been developed by ODW, and has been in operation since 1988, when ODW assumed responsibility for the water quality data from the State Water Resources Control Board's, State Water Quality Information System (SWQIS). WQM maintains drinking water quality monitoring results, locations of drinking water sources, and operating status of each source.

c. Water Quality Inquiry

Water Quality Inquiry (WQI) is the portion of the system that will give district offices access and the ability to generate reports from WQM. WQI also will interface WQM to PICME.

2. Local Environmental Health Jurisdictions

LEHJs historically have been responsible for enforcing the California SDWA requirements on small water systems. This will change with the implementation of AB 2158. There are 57 LEHJs that have oversight jurisdiction in the 58 counties in the state. The City and County of San Francisco does not have a small water system program.

Due to the split jurisdiction there was no coordination between LEHJs and the Department for maintaining an integrated information system. Until October 1990, many LEHJs had utilized the Statewide Environmental Evaluation Program System - Water Program (SWEEPS) to help manage and report data on small water systems as well as other environmental programs. Some LEHJs developed their own information systems. There were various reasons why the SWEEPS program did not meet the needs of all of the agencies involved in the drinking water program, such as it did not give a timely response. As such, the SWEEPS program was not widely supported and produced significant reporting errors to the point that federal and state funding for this program was discontinued.

To determine the status of how LEHJs maintained information on small water systems a survey of data management systems was conducted in January 1990. These findings are illustrated in Figure 9.1. The findings of the survey found that LEHJs use a variety of information systems. Out of the 55 responding LEHJs, 73% (40 out of 55) used SWEEPS for some portion of their information management system. Only 28 or 51% of the responding LEHJs were using SWEEPS alone for their information management and reporting, whereas 12 or 22% used SWEEPS with an additional information management system. Eleven of 20% of LEHJs used their own information system instead of SWEEPS. Only 4 LEHJs did not have electronic information management, relying instead on paper files.

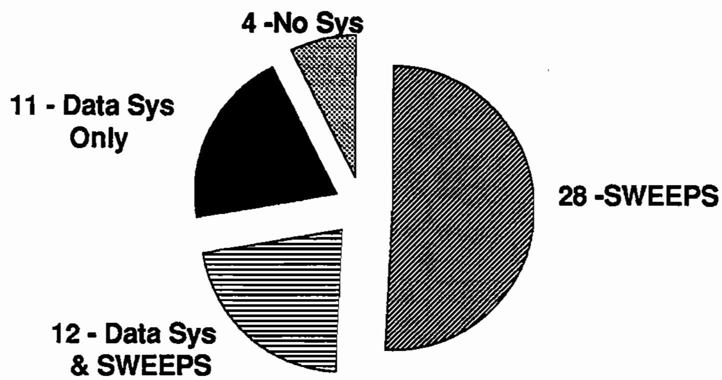

Figure 9.1. Distribution of LEHJ Data Systems

The major findings of this survey indicate that LEHJs were not effectively tracking the key elements of the drinking water program. Only 38% of the LEHJs were tracking compliance of the small water systems.

The problems with the data management program of LEHJs has been a concern for both ODW as well as the individual LEHJs. ODW has been working with LEHJs through the California Conference of Directors of Environmental Health Water Task Force to develop a consensus to solve the data management problem. ODW and the Water Task Force have developed an interim plan to begin reporting small water system program information within the resources available to LEHJs. This interim plan was implemented beginning January 1, 1991, and will be in effect until the long-term plan is developed and implemented under AB 2158, beginning July 1, 1992.

B. IMPROVEMENT - CURRENT DIRECTION

ODW's information management work plan and the LEHJ interim plan are only the initial steps toward developing a comprehensive, effective, and efficient statewide information management system for the drinking water program. It is apparent that the two plans, ODW's for large water systems and the interim LEHJ plan for small water systems, must be integrated for effective implementation of AB 2158. The ODW - Data

Management Committee, the Department's Data Systems Branch, and Water Task Force are working to integrate these two systems, and develop the long-term statewide information management program. The technology and knowledge to develop the long-term plan are available. However, additional resources will be needed for its implementation.

C. INTERACTION WITH OTHER WATER QUALITY INFORMATION SYSTEMS

There is a general consensus that information about the quality of California's drinking water needs to be readily accessible by numerous parties. Yet, the accessibility and integration of information from a variety of sources is not easily done and readily available. There have been several attempts by state agencies to compile and maintain this type of data, but with little success. Every state, federal, and local agency maintains it's own information system to meet the needs of that program. Some agencies even store and maintain the same data. California's geographical and jurisdictional complexities along with the numerous agencies that generate, use, and store water quality data makes the accessibility to water quality data very difficult. There is even a law prohibiting state data centers from linking together and sharing information.

The integration of water quality information between different agencies can only occur if two main issues are resolved. One, there is a need to develop a common method to share the information developed by each agency. Two, there is the need for the coordination and cooperation between all agencies for the sharing of the information.

There have been recent technological developments that makes integration and sharing of various types of information possible. The most promising development for this purpose has been in the area of Geographical Information Systems (GIS). GIS lessens redundancies, improves efficiencies, reduces costs, preserves data integrity, and allows greater access to the information supplied by other agencies. Because of the advantages of GIS, numerous city, county, state, and federal agencies are turning to GIS to handle their data needs. This growing demand for GIS is reflected by the Legislature passing AB 3590, which would have authorized a Geographical Information Task Force, convened by the Teale Data Center, to develop standardized GIS formats and procedures for city, county, state, and federal agencies. This legislation was vetoed, but the need and demand still exists.

GIS applications have and would benefit ODW. Some examples are: (1) land use information and locations of Toxic Waste Generators (Teale

Data Center 1990) can be used with ODW source location information (Teale Data Center 1990) to determine vulnerability of that source to contamination, and possible wellhead protection strategies, and (2) source location information was used with geologic information in ODW's special study of radon in ground water (CDHS 1990).

The coordination of the various agencies that would share information would need to be done by an agency that has experience with GIS and other information systems. The Teale Data Center is currently the most experienced and knowledgeable state agency involved with GIS. Their expertise in this field is being sought by other state agencies. The Teale Data Center is currently completing a needs assessment for the SWRCB of all of its information systems. A statewide needs assessment of all state agencies by the Teale Data Center would go a long way to increasing the accessibility, integration, and sharing of information.

D. COMPUTER MODELING AND REGULATORY APPLICATIONS

Computers not only provide an excellent medium for storing and retrieving vast quantities of information quickly, easily, and efficiently, but are also a potential tool that could aid in the development of regulations. While computers may be used with existing software packages and water quality data (e.g., GIS, to map out the distribution of contaminant plumes to identify contaminated areas) models may process information to simulate past occurrences and predict future events to illustrate the potential impacts of regulatory action. Processing data and developing the mathematical equations to simulate an event, past or future, is known as modelling.

Environmental engineers use models that are mathematical representations of transport, chemical, and biological phenomena that occur in the real world. Contaminant transport in the environment is a process that is composed of many elements thereby making any mathematical representation reasonably complex. Engineers find that any equation or group of equations used to simulate the real world, while accurate, are often too complex to be solved through the use of hand calculator or simple software packages (e.g., spreadsheets). Even after applying simplifying assumptions to the equations, the solutions may still be involved. Even solutions to the simplest of many of these equations may involve evaluating long series (i.e., many calculations must be done repetitively before arriving at a solution). Computers provide an excellent platform for problem solving requiring iterative solutions.

With their ability to execute large numbers of instructions in short periods of time, computers are excellent candidates for providing regulators with simulations of treatment processes, developing watershed management scenarios, or describing ground water movement or ground water contaminant transport. Such tools could be used by regulatory agencies to determine the effect and need for proposed regulations in real world situations. For example, ground water models could be used by a ground water basin management program to determine a zone of capture (i.e., a bounded region that recharges a ground water aquifer and impacts a water supply well). Similarly, ground water models could be used to identify those criteria that should be regulated to ensure protection of the potable water supply.

More detailed examples of how computer simulations could be used by the regulatory community was provided in a recent book published by the National Research Council (1990). The book discussed the concept of how ground water models could be used to address regulatory issues. NRC recognized the fact that models do not provide a panacea for all the regulatory issues that face national, state, and local governmental agencies. Rather, models can be used as a tool, in specific cases, to assess the risks and potential consequences of any regulatory action, albeit good or bad.

While models may be useful for evaluating problems, designing strategies for managing resources, and assessing information collection needs, models used for decision making must be well documented and validated so that the results can be duplicated, and the contents of the model examined and criticized. Using models in a regulatory setting means that any risk manager must have sufficient knowledge such that a complete and thorough understanding of the limitations of any model selected for use are known. Every regulatory agency involved in environmental concerns should have the resources, whether it be a group of people, either under subcontract or within the regulatory unit, dedicated to the task of understanding and applying models within a regulatory framework.

As an example of how models could be used in a regulatory application, consider the ground water transport models available today. Ground water models are capable of modelling not only the physical and chemical processes that govern transport, but are continuing to add detail, such as biological transformation that can retard or promote contaminant transport through soils.

Present monitoring regulations for man-made organic compounds relies on simple grab samples to characterize the water being pumped from a given source to determine compliance with the primary drinking water standards. It is recognized that pumping rates and patterns may effect the concentration of contaminants removed from an aquifer. However, it is not known how much variability is introduced by manipulating the well's pumping schedule. Variability is important because the statistical confidence in the water quality data is directly proportional to the variance, a measure of the variability. Ground water models may be used to simulate pumping and ground water flow patterns to determine how much variability in a given chemical concentration would be encountered. Once the variability is known, monitoring patterns and frequency to account for this variability could be established so that the statistical confidence in the water quality data reaches an acceptable level.

Ground water models could also be used to improve the exposure assessments by providing specific information on present and future contaminant concentrations in specific wells. For example, in the case of carcinogens, the number of theoretical excess cancer cases is directly proportional to the contaminant concentration. If the contaminant has been banned from use, one would expect the concentration to decrease with time. Since the exposure assessment assumes a lifetime exposure (70 years) the rate of decrease will effect the exposure assessment. Presently, a worst case scenario is used. It is assumed the contaminant concentration in the well remains constant, indefinitely. If the concentration does decrease with time, the present method of assessing the exposure to any contaminant overestimates the number of theoretical excess cancer cases.

Even with the present state of knowledge, mathematical models require continual modification and upgrading to improve performance and provide consistency with current research. Since models are continually changing, the use of specific models should not be required by regulation. However, the lack of specificity in the regulations should not preclude their use within a regulatory framework. The state should be willing to provide funding, for both research and personnel, to develop and improve the use of models in order to improve the decision-making and regulatory capabilities of it's agencies.

CONCLUSIONS AND RECOMMENDATIONS

A strong regulatory program requires an effective and efficient information management program to collect, organize, and make accessible the information necessary to carry out that program. The new monitoring regulations have substantially increased the amount of water quality data and compliance information, forcing ODW to develop a system to handle the information or be overwhelmed by it. In addition, the USEPA has made information management and reporting a priority issue for states to retain primacy and continued federal grant funding. ODW has accepted this challenge; it is implementing an interim plan to meet USEPA reporting requirements and to handle the information being generated.

There are issues and factors that will affect the long-term effectiveness and quality of ODW's ability to handle this information. The following are the major issues and factors that need to be addressed:

- While an initial program is being implemented, ODW will need additional personnel and equipment to address future information management needs that will be generated by new USEPA requirements.
- There is a serious gap of information regarding the quality and status of drinking water sources for small water systems. Since each LEHJ has been operating independently, a comprehensive information management system for small water systems is nonexistent. Inclusion of small water system data will require implementation of more effective state-of-the-art methods for entering and managing this additional information.
- More comprehensive and consistently collected information is required for regulation development and statewide exposure assessments. With few exceptions, collection of information for unregulated contaminants in drinking water has historically been carried out only when special funds are made available, and have been sporadic, reactive, and usually inadequate to carry out an effective statewide assessment.
- There are several agencies involved in the regulation of public water systems as well as the regulation of water quality. There is a continued need for each of these agencies to maintain data management systems for effective operation and management of their own program. However, there also is a need to share and integrate this information between programs.

Therefore, the ability of ODW to meet future information needs and integration with other local, state, and federal agencies data systems will need to be assessed and evaluated by an appropriate agency. The Teale

Data Center is already involved in doing needs assessments for other state agencies involved in water quality information and therefore should be authorized to do a statewide needs survey of all state agencies involved with water quality information. The needs assessment for ODW should specifically address the issues noted above.

Recommendation: The Teale Data Center should be authorized to do a statewide needs survey of all state agencies that collect and use water quality information. The statewide needs survey can determine the needs and costs for each agency to develop and implement a statewide integrated information management system. The needs assessment for the Office of Drinking Water also should address the long-term needs.

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CHAPTER X

SMALL WATER SYSTEMS

Chapter IV described in detail the high level of noncompliance of small water systems as compared to large water systems. On the basis of the Department's evaluation of small water system problems in California, it is concluded that there are six main issues contributing to this high rate of noncompliance. These include:

- Financial and Technical Limitations
- Regulatory Program Issues
- Planning and Permitting Issues
- Operation and Maintenance Issues
- Outreach Programs
- Regional Solution Issues for Small Water Systems

The following sections of this chapter discuss each of these issues, and the steps currently being taken to address them.

A. FINANCIAL AND TECHNICAL LIMITATIONS

The lack of adequate resources for the utilities is the most prevalent obstacle in dealing with small water systems; in most cases, it is also the most difficult and controversial. Additionally, the lack of resources to support public information and technical assistance programs significantly impacts the ability of small systems to comply. Each of these is discussed separately below.

1. Utility Resource Issues

USEPA has reported that approximately 90% of small water systems nationally suffer from the following circumstances related to operation and maintenance, and capital improvements (USEPA 1990). These same problems and issues have been observed in California.

a. Operation and Maintenance Costs

Since the customer base for small systems is so small, the costs for operation and maintenance cannot be spread over enough customers to keep individual customer's costs at reasonable rates. For example, Figure 10.1 illustrates the monthly fees per service connection, supporting only a portion of compliance costs (i.e., an operator, permit fees, and monitoring costs), could vary from over $50 for a system with 25 connections to $10 for a system with 200 connections.

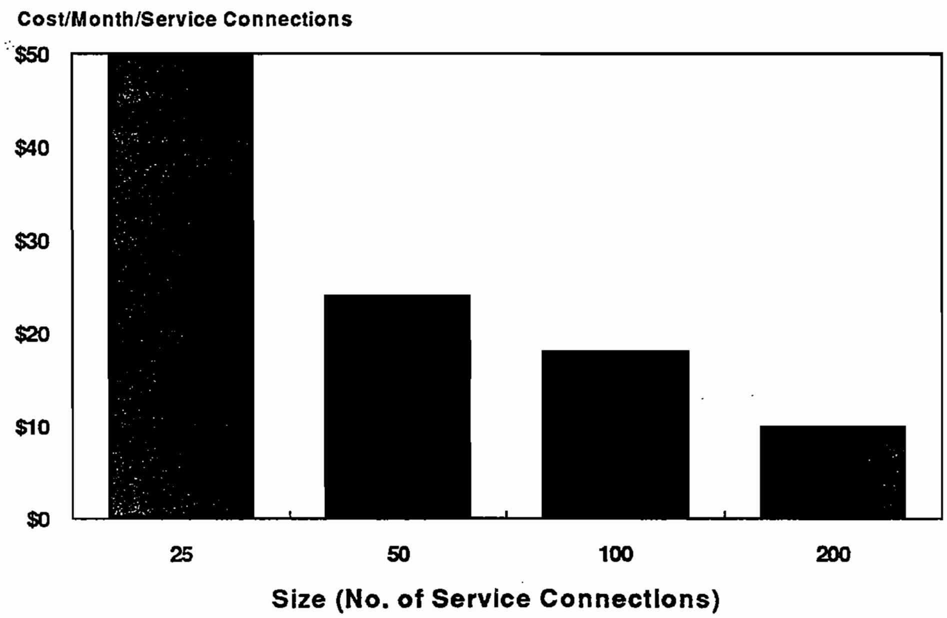

Figure 10.1. Estimated Economic Impact of Regulatory Requirements on Small Water Systems[a]

[a] Costs based on estimated new permit fees, provision of certified operator, and monitoring.

The problem is often compounded by the fact that many customers served by small water systems often have low or fixed family incomes, and instituting rate increases is difficult. As a result, revenues are often insufficient to offer salaries to attract and retain skilled managers and operators, and to meet the day-to-day fiscal operating costs and to fund reserve accounts for system repairs and replacement. In fact, many small water systems are operated wholly or partially by volunteers who are usually property owners being served by the system.

The fact that small systems are often isolated geographically, their operators do not attend conferences and training workshops. This does not allow them to increase their technical knowledge and awareness of available resources.

b. Capital Improvements

Due to a limited resource base, small water systems have limited revenues and assets. These same systems are generally the ones that require major capital improvements because of inadequately designed and constructed distribution systems and sources that require additional development and treatment to meet new standards. However, because of their size, small systems have four major difficulties in funding capital improvements:

1. They generally lack the management expertise and knowledge to effectively access available funding sources. This is particularly true relative to federal and state public assistance programs.

2. They are not large enough to initially fund and maintain reserve accounts that are adequate for other than minor improvements.

3. Obtaining loans to finance system improvements is difficult because banks consider most of the small water systems a high-risk investment due to their limited ability to repay loans.

4. Many small systems are located in rural or other low housing density areas with low population growth rates. Thus the systems have no predictable 'new service connections' base to assist in the construction of capital improvements.

Until recently, state law limited the fee a water system could charge future users for capital improvements. To assess future water users for new capital improvements, water systems have been authorized to levy a "standby fee" (a fee paid by property owners who are not part of the water system) on all lots within their jurisdiction. The fee had been limited to $10 dollars per acre per year. However, recent legislation, AB 3047 (Chapter 834, Statutes of 1988) authorizes water systems to revise and raise the standby fee if certain conditions are met, and procedures are followed. This change in state law appears to enable existing and future water users to increase their ability to pay for the required improvements.

c. Lack of Technical Capability

The above sections dealt with the lack of skilled operators, management expertise, and funding. All of these issues, especially the lack of adequate funding, contribute to the fact that small water systems generally operate with the most basic, and often antiquated, technology and equipment. Some small water system sources are located in areas with no available electrical power, and this exacerbates the problem. Technical capability that is available for the large water systems to provide safe, wholesome, and potable water is usually not installed in the small water systems due to the initial cost of the facility, cost of operation, and the continuing cost of employing a certified operator of appropriate grade.

B. REGULATORY PROGRAM ISSUES

The drinking water regulatory programs as envisioned and authorized by the California SDWA are intended to ensure the California consumer that public drinking water supplies can adequately and reliably deliver safe, wholesome, healthful and potable drinking water at all times. In meeting this responsibility, the programs are also intended to ensure adequate public notification when the public systems fail to meet drinking water standards, and that appropriate actions are taken to correct any deficiencies in the systems. The following discussion of this issue focuses first on the impact that an effective regulatory program has on compliance rates and secondly, on the direct problems of the regulatory agencies, principally ODW and LEHJs.

The lack of adequate resources available to state and local planning and regulatory programs is a major hindrance to the effective resolution of the small water system problem. Of particular concern with the regulatory program are the permit fees necessary to support the program. Resource issues related to planning and regulatory programs follow.

1. Compliance Program

It is apparent from the data presented earlier in Table 4.4 that small water systems in California have a major problem in terms of complying with regulatory permit, monitoring, MCL, operation and cross-connection control requirements with over 63% of the systems in noncompliance with one or more standard. Clearly, this noncompliance rate will increase further as the new, more complex, and more expensive requirements are implemented.

In order to determine the impact of a regulatory program on the noncompliance rates of small water systems, a comparison was made between the existing noncompliance rates of community public water systems regulated by the ODW (systems between 200 to 500 service connections) and those regulated by LEHJs (systems between 26 and 199 service connections) for the calendar year 1988. Figure 10.2 shows the results of this comparison and indicates a dramatic decrease in the noncompliance rate when comparing systems with 101 to 199 service connections to those with 200 to 500 service connections. Since the only significant difference between these classes of systems is the agency regulating them, the reduction in rates is attributed primarily to the effectiveness of the regulatory effort.

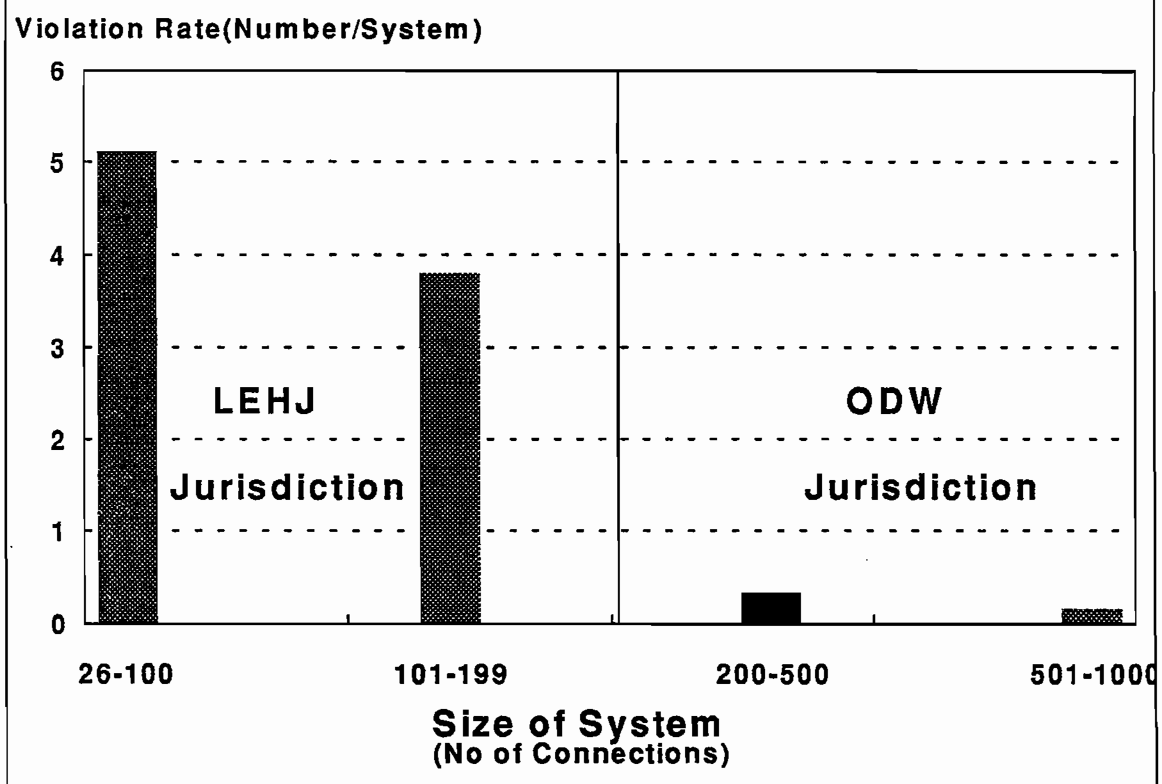

Figure 10.2. Violation Rates for Small Community Water Systems by Size of System and Regulatory Jurisdiction[a]

[a]Number violations/Number systems in category

In order to identify the key reasons why the ODW regulatory program appears to be more effective in achieving high compliance rates than the LEHJs, a comparative assessment was conducted of the key program elements including permits, surveillance, inspections and enforcement. The results of that assessment are discussed below.

a. Permits

All permits issued by ODW are based on a complete and thorough documented technical evaluation of the water system to assess its ability to comply with drinking water regulations. In the event the system cannot comply, the permit contains conditions to ensure that the system is brought into compliance as soon as possible. The conditions contain schedules for compliance and, because of the documentation, become legally enforceable orders in accordance with Section 4034, HSC. LEHJs on the other hand, generally do not conduct a thorough technical evaluation, nor issue permits that contain enforceable provisions. In many cases, the LEHJ permit is simply a mechanism to collect annual fees.

b. Surveillance

ODW surveillance activities include a monthly review and necessary follow-up of monitoring and compliance reports submitted by utilities, and investigation of consumer complaints. This includes a tracking system to ensure that utilities have conducted all required monitoring, reported results necessary to comply with drinking water standards, and have taken actions necessary to comply with permits, orders and other directives. LEHJs for the most part have very limited surveillance activities, and these are principally focused on the investigation of and follow-up on complaints.

c. Inspections

ODW has historically established routine inspections or sanitary surveys, with written reports of the results to the utilities as a cornerstone of its regulatory program and, until recently, has endeavored to conduct the surveys on an annual basis. The importance of this activity was recognized by the Legislature in 1986 when it included in AB 2158, a mandate to conduct the inspections on an annual basis. However, limited resources and higher program priorities (i.e., establishment and implementation of new drinking water standards) have caused ODW to reduce its inspection frequency during the past two years to less than 40% on an annual basis. Few, if any, LEHJs have established routine inspection programs and have historically relied upon assistance from ODW (formerly Office of Local Environmental Health Programs) to conduct sanitary survey inspections. As such there is frequently little or no routine communication between LEHJs and the small water system utilities.

d. Enforcement

Since 1978, Sections 4032-36, HSC, have contained civil and criminal enforcement authorities. In 1986, the HSC was amended to include citation authority with provisions for administrative fines. These authorities are available to both ODW and LEHJ to enforce compliance. Only ODW, with a few LEHJ exceptions, has taken steps to use these authorities. Since late 1986, ODW has adopted and implemented a formal enforcement policy (ODW 1986) that embraces the following principles:

- Voluntary compliance by utilities is the most cost-effective use of both regulatory and utility resources. This can be obtained by communicating with the utilities regarding drinking water standards and requirements, and with specific dates for compliance. Technical assistance and training resources will be directed to ensure that the purveyors know what the requirements are and how they can bring themselves into compliance.

- One hundred percent compliance with monitoring and reporting requirements is essential to ensure adequate public health protection. Without these data, it is not possible for regulatory authorities to assure that the public is receiving drinking water that meets health standards. Failure to monitor or report may result in ODW issuing a citation.

- Utilities that are out of compliance are generally given one warning unless the compliance problem is flagrant and irresponsible. Failure to comply with the warning will result in a formal enforcement action (i.e. citation or order).

In the four years since this policy was adopted, ODW has found that the number of formal enforcement actions increased significantly for the first two years but has since decreased substantially as the utilities have become aware of the consequences of non-compliance. LEHJs, on the other hand, have collectively adopted a formal enforcement policy through efforts of the California Conference of Directors of Environmental Health, but have not, with a few exceptions implemented an enforcement program.

It is also recognized that there are a significant number of small community systems that are potentially not economically viable (i.e., unable to totally comply with drinking water standards within economic reason). However, an effective regulatory program will result in significant improvements and perhaps, most importantly, consumers will be advised of their system's noncompliance and the associated public health risks. This is brought about through public notification when violations occur, and through the annual water quality report that is required to go to each consumer.

In conclusion, it is apparent from this assessment that LEHJs small water programs have not had activities that resulted in appropriate enforcement follow-up actions and, as a result, the small systems under their jurisdiction have much higher noncompliance rates. It may also be concluded that an effective regulatory program is one that ensures that public water systems are made aware of drinking water requirements and the legal consequences of noncompliance. Since most public water system owners and operators are committed to providing drinking water that not only meets standards, but exceeds them, a high degree of compliance will be obtained without formal enforcement actions. ODW has estimated that as much as 75% of the noncompliance could be corrected through a more effective enforcement program.

2. Local Environmental Health Jurisdiction Issues

There are a number of reasons why a majority of LEHJs have never developed adequate small water system regulatory programs. These include the following, in order of their significance:

a. Lack of Adequate Resources

Currently, the small water system compliance program as administered by LEHJ is funded by a combination of permit fees and county general fund support. Based on a survey of the counties in January 1991, approximately 50% of the county small system programs are funded from permits with the remaining 50% from general funds. These fees range from approximately $50 per year to over $500 per year, depending upon the county and size of system. It should be noted that the funding sources vary considerably depending on county internal priorities. Many counties reported that their boards of supervisors were directing that county drinking water programs be 100% fee supported, if possible. On the other hand, prior to 1990, the large water system program was funded principally with a combination of general funds and USEPA program grant funds. Large water systems paid no fees.

Based on SWEEPS information for LEHJ water program staff hours expended and the system inventory for fiscal years 1986-87, there were approximately 45 person-years(PY) assigned for the inspection and monitoring of small water systems. Since that time there has been some increase in overall staffing, estimated at 5 PYs, for a current total of 50 PYs. It has been estimated by ODW that this resource level is less than 50% of that needed to provide for annual inspections, information management, surveillance and enforcement activities required by the California SDWA.

The reasons why many LEHJs have not instituted fees sufficient to carry out an adequate program are attributed to:

- Fees would have to be raised significantly over existing levels in order to meet minimum program needs, and local boards of supervisors would not be likely to approve the increases. For example, based on the 1991 ODW survey of county costs, the average LEHJ permit fee for small water systems is approximately $275 per year with a 50% subsidy from the county general fund. This can be compared to the expected average fee of $1,000 per year necessary to meet the requirements of AB 2158.

- The difficulty LEHJs have experienced in raising fees has been exacerbated by the fact that there appears to be a perception by County Health Officers and consequently, boards of supervisors, that small water systems are not a public health problem because of the lack of documented disease outbreaks within California.

- There has been a lack of pressure by ODW and USEPA to bring small systems into compliance with drinking water standards. In other words, there has been little incentive for the boards of supervisors to increase fees or other program funding. Some boards of supervisors simply do not consider drinking water to be a high priority issue.

b. Lower Program Priority

LEHJs are mandated by state law to administer programs for solid waste, housing, food protection, underground storage tanks, liquid waste disposal, institutions, recreational health, vectors, and more recently, medical wastes. Most of these other programs are either supported by contracts from the state or have fees established at the local levels to support adequate programs. As a result, these other programs often take priority with LEHJ.

The LEHJ staff do not remain in the water program long enough to accomplish the many goals of the California SDWA. There is a wide variation in the pay scale of LEHJ staff who administer the California SDWA and this is reflected in the variation of experience and expertise among the different programs. In general, few programs have been able to attract and retain the experienced and qualified staff.

c. Conflict of Interest

Small water systems lack an effective organization(s) to represent their interests before the Congress, California Legislature, and ODW. Due to this fact, most new statutes and regulations reflect concerns with large water systems and major utilities. They do not accurately reflect concerns of small water systems. Therefore, almost by necessity, LEHJs have found themselves in a position representing the interests of small water systems because they are the only group familiar with the issues. This creates a direct conflict of interest for the regulator to represent the interests of the regulated entity. Furthermore, many counties directly operate public water systems such as special districts. To some extent, this conflict may make it difficult for a county agency to regulate other county agencies.

d. Lack of Accountability to State

As pointed out earlier, state law provided the counties with the responsibility for regulating systems under 200 service connections. Until 1990, however, there was no provision for state oversight, no accountability to the state, and no penalty if counties failed to enforce the California SDWA. As a result, LEHJs were accountable only to their boards of supervisors. Since some county governments strongly support development, with little concern for the impact on local small water systems, the Environmental Health Directors, are at times, not able to take action against water purveyors who violate standards because of the opposition of county governments to restrictions on development.

e. Lack of Staff Expertise

LEHJ staff have generally not developed the technical expertise needed to address many of the new problems now facing the water utilities of the state. There are, for example, few LEHJ staff with technical experience in surface water treatment, wellhead protection and treatment, organic chemical monitoring, treatment for the removal of organic chemicals, and issues that will arise with the new DBP regulation, lead regulation, and other amendments of the federal SDWA.

3. Office of Drinking Water

There are a number of deficiencies in the ODW program that have impaired its effectiveness and ability to meet the objectives of the California SDWA as it relates to small water systems. These include issues related to oversight of small water systems, information management, and technical assistance. Each of these, particularly as they relate to small systems, is discussed below.

a. Small Water System Oversight

ODW has been designated as the state primacy agency by USEPA for drinking water in California. However, prior to the passage of AB 2158, ODW had no direct authority over LEHJs who had primary responsibility for small water systems with significant violations of primary drinking water standards. Additionally, while ODW has a responsibility to report the compliance status of public water systems to USEPA, it had no authority to collect the information from LEHJs. As a result there is currently no information system to collect, maintain, and report these data. In 1989, USEPA threaten to withdraw California's primacy delegation unless state law was changed to provide more state control and accountability over small water systems. With the passage of AB 2158, the oversight and information management issues are expected to be resolved since ODW has been given statutory responsibility for all public water systems LEHJs have been mandated to provide monthly compliance.

b. Information Management

The problems pertaining to small water systems information management have been discussed in Chapter IX. It is apparent that the drinking water program in California can only succeed with the joint partnership of LEHJs and ODW. In this endeavor the information on small as well as large water systems must be integrated into a statewide information management system. Even though PICME was developed to be an open system offering the greatest flexibility for LEHJs to provide information on small water systems, ODW needs the cooperation and commitment by LEHJs to establish and maintain one accurate statewide information management system for the drinking water program. It is apparent that this will be a costly project and additional resources are needed to bring it to fruition.

c. Technical Assistance to Local Environmental Health Jurisdictions

Historically ODW has provided assistance to LEHJs, but it was principally directed to carrying out routine functions such as inspections and plan checks. This assistance did not contribute to developing additional LEHJ program authority, resources, or capability. As a result, when it becomes necessary to redirect state resources because of higher priorities, LEHJs are left with no permanent improvement in their programs.

It is apparent that technical assistance to LEHJs will become even more necessary in the future if the small water systems are to be brought into compliance with the California SDWA. This fact was recognized by the Legislature through AB 21, which requires maximum technical assistance to LEHJs. Although the Legislature directed ODW to provide the technical assistance, it did not provide state resources to accomplish this. Presently, ODW is providing what technical assistance it can by utilizing federal grant funds.

4. Impact of AB 2158 Fees

AB 2158, enacted by the Legislature in October 1990, shifts the responsibility for the regulation of small water systems from LEHJ's to ODW effective on July 1, 1992, and provides a mechanism to fund the program through state collected fees on small systems. The purpose of this legislation was to centralize the responsibility for the drinking water program, and to provide the additional regulatory resources needed. Recognizing that in some instances, the small system program may be best handled at the local level, the Legislature authorized ODW to contract with some counties to run the small system program. There are several significant issues that jeopardize the implementation of the program as envisioned by AB 2158.

First of all, fees necessary to support a minimum regulatory program based on the 'fee-for-service' concept required in AB 2158 will impose unreasonably high monthly service charges on the smaller community and non-community systems. Preliminary analysis of the fee regulations currently being developed by the Department indicates that these fees will range from $1,000 to $1,800 for the small systems. This translates to a range from a low of $14 to a high of $67 per service connection per year. It is very likely that there will be a strong protest from these regulated systems, and many will be unable to pay the fees, requiring California to take legal action. As a result, the net revenue available to implement the program could be much less than needed. It is concluded that the costs to implement a regulatory program for small systems may have to be subsidized in order to make it effective and reasonable.

The fee schedule for small systems specified in AB 2158 could be amended to provide relief for small community systems by providing a subsidy from either the state's general fund or an increase on large water system fees. For example, if the small system fund were subsidized with $1.5 million, the maximum fee per connection imposed on small community systems could be limited to $1 per month. If the subsidy were funded from an across the board increase on large systems, the annual cost per connection would only be $0.20.

Based on the 1991 survey of county costs conducted by ODW, it appears that for some counties, the cost to conduct the small water system regulatory program exceeds the cost of the state to conduct the same program. This is apparently due to high overhead costs that some counties require for contract services. It is the understanding of ODW that the legislative intent concerning the cost to administer the small system program and the subsequent fees imposed on these systems should be based on minimum costs that would take the state to do the program, with reasonable allowances for administration and county oversight. In order for the contracting concept to be feasible, therefore, those counties whose costs are higher than the state's may need more flexibility in order to participate in the program.

For example, AB 2158 could be amended to allow LEHJs who have demonstrated the desire and capability to regulate small water systems under state oversight, the option to assess and collect additional fees themselves, as necessary (and perhaps combined with the state fee) to meet the counties' higher costs of the AB 2158 requirements. LEHJ would still enter into a contract or other binding agreement with the state to carry out the minimum water system program as defined in regulations adopted by ODW. LEHJs would also be required to remit a portion of their fees to ODW as necessary to support the state overview process. This would allow flexibility to LEHJs to raise the additional revenues necessary to support their program.

C. PLANNING AND PERMITTING ISSUES

This issue relates to the lack of state program coordination, regional planning requirements, utility planning coordinated with local government plans, and an adequate water system permitting process, which has allowed the creation of many non-viable water systems. Because of the lack of a legislative mandate, there is no program at the state level that addresses planning issues for the provision of safe drinking water supplies. As a result, there has been no statewide policy development to ensure coordination of the many programs and jurisdictions involved, but also no strategies and programs for the development of countywide water supply plans, utility master plans, and engineering facility studies. The lack of these preventive type planning programs has significantly impaired the development and implementation of regional solutions that may involve consolidations or restructuring, as well as the implementation of an effective drinking water, wellhead protection program for the state. Each of these areas are discussed in greater depth below.

1. Policy and Program Coordination

As has been discussed previously, there are a number of state agencies involved in the regulation of small water systems sometimes with conflicting and duplicate requirements. As a result, there is a need for consistent statewide policies and direction and the resolution of interagency issues.

a. Proliferation and Consolidation

There is no statewide policy direction regarding the proliferation of new small water systems, or the implementation of regional solutions to correct the existing problem, and to ensure the most cost-effective solutions. Each level of government has been left to sort out solutions to the problems on their own initiative, and has resulted in inconsistent and sometimes conflicting regulations and guidance. It has also resulted in the use of grant funds and publicly financed solutions that in many cases are not the most cost-effective solutions. As an example, many millions of SDWBL funds are being spent to correct problems in water systems that never should have been allowed to be established in the first place. In other words, the state is now paying to correct planning mistakes of the past.

The Legislature has recognized this as a concern and has directed ODW, through AB 2158, to include in a January 1, 1996, report on the effectiveness of the AB 2158 legislation, an assessment on the need for consolidation of systems with fewer than 200 service connections and recommendations on how to accomplish this. In light of the comprehensive nature of this SDWP and the scope of this report, it is appropriate to consider this issue now with a recommendation to the Legislature. Such preliminary recommendations are included at the end of this chapter.

b. System Viability

The passage of AB 2303 and AB 2158 established financial responsibility requirements for new public water systems. As a result of this legislation, the Department is now in the process of addressing the issue of preventing the formation of new financially nonviable water systems. However, it can not address the issue of how to effectively deal with the many existing nonviable systems. Many government programs, particularly grants and loan programs such as the FmHA and the SDWBL programs encourage the continuance of such nonviable systems through grants and low-interest loan programs that subsidize the existence of such systems when a regional or consolidated solution could be more cost-effective. The state should have a policy to prohibit or discourage the use of state funds to continue the subsidization of nonviable water systems.

c. Financial Institutions

Because of increased publicity in recent years about drinking water contamination problems, consumers are more aware and concerned with the provision of safe, reliable sources of drinking water. This in turn has created problems for financial institutions making or underwriting loans for the sale of new or existing residential and commercial properties. In the past, these institutions have taken losses on loans because people have defaulted or refused to rent property where no water of acceptable quality could be found, or the sale of the property has been tied up in legal disputes. As a result, some lending institutions, such as HUD, requires a certification from ODW or LEHJ as to the adequacy of the quality of the drinking water supply before it will underwrite the loan. In the event the system is not in compliance with drinking water standards, the refusal of the lending institution to make a loan has resulted in immediate steps to bring the system into compliance. This has been successful in protecting the consumer in sales of properties with individual wells. Since there is no mandatory requirement, this is not practiced by all lending institutions.

2. State/Regional Planning Deficiencies

At the time the majority of small water systems were created in the state, General Plans with elements addressing public services were not mandated by the state. The only basic requirement to be met when creating a new water system was to demonstrate a safe supply that had been permitted by LEHJ. Most LEHJ water supply permit review and approval processes at this time were inadequate in that they did not address ownership, management, financial responsibility or the ability of the system to reliably meet quantity and quality standards in accordance with growth projections for the community. In many instances, systems were allowed to come into existence without formal permit approval.

The result was that many small water system problems were created in California due to inadequate planning controls. Specifically, this includes the proliferation in the number of small systems that must be regulated, creation of systems with overlapping or adjacent service areas, conversion of recreational to residential communities, and inadequate control over residential developments that rely upon individual well supplies.

California still has no state or regional planning requirements to ensure that new and existing public water systems have adequate long-range supplies, and can meet current and anticipated demand for safe drinking water in accordance with drinking water standards and local land use plans. In recent years a number of counties such as Sonoma, Lake, Stanislaus, and San Joaquin have undertaken countywide studies of drinking water issues in response to specific problems in the county. These studies have resulted in formal county policies and plans to deal with the proliferation of new systems and consolidation of existing systems. While extremely valuable, these policies have not addressed the coordination of water system planning with land use and growth projections for the county. In addition, PUC and DOC have developed and implemented policies that have prevented the proliferation of new small investor-owned and mutual systems in areas that could better be served by an existing facility.

a. Proliferation in Numbers and Types of Systems

As discussed in Chapter II, there are over 7,800 small public water systems (excluding state small systems) in California. Of this total, 2,560 are small community systems and 5,240 are non-community. Since the early 1970s, there has been essentially no change in the number of small community systems. However, during this same period, there has been nearly a 90% increase in the number of noncommunity systems.

Figure 10.3 illustrates the ownership categories of small systems, and shows that approximately 75% of the systems are in private ownership of which there is a multitude of categories. Additionally, the majority of the privately owned systems are non-community, created to meet a specific need (e.g., campground, ski area, and restaurant). This supports the conclusion that the provision of safe drinking water in the rural, unincorporated areas of the state has not been planned, but rather allowed to happen after the fact in order to support planning decisions already made for other reasons.

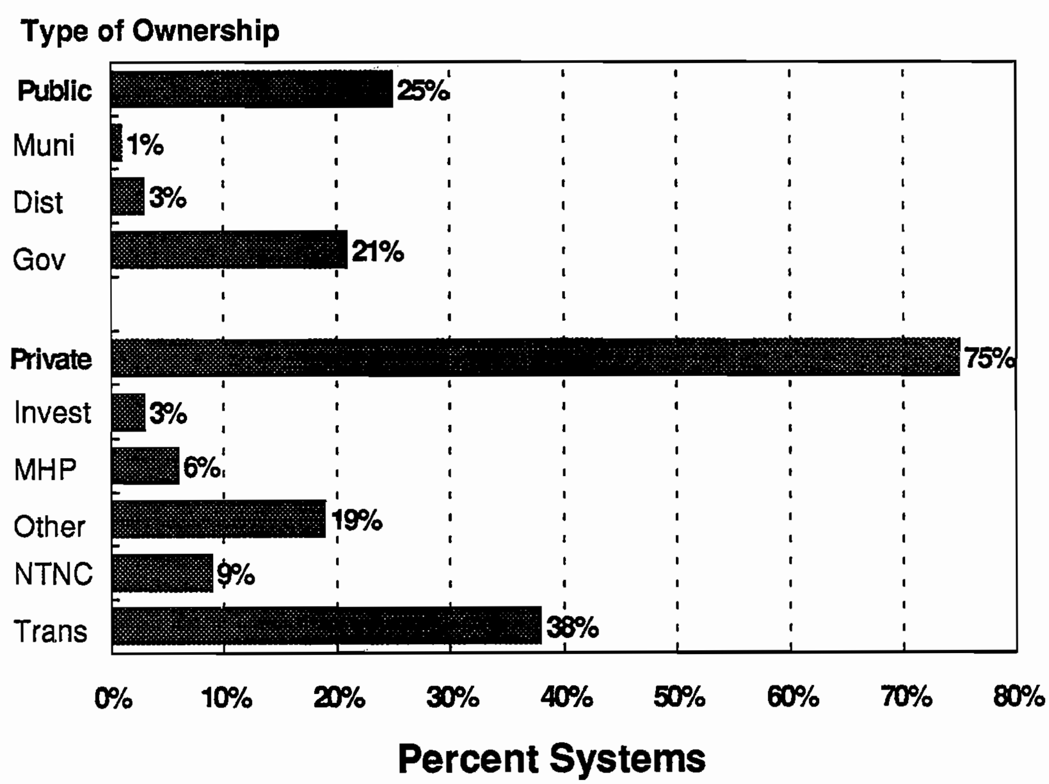

Figure 10.3. Ownership Categories of Small Systems (excluding State Small)

b. Overlapping or Adjacent Service Areas

Typical examples of these types of problems have occurred when local authorities have allowed small subdivision developments to be served by their own water systems even when located in the immediate vicinity of larger water systems. While most of these problems were created prior to the establishment of LAFCO and County General Plan controls, there is no statewide policy or regulation to prevent them from continuing to occur.

Figure 10.4 shows a typical urban area in California with its current LAFCO defined sphere of influence and the location of small water systems within this area, where a large number of small systems were allowed to be created in the immediate vicinity of an incorporated city that later became the sphere of influence of the city. It is felt that this example is typical of most urban areas of California. The figure shows that currently there are 48 small water systems within the sphere of influence of the city and another 18 systems within a 5,000 feet radius, arbitrarily selected as a distance where it may be technically and economically feasible to provide service by the city. While it is not known at this time how many small systems in this urban area are currently meeting drinking water standards and could remain economically viable in meeting current and new drinking water standards, it is apparent that it would have been far more cost-effective for these systems to have been served initially by the city.

c. Conversion of Recreational Communities to Full-Time Residential Communities

Many part-time occupancy vacation and resort communities have been permitted in California. These communities in many cases have not been required to meet the same standards for provisions of public services as full-time residential communities. In recent years, the high costs of housing in the urban areas of California have forced residents to extend their commuting range into these recreational areas. As a result, the public services designed and constructed for part-time use have been over-taxed and have proven to be inadequate to meet the full-time demands. The cost to upgrade the systems to meet drinking water standards is expensive, and without public financing, may not be feasible.

d. Individual Or Non-Public Water Systems

The state drinking water laws do not extend to systems serving less than five service connections or to sources serving individual residences. Nearly all county ordinances in California allow the construction of homes with individual water supplies (mostly ground water) in accordance with approved zoning requirements. Many instances have

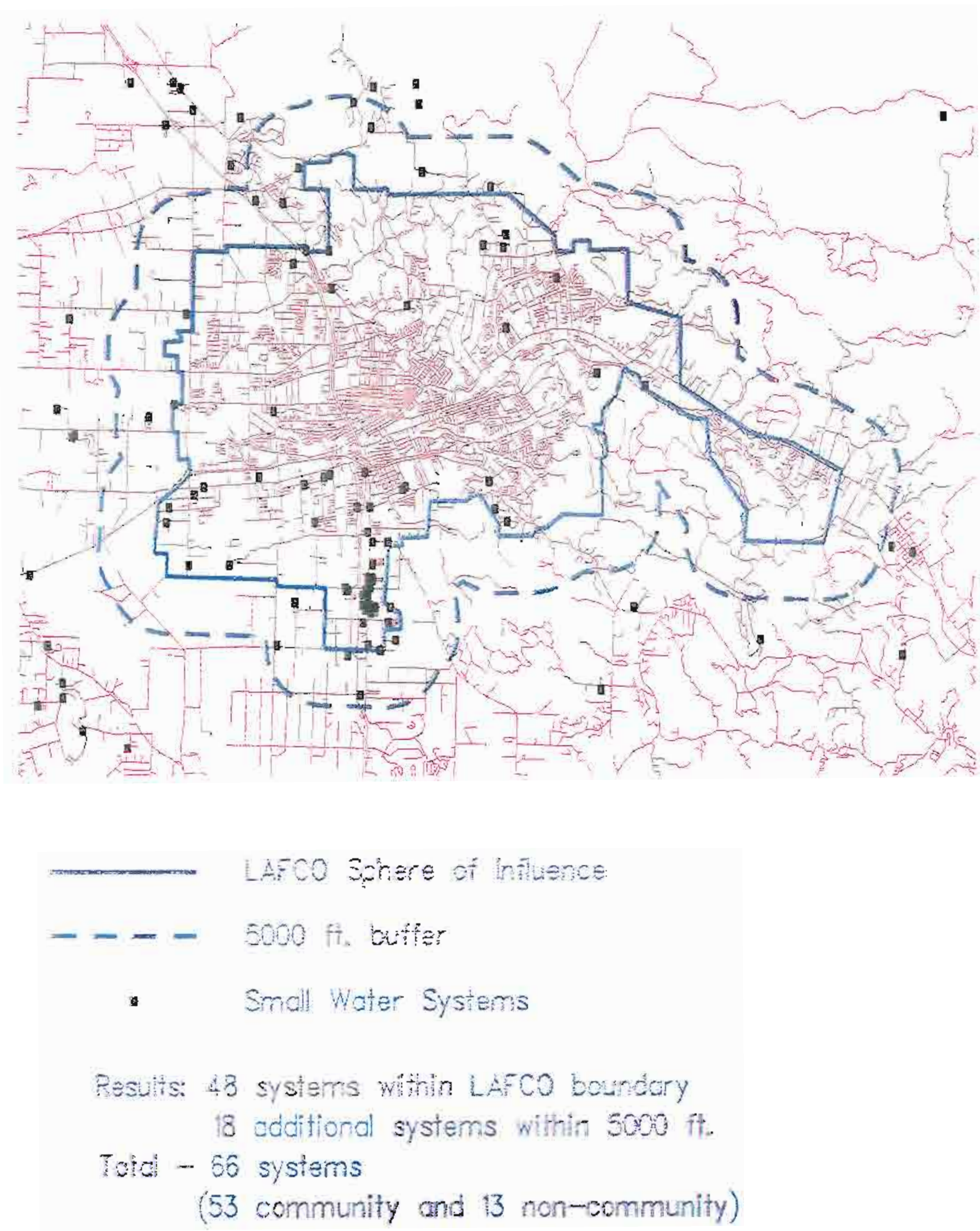

Figure 10.4
Proliferation of Small Water Systems
Within an Urban Area (Santa Rosa)

occurred wherethe ground water aquifer serving clusters of individual homes has become contaminated with chemical and/or microbiological contaminants. There is no state requirement that the water quality of such sources be monitored. As a result, when these properties are sold, new buyers are at risk, and when problems occur, they look to local governments for a solution.

In summary, the California has no state or regional planning requirements to ensure that new and existing public water systems can meet the current and anticipated demand for safe drinking water in accordance with drinking water standards and local land use plans. Additionally, there is no requirement for counties to take actions to ensure that individual supplies are safe and adequate. In recent years a number of counties like Santa Clara, Santa Cruz, Sonoma, Lake, Stanislaus, and San Joaquin have undertaken countywide studies of drinking water issues, generally in response to specific problems in the county. These studies have resulted in formal county policies and plans to deal with the individual supplies, proliferation of new systems, and consolidation of existing systems. In general, these policies have not addressed the need for coordination of water system planning with land use and growth projections for the county.

3. Lack of Utility Planning

There is no regulatory requirement in California for water utilities to develop and maintain water system management plans to ensure continued compliance with SDWA requirements and consistency with local land use plans. Even though it is not a regulatory requirement, the larger utilities, generally those serving more than 10,000 service connections, frequently have such plans as an element of their overall management practice. Such plans generally describe the management of the system, physical facilities, growth in the service areas, operation and maintenance, provide a facilities improvement plan with prioritized schedule of improvements, and a financial plan to ensure its economic viability. For the smaller utilities, these plans are not generally developed unless the utilities are directed to do so by a compliance order or citation issued by an LEHJ or ODW. Even then, they are usually developed only to address the immediate compliance problems.

The lack of these plans has contributed to the overall high rates of noncompliance by small water systems by allowing systems to be created with; (1) sources of supply that are inadequate during drought periods and/or unable to meet the growth demands in their service area, (2) systems with overlapping service areas that compete with each other for customers, (3) conflicts between land use and water system plans when local government and water utilities fail to consult with each other

resulting in conflicts between planned growth and the provision of facilities, (4) duplication of facilities such as developing sources or storage reservoirs adjacent to another system's facilities when both could benefit by sharing construction and operation costs, (5) system designs that are not cost-effective for expanding needs, (6) system designs that are incompatible with adjacent facilities because of a lack of consideration of growth and the possibility of system consolidation or interconnection, and (7) inadequate rate structures to provide for system replacement needs and improvements to meet new drinking water standards. Thus, an inordinate share of the systems resources are directed to providing the quantities of water needed rather than quality. This is particularly a problem in many of the older systems that are experiencing growth with undersized mains and distribution reservoirs. These facilities must be replaced to meet the demand that leaves few resources to be devoted to water quality improvements and compliance with monitoring requirements.

4. Permitting of Non-Viable Water Systems

All community public water systems come into existence through action of local government. Due to the lack of planning policies dealing with the number and locations of public water systems, and the lack of regulatory authority to effectively deal with the management and financial responsibility of the systems, it is expected that many of the small community water systems will find it technically and economically difficult to come into compliance with current and future drinking water standards. Public health requirements that were thought to be adequate for the protection of public health at the time they were instituted, and inadequate permitting procedures by LEHJs, will also prove burdensome to the small systems attempting to come into compliance.

Since 1949, the California SDWA has required the issuance of a permit for all public water systems that is based on a technical evaluation of the system, to certify that the water system is capable of providing a reliable and adequate supply of pure, wholesome, healthful and potable water. For small systems, the permit is issued by LEHJs. There are many examples in most of the state's counties where small water systems were created to support new subdivision without meeting the requirements necessary for the issuance of a water supply permit or where no permit at all was issued. This has resulted in a large number of systems with inadequate management and physical facilities. Historically, this has been a problem for LEHJs principally because of their lack of resources, and lack of technical expertise in some cases. Prior to the late 1970s, the problem was particularly significant for new subdivision developments and small non-community systems such as employee camps, and businesses. Very small systems (less than 15 to 50 service connections) were often installed by developers in the course of subdividing lots for sale. Once the lots were sold, these sometimes marginal systems were often turned over to a "homeowners association." Because they are informal voluntary associations, these homeowners associations seldom have the management capability and knowledge necessary to adequately operate a water system. While most of these systems met the regulatory requirements at the time they were built, developers had few, if any, ongoing requirements to meet, putting many of the systems into a noncompliance status.

For purposes of this report, a nonviable water system is defined as a community system that is economically unable to comply with existing drinking water standards. The definition is limited to community systems because it is assumed that many noncommunity systems of a profit nature can be shut down if it is too expensive to bring them into compliance, and state small systems have been removed from full regulatory requirements by AB 2158. While economic viability is largely determined by a consumer's willingness and ability to pay for drinking water, USEPA has estimated that a cost of up to 2% of the median household income is a limiting cost. Using the federal household poverty income level in 1987 of $11,612 and California 1987 average median household income level of $30,200, a range of monthly service charges of $20 to $50 would be the maximum that a consumer could be expected to pay for water in California.

At the state level, recognizing the problems stated above and as a result of consumer complaints and law suits, PUC and DOC developed regulations regarding public water systems that:

(1) Discourage the development of a new, privately owned water system in an area which could be served by an existing water system (CPUC 1979) and

(2) Require the demonstration of ownership, management and financial responsibility for certain types of water systems.

These actions have successfully stopped the proliferation of new investor-owned and mutual corporation water systems that are economically nonviable and is the type of concept that needs to be applied to all public water systems.

The California Legislature has also expressed its concern with creation of financially nonviable small water systems through enactment of AB 2303 in 1989 and AB 2158 in 1990. These acts require the demonstration of financial responsibility as a condition for receiving a permit for all public water systems, and prohibits the formation of water systems owned by unincorporated associations. It is expected that the authority provided in AB 2158 to demonstrate financial responsibility will be sufficient to prevent the formation of new financially nonviable small water systems.

At the local level, some counties have established policies in their General Plans and adopted ordinances to discourage or prohibit the proliferation of new small water systems and encourage the consolidation of existing small systems wherever feasible. All counties tend to discourage such formations if there is an existing system nearby that can and will provide service. In the less populated areas of the state where there is a trend to develop isolated residential areas (i.e., a subdivision located away from town where a farmer or rancher has chosen to convert all or a portion of his land to development), this often presents a situation where there is no existing system. County planning and building departments are hard pressed to prevent formation of a new system in this case. This type of situation is more common in northern California where much of the desirable developable land is remote from existing systems.

Some counties have ordinances that require permits for any system that serve from two to four connections. These ordinances also often discourage, and in some cases, prohibit formation of such new systems if existing systems are near that can provide service. Kern County, for instance, will not issue a permit to drill a private well if there is a water system that can and will provide service within 300 feet. Madera County prohibits formation of new systems if existing systems are near by.

D. OPERATION AND MAINTENANCE ISSUES

1. Problems

California's small water systems are experiencing noncompliance at significant rates, and upcoming regulations are likely to make noncompliance rates even higher. Inadequate operation and maintenance is the single most important contributing factor in small system failing to meet drinking water standards. For example, during the 1989 time period, nearly 50% of the small systems in California violated the bacteriological monitoring requirement as compared to about 6% of the large systems as shown in Table 4.4. The California SDWA requirements are complex, and the technologies used to achieve compliance are costly and not necessarily well adapted to small systems. Noncompliance problems at small systems are likely to increase as additional requirements go into effect and small systems struggle to understand what the new regulations require of them.

Lack of competent operation and maintenance is frequently the result of nonexistent or part-time management and diffused ownership. Sometimes, it is the result of bad faith on the part of purveyors. The end result is that no one takes responsibility to assure proper operation of the system. No one sees that water samples are taken. When equipment breaks, it is not repaired quickly. In some cases, users must get help themselves because the purveyor does not respond, and working through the courts to force the system owner or operator to correct the problem is a lengthy, cumbersome, and costly process. As shown in Figure 4.13, over 90% of the primary drinking water standard violations are due to operator failure to comply with monitoring requirements. Additionally, the lack of compliance with cross-connection control program requirements, which is about 80% (as shown in Table 4.4) for small water systems, is also considered as an operation/maintenance deficiency.

2. Reasons for Problems

Many small systems were in operation for many years prior to the establishment of current drinking water standards, with minimal or no monitoring requirements. From their viewpoint, drinking water has been produced all these years without people getting sick and customers can not understand why, all of a sudden, it is necessary to do all this sampling and meet new standards. This attitude is indicative of the lack of an adequate regulatory program by LEHJs and little, if any, routine outreach by ODW.

A major criticism from small system operators is that they have not been informed of, or understand, what is being required of them. They further complain of the lack of training opportunities for them at costs they can afford. Their contention is that they cannot be expected to comply if they have no opportunity to develop the necessary knowledge.

Neither ODW or LEHJs have a program, and few if any resources, directed to provide training and assistance to small system operators. Water utility organizations, such as the AWWA and ACWA, are largely focused towards the larger utilities since they are the ones financially supporting them. The CRWA is just now developing an organization in the state, and has neither the membership nor resources to devote to this issue at this time. However, they do have an interest in the matter, and plan to pursue it within their limited resources in the future. The Rural Community Assistance Corporation, funded by USEPA and FmHA, does provide a limited amount of training and technical assistance, but it is also constrained by the scope of its program (i.e., deals with all aspects of rural development and resources).

As shown in Table 4.4, 56% of the small water systems are in noncompliance with the requirement to retain a certified operator of appropriate grade. The inability for small water systems to hire and retain trained certified operators is attributed to various factors. These factors include the lack of financial incentives to become certified; turnover in personnel because once an individual has become certified; opportunities for higher paying positions become available in the larger communities; and difficulty in obtaining the necessary training in rural areas to successfully pass the certification exam.

3. Operation and Maintenance Contracting and Satellite Management

There are viable alternatives for small systems to the hiring of their own operator, such as contract services, satellite management, and regional management through a joint powers agreement.

Operation and maintenance contracting is perhaps the easiest of these alternatives to implement, and is an affordable and efficient option for small water systems because their systems frequently do not require constant attention with full-time operators. Instead of hiring full-time operators themselves, small systems can contract with private companies to obtain trained certified operators on an as needed basis.

Operation and maintenance contracting for small systems has not been used extensively in California because there are a limited number of firms offering contract operation and maintenance services. It is expected that if the operator certification requirement was being enforced it would stimulate the development of the contract operation and maintenance industry. One of the clearest cases of this relationship occurred in Oregon in the late 1980s when the state adopted and enforced a new requirement that all community water systems have certified operators. A direct result of that requirement was that contract operation and maintenance firms emerged to meet this need. These firms attributed their growth to the enforcement of the mandatory operator certification requirement.

As a general rule, contract operators have advised ODW that it is not cost-effective for a private firm to contract for fewer than 700 total service connections. Thus, a firm would have to have contracts with a number of small utilities in order to make such services economically feasible. As a result, there should be regional or county planning to identify areas where contract operation and maintenance is not currently available. In such cases, the planning entity could work with small systems to identify possible customers for contract operators, thereby assuring that an adequate market exists. Alternatively or in addition, the planning entity may wish to work with larger utilities to persuade them to provide contract operation and maintenance services as a satellite management agency. Since large utilities may not always be willing to participate, the state should consider developing incentives to encourage larger utilities to become satellite managers or operators.

Contract liability for system violations can be a deterrent since contract operators may be accountable for compliance of systems they operate, even when system owners are unwilling to implement the contractor's recommendations for system improvements. For example, if a contract operator recommends buying a new chlorinator in order to correct an MCL violation and the system owner refuses to do so, the contract operator might still be held liable if someone is injured as a result of the violation. However, in compliance actions, ODW holds the owner of the system responsible for correcting violations.

E. OUTREACH PROGRAMS

Both ODW and LEHJ regulatory programs have limited, if any, defined outreach programs in terms of technical assistance and public information. The lack of such programs directed to small water systems is considered to be a significant contributing factor to the high rates of noncompliance, particularly for those related to operator knowledge and skills. This is apparent when reviewing the statistics presented in Table 4.4, since the major reason for noncompliance with drinking water standards is due to noncompliance with monitoring, operator certification, and cross-connection control requirements. This fact is also confirmed by a recent USEPA study of 20 to 30 small system treatment plants on their compliance with the new federal SWTR. In that study, it was observed that the principal reason for system noncompliance was due to a lack of understanding on the part of the operators on how to effectively operate their plant (USEPA 1989).

In order to determine the effectiveness of technical assistance versus enforcement as a means to achieve compliance with drinking water requirements, USEPA funded the NRWA and the Florida Environmental Resources Agency to conduct a study in Florida in 1990 (NRWA 1990). In that study, the effectiveness of only using a regulatory effort conducted by the Florida Environmental Resources Department was compared to a technical assistance program whereby NRWA, through its Florida affiliate, provided extensive technical assistance to small water systems in Hillsbourgh County. At the end of one year, the results were measured in terms of improved compliance rates and costs to achieve the improvements. This study showed that significant improvements in compliance could be obtained with technical assistance, and that technical assistance may be more cost-effective than the use of a strict enforcement approach. The study did not measure the long-term effectiveness of this approach and did not evaluate the impact of implied regulatory pressure (i.e. awareness on the part of small water system utilities of enforcement actions for noncompliance). Strong enforcement combined with the provision of technical assistance could be the most effective program.

1. Contracting with Third Parties for Technical Assistance

It is difficult for state regulatory personnel to provide technical assistance directly. While it is true that some technical assistance is provided during sanitary surveys and inspections, full-time comprehensive technical assistance programs are inconsistent with the enforcement role of the regulator. Equally important, small system operators indicated that they are more likely to approach a third party for technical assistance. Operators are often reluctant to admit their operation and maintenance problems to a regulator for fear that the regulator would be required to take an enforcement action rather than provide technical assistance.

Contracting with a third party would give California the opportunity to leverage the resources of that third party. One approach used by several other states (e.g, Utah, Arkansas, Kentucky, and Florida) is to have the state drinking water program contract with NRWA to provide technical assistance that is targeted at specific compliance problems. NRWA receives grants from USEPA and FmHA for the provision of technical assistance to water systems. NRWA allocates the grant money to its state affiliates, and each affiliate receives the same amount. The affiliate in Kansas receives the same amount of money as the affiliate in California, even though California has more systems, a larger land area, and higher living costs. Thus, California's share of the limited NRWA federal grants do not go as far as those in some other states. For example, Utah began contracting with the Utah Rural Water Association in the early 1980s, wherein the state provided funds for an additional circuit rider, and targeted the additional assistance at significant non-compliers. Since NRWA already has established the infrastructure to provide technical assistance, the addition of more staff to provide technical assistance is cost-effective.

In addition to NRWA, other organizations or private consultants may also provide operation and maintenance and technical assistance support to small systems. The California Rural Community Assistance Corporation and the California-Nevada Section, AWWA are two such groups; these organizations may provide training materials, conduct workshops, and disseminate information on various technical and compliance issues of importance to small water systems.

The State of Pennsylvania initiated a Technical Assistance Program for Small Systems (TAPSS) in 1989 using private consultants. The purpose of their program is to help small water systems comply with new requirements and achieve a corresponding reduction in violations, and to improve operation and maintenance practices in three specific areas of water system operation: filtration, disinfection, and corrosion control. This was accomplished by providing technical assistance in water system operation and maintenance, recommending capital improvements where necessary, and improving the water suppliers' understanding of regulations and requirements.

Pennsylvania has reported that one of the more significant results of their program has been an increased awareness by the operators of the many complex, current and forthcoming requirements. Even more important is the operators' increased knowledge and understanding of the public health significance behind these requirements. Unlike a standard classroom training course, the contractor was able to make recommendations for operational improvements and apply training principles on the spot. In many cases, the owners and operators of the small systems received recommendations and solutions to problems they have been facing and were unable to solve for several years (Commonwealth of Pennsylvania 1990).

2. Unique Operation and Maintenance Problems Facing Surface Water Treatment Systems

As California's small water systems using surface water begin to face the reality of complying with the California's new surface water treatment regulations, it would be appropriate to broaden the use of CPEs. CPEs are part of a USEPA initiated comprehensive approach to optimizing process control for complex treatment plants. CPEs assess the impact of operation, maintenance, and administrative practices on treatment plant performance (USEPA 1990). A CPE involves inspections, review of records, and special studies, such as the development of turbidity versus time profiles of a plant's filters before and after backwashing to determine whether the filters are performing adequately. A CPE may be followed with a CCP during which factors identified as limiting performance are systematically addressed. A CPE can determine whether the main factors limiting performance are operations-related and, if so, can optimize existing process controls through improved operations and maintenance. As a result, the need for expensive new capital investment in plants and equipment may be reduced or eliminated. In a study of thirteen small water treatment plants having compliance problems, in Montana, Ohio, and Kentucky, only one facility was found to require major facility modifications in order to comply with the federal SWTR (USEPA 1989).

It is important to educate small system operators about the potential benefits of conducting CPEs. Once informed, they may wish to purchase these services from private vendors. Additionally, it would be appropriate for the state to include a limited number of CPEs and CCPs, as an element of its technical assistance program.

3. Public Information

Good outreach and communications with the water suppliers, general public and public health officials are needed to develop better compliance and a broader constituency. Organized constituents among small water systems are essential in implementing an effective safe water program. Large systems are extensively involved in California's regulatory process, participate in professional society activities, and employ professional lobbyists to advocate their interests. Small systems, in contrast, lack lobby groups and rarely participate in the large system dominated professional societies. As a result, they are often unrepresented in the development of new regulatory requirements, and are unaware of policy changes that may affect them.

In order to provide a forum for the many groups involved with small water systems to have input in the development of this report, ODW established a Small Water System Advisory Group with representation from CRWA, Rural Community Assistance Corporation, County Supervisors Association of California, LAFCO, LEHJs, Western States Mobile Home Association, Small Water Environments Today (SWET), and ACWA. This forum could continue to serve effectively as a small water constituent group. However, it should be expanded to include representation from groups representing non-community systems, such as parks, ski areas, schools, factories, restaurants, and financial institutions.

An effective California public information program should include not only timely and accurate dissemination of information on the quality of California's drinking water, but also on new legislative requirements, regulations, policies, training opportunities and technology transfer. These information should be directed as needed to consumers, governmental authorities, LEHJs, and the utilities in order to ensure effective coordination of programs. A newsletter for water system operators, such as Utah's OpenLine, could keep operators up to date on regulatory requirements, and provide a forum for exchange of technical information. ODW has no program and limited resources directed to this end.

The benefits of such a program would be to help make the public and small system utilities aware of how they can become involved in the regulatory process. Outreach to the general public can help increase awareness of California's drinking water program. People can learn about the challenges to providing a safe water supply through newspaper articles, public service announcements, school programs, and other mobilization activities. People will be more interested in supporting safe water programs when they know more about the risks associated with waterborne disease.

F. IMPLEMENTATION OF REGIONAL SOLUTIONS

Regional solutions can be essentially categorized as management and consolidation options. Management options are the formation of working relationships between two or more water systems in an area, including such items as basic service contracts, public-private partnerships, joint-powers agreements, and satellite management. Consolidation options include such actions as district establishment and changes in organizations, such as annexations, consolidations, and reorganizations.

Because of the numbers and sizes of small water systems with a limited economic base, the impact of increased regulatory pressure to comply with existing and new drinking water standards, and the increased permit fees to support regulatory programs, it is apparent that all small water systems will be significantly impacted, with many becoming economically nonviable. That is, it will become so costly to maintain and operate their system, owners will look for options to get out of the business. It is also apparent from the urban area example of proliferation of small systems, typical of many counties and urban areas of the state, that regionally planned solutions may be the most cost-effective, if not the only, solution to the problem. Even though there have been examples of successful regional approaches in recent years to resolve small system compliance problems, there are significant barriers that prevent their widespread acceptance and implementation in the state. These barriers and a discussion of each, follows.

1. Lack of Local Responsibility

There is a lack of incentive for a local organizational unit of government to assume responsibility for evaluating the feasibility of and implementation of regional management or consolidation options. To be effective, such options must be developed and implemented at the local levels; technically, the County Board of Supervisors is the body to assume this responsibility. On the basis of lack of local support for LEHJ small water system regulatory programs, it is apparent that some County Boards of Supervisors are either unaware of the health issues related to small water system noncompliance with drinking water standards or consider it a lower priority within the county. ODW estimates that over 62% of the state's small community systems have fewer than 50 service connections and may not remain economically viable in meeting new drinking water standards. In most cases consolidation will offer the only cost effective solution, but this is not the case with all counties. Several counties including Lake, Sonoma, Stanislaus and perhaps others that we are not aware of, have taken steps to begin addressing this issue of regional office management or consolidation options.

The Legislative Analyst, in its report in the 1989-90 budget bill recommended that the Legislature impose a mandate upon counties to develop consolidation plans for small systems. ODW agrees with this recommendation, but the mandate should be broadened to require a comprehensive water plan for providing safe drinking water to all residents of the county and that these plans should consider both regional management and consolidation options. These plans should be required to be an element of the county General Plan to ensure effective coordination with future land use development.

2. Desire for Local Control

There is a desire among most local governments to maintain local control. In many rural unincorporated areas of the state, the only forms of local government are the elected boards of supervisors or directors of water districts or mutual water companies. Since these boards have the power to decide how many connections will be served, they are involved in the decision making process for growth in their area, and as such, there is a reluctance to relinquish their authority to an organization less accessible to the community. It is the policy of ODW not to interfere in the type of organization that a system chooses to have as long as the system can meet drinking water standards. In many cases it has been observed that very small water systems (i.e., those with fewer than 50 service connections) cannot remain economically viable and meet drinking water standards at the same time without significant subsidy from the state or federal government in the form of system improvement grants or low interest loans. Additionally, with increased compliance pressure by ODW to meet drinking water standards and new financial responsibility regulations, it is expected that many of the smaller systems, that previously were reluctant to join a regional or consolidated system, will look for such solutions. It will be important, then, to have an effective means to implement such solutions as were discussed above.

Some concerns have been expressed that consolidated or regional systems will encourage growth and require CEQA compliance. Because past projects to encourage these approaches have been conducted on a case by case basis without benefit of a regional plan, many consumers are very reluctant to proceed because of possible growth inducement. If such projects were identified in the County General Plan, the growth issue could be adequately addressed along with other CEQA concerns.

3. Lack of Resources

The lack of resources to fund planning studies is another barrier to implementation of regional solutions. To ensure effective use of regional options, planning should be conducted at both the regional level, as discussed above, and on an individual project feasibility level. Without funding, counties can be expected to strongly oppose a mandate from the state to prepare such plans without the commensurate resources to implement the mandate. Additionally, a funding mechanism must be provided to conduct engineering feasibility studies for individual consolidation projects. Ultimately, consumers within the existing systems being consolidated must be willing to pay the price to implement such options. Such solutions would have to show that they are more cost-effective than other alternatives, such as remaining as a single system. Without the organizational leadership and funding to conduct such studies, it is not likely that consumers and particularly boards of supervisors will agree to change.

To resolve these difficulties California should provide funding to support the development of countywide regional plans with requirements that the plans identify a source of funding for the conduct of engineering feasibility studies. For example, a revolving fund was established to fund such studies in Sonoma County. If a project developed as a result of the study, the funds to conduct the study were repaid. On the basis of a clear policy from the Legislature supporting consolidations and regional options, ODW should then develop ranking criteria for the use of state and federal funds to give those systems utilizing consolidations or regional options a high priority.

4. Participation by Existing Well-Managed Public Water Systems

There may be reluctance or refusal by an existing, well-managed public water system to participate in regional solutions. In many situations there is little or no incentive for an existing public water system to participate in a regional solution since it may increase the scope of their management problems, limit their ability to grow within their service area, and be costly to implement. In the larger public interest of the state, and to ensure that all consumers are provided with a safe, reliable, and adequate supply of drinking water, it is appropriate for California to mandate, as a condition on the public water systems operating permit, that they participate in regional solutions. Such mandates would and should come through the county planning process that all utilities and other interested parties participate. Once the plan has been prepared with the designation of regional solutions, with a financial plan for implementation, and has been approved by ODW, all utilities should be mandated to participate.

CONCLUSIONS AND RECOMMENDATIONS

Before 1970, there was a significant increase in the number of water systems in the state. California now has more than 10,500 public water systems in the current inventory. Nearly 90% of these are small systems that serve fewer than 200 service connections.

There are unacceptably high rates of noncompliance with drinking water standards by small water systems, with over 63% of the systems in noncompliance with one or more requirements. These rates are approximately 10 to 30 times higher than corresponding rates for large water systems in California. Non-community transient systems have the highest rates of noncompliance among the small water systems. One of the main factors is the lack of an adequate regulatory program that has focused on small water systems.

Additionally, it has been estimated that over 60% of the 2,560 small community systems, many of which were allowed to be created due to inadequate planning and permitting procedures, will be unable to come into compliance with new drinking water standards due to economic limitations.

There are significant populations at risk in the California due to small water system noncompliance with safe drinking water standards. Nearly one million people including residents, workers, school children, and individuals in the various state institutions, are served by small systems on a daily basis. Additionally, there are an estimated 260 million visitor-days of use of the California's non-community water systems serving parks, resorts, hotels, motels, small restaurants, and other facilities. Given the high rates of non-compliance with bacteriological standards (i.e., greater than 57%) these populations are subject to significant risk of illness from microbiological contaminants. All Californians (and visitors, too) benefit from safe water provided by both small and large water systems. With an effective program to ensure safe public water supplies, Californians can travel across the state without any concern as to the safety of water supplies at non-community and non-transient, non-community systems. As such, the state should be willing to do whatever is necessary to implement an effective but reasonable compliance program for all public water systems.

Over 90% of the sources of supply for small water systems are from ground water. This is because of the general availability of ground water and it has been easier and cheaper to comply with drinking water standards. Based on the AB 1803 organic sampling of over 50% of the wells used by small systems, there is a threat to the quality of ground water aquifers used by small water systems in or near urbanized areas. This threat comes principally from the industrial and commercial activities associated with these areas. Local land use plans generally do not include comprehensive evaluation of the recharge areas for local ground water aquifers used for public water supplies, and small water system owners are unaware and/or incapable of evaluating and responding to local land use decisions which may effect their supply.

Recommendation: The scope and public health significance of the small water system problem requires the development of a comprehensive strategy that focuses on the correction of existing problems, and second, on the prevention of new problems. This strategy should include elements for improved program coordination, water system planning, regional solutions, a strengthened regulatory program, improved operation and maintenance of existing facilities, adequate and reliable resources, and an increased public outreach activity focused on technical assistance and public information.

Regulatory Program Issues

An effective regulatory program, at a minimum, must consist of information management, permits, routine inspections, surveillance and monitoring, and timely enforcement functions that are adequately funded. LEHJs, although authorized by Section 510, HSC, to assess fees necessary to implement a small water system program, currently have less than 50% of the minimum resources necessary. This is attributed principally to problems that LEHJs have had in getting their boards of supervisors to approve the necessary fee schedule increases, together with lack of oversight pressure from ODW.

The lack of effective regulatory programs by LEHJs is one of the major reasons for the high rates of noncompliance with drinking water standards by small water systems in California. This is particularly true of compliance with monitoring requirements.

The regulatory authority recently enacted in AB 2303 and AB 2158 requiring the demonstration of financial capability as a condition of receiving a water supply permit, together with the prohibition on formation of new small systems with unincorporated association ownership, is expected to be helpful in preventing the formation of new, nonviable water systems.

Economically nonviable, small community water systems are defined as those systems for which it is economically infeasible to bring the system into compliance with drinking water standards even with a regional solution. It is not known at this time how many of the small systems will fall into this category. The only option provided in the California SDWA in dealing with these systems is to take legal action to force them into compliance regardless of the economic circumstances. An authorization allowing a reasonable timeframe for compliance, provided that the public health is not endangered, may dissuade some owners from abandoning their systems as they realize the difficulty and costliness involved in achieving compliance. The current provisions are inadequate to affect a reasonable solution to the problem due to the lack of funding support to bring such systems into compliance. It is unlikely that courts would mandate such enforcement provisions without a reasonable solution or a clear expression of intent by the Legislature.

The California SDWA recognized the probability that certain water systems would be unable or unwilling to comply with drinking water standards. Section 4035, HSC, provides for a court appointment of a receiver to operate and maintain the system if such a situation occurs. There have been many occasions in the last several years when ODW has sought to utilize this section to deal with recalcitrant water systems. ODW has either been unsuccessful or reluctant to try because of the difficulty in locating another water system or person to be designated as a receiver, and has experienced frustrations dealing with the judicial "burden of proof" required to support taking of private property.

Recommendation: The Legislature should consider legislation to allow counties the option of establishing their own fee schedule in addition to the state fee, for systems less than 200 service connections, in order to generate sufficient additional revenue to conduct the small water system program in accordance with the state's contractual requirements.

Recommendation: The Legislature should consider alternatives for subsidizing the small water system regulatory program so that the regulatory fees passed on to consumers served by small systems are more in line with those fees passed on to the large water systems consumers.

Planning and Permitting Issues

Over the last decade there has been considerable state legislative concern for the need to do regional environmental planning for wastewater disposal, air quality, solid wastes, and water resources. This has resulted in statutory requirements to accomplish this at the local or regional level. The Legislature has also directed the development of urban water supply plans with a focus on conservation. To date there has not been a recognition of the need for comprehensive planning on a statewide as well as regional basis to ensure the provision of adequate and safe drinking water supplies, and protection of existing supplies. As a result, there exists no comprehensive planning requirement in the state to ensure the continued provision of safe public drinking water supplies that have been coordinated with state and local land use policies and practices. Planning and permitting decisions for small public water supplies have largely been, and continue to be, made on a case-by-case basis. The past practice of permitting new systems in areas that could best be served by an existing system still continues in the state. Past policies and ordinances enacted at the county level to deal with these issues are problem specific. While this has generally been effective in resolving specific problems at the time, it generally does not result in the most cost-effective long-term solution.

Additionally, there is no regulatory requirement for utilities to prepare engineered master plans coordinated with local land use plans, which describe their sources of supply, physical facilities, existing and future service area, financial management and improvement plans. This is particularly a problem for investor-owned systems.

Recommendation: Legislation should be enacted requiring that individual residences using a private water supply be required to disclose complete information on the bacteriological and chemical quality of the water supply and how it compares to drinking water standards as a condition of sale or transfer of the property. Real estate brokers and financial institutions making loans on the property should be required to ensure that the disclosure is made to all prospective buyers. All new private water supply well owners should also be required to provide this type of information prior to occupancy of a new residence.

Recommendation: Legislation should be considered requiring all new public water systems and existing systems with more than 1,000 service connections to prepare an engineered master plan describing their existing and future system.

Operation and Maintenance Issues

Over 85% of small water system noncompliance is due to failure on the part of operators to monitor and report on water quality or to comply with operator certification and cross-connection program requirements. These violations can be corrected with minimum expense. The capability of small systems to comply with new drinking water standards is limited due to the high cost to implement them, the complexity of the regulations, and the inability of many small system operators and managers to understand them. Thus, it is expected that rates of noncompliance with drinking water standards for many small systems, particularly for the small community systems with fewer than 50 service connections, will remain relatively high.

In California, there are no adequate training and technical assistance programs for small water system operators. The state does not have a defined program or resources directed to provide training and assistance. It has been observed in other states, particularly Florida, Pennsylvania and Texas, that technical assistance to small water system owners and operators can be very cost effective in resolving noncompliance issues. It has also been observed that this effort can be effective in assisting small systems in avoiding timely and costly capital improvement projects through improved operation and maintenance. The state currently has no program directed to providing such comprehensive technical assistance to smaller utilities.

Problems related to ODW's certification of operators for small water systems stem from the following; (1) minimum qualifications for water treatment operator certification do not reflect current water quality problems, (2) once certified, operators are not required to have expertise in treatment technologies, and (3) less experienced operators are allowed to operate the small water systems with no correlation to the systems' complexities. As a result of these problems, small water systems may not have operators with the expertise to ensure a safe drinking water supply. ODW has recognized these problems and is in the process of revising the program.

While there are viable cost effective alternatives for small systems to hiring their own operator, there are barriers that prevent the use of these alternatives. California must promote these alternatives and find ways to overcome these barriers so that small systems can achieve compliance with the drinking water standards and ensure public health protection.

Providing technical assistance to small water systems that cannot afford expensive consultants has proven to be an effective means of reducing noncompliance at a relatively low cost. Several states are providing funding for this type of assistance through third party contracts. Based on noncompliance rates in California and the demand for financial assistance, a major need for this type of technical assistance appears to exist. This type of assistance should be administered in accord with criteria and guidelines established by a technical assistance coordinating committee with membership from ODW, AWWA, ACWA, CRWA, LEHJs, and the California Conference of Directors of Environmental Health.

Recommendation: The Legislature should evaluate the feasibility of authorizing and funding the development and implementation of a comprehensive small water system technical assistance program conducted by contract with a third-party.

Recommendation: Legislation should be considered that would establish authority to create satellite management agencies in accordance with criteria established by ODW. This legislation should also allow ODW to require the use of either a contract operator or a satellite manager for small water systems that are determined to be incapable of providing proper operation and maintenance.

Outreach Programs

An effective California public outreach program should include timely and accurate dissemination of information not only on the quality of California drinking water, but also on new legislative requirements, regulations, policies, training opportunities, and technology transfer. This information should be directed as needed to consumers, governmental authorities, local health authorities, and the utilities, in order to ensure effective coordination of programs. ODW has no program and limited resources directed to this end. As a result the affected groups do not understand the health risks associated with their drinking water, and are unaware of regulatory requirements and applicable justifications. A number of other states such as Florida, Maryland, Pennsylvania, and Texas faced with this problem instituted public information and training programs that have been very effective in resolving noncompliance issues.

Recommendation: The Office of Drinking Water should be authorized to develop and implement a comprehensive outreach

program designed to inform and educate consumers, governmental authorities, health officials, and water utilities. The program should include periodic newsletters, workshops, training seminars, and media presentations.

Recommendation: The Department should consider continuing the use of the Small Water System Advisory Group.

Regional Solutions Issues for Small Water Systems

There have been a number of successful regional solutions to small water system problems in California over the last several years. Yet there have also been a number of areas where regional solutions would be appropriate, but have not occurred for a variety of reasons.

On the basis of the number of systems that are nonviable, there is a need in California for effective, easily implemented regional solutions to help resolve the small system problem. In this respect, there are many options available for regional solutions that have been proven to be cost-effective. However, there has been a lack of legislative directive or statewide policy that directs governmental activities and programs toward regional solutions to the small water system problems.

Planned consolidation of small nonviable water systems to resolve noncompliance problems has been successful in some California counties. However, these success stories did not occur because of a desire on the part of water system owners to comply with drinking water standards. Rather, they occurred because of consumer concerns about service and are all associated with feasibility planning, the use of SDWBL funds, and increased compliance pressure. Because of the economy of scale that regional solutions offer, such as consolidations and regional management, they are the only feasible solution in many cases for small nonviable water systems.

There is a general unwillingness by local authorities to assume a leadership role in identifying, studying, and implementing regional solutions. This is particularly true of county boards of supervisors faced with increasing state mandates and shrinking budgets. Financial assistance for regional planning, engineering feasibility studies, and construction of regional facilities is essential to effectively implement such solutions and expedite the time frame for accomplishment. Currently there is no funding mechanism for these needs.

The experience in the State of Washington has been that satellite management of small water systems by existing, well-managed large utilities, as directed by the state, has been very effective in resolving management and operation and maintenance problems of many small water systems. The costs for performing satellite services should be borne by the systems receiving the benefit of the service.

Section 19, AB 2158 requires ODW to report to the Legislature by January 1, 1996, with recommendations on "the need for consolidation of systems serving less than 200 service connections and how to accomplish these consolidations." This SDWP report to the Legislature provides a preliminary initial evaluation of the small system problem, the need for regional solutions, including consolidations. ODW has concluded that recommendations should be made now rather than waiting until January 1, 1996.

Recommendation: In future legislation to assist small water systems, the Legislature should encourage consolidation of small water systems whenever feasible. As part of this legislation, consideration should be given for the assignment of the responsibility to the county for identification, planning, and implementation of intra-county regional solutions to small water system problems as an element of a comprehensive water system plan for that county. Since public water systems operate for the public good, it is also recommended that authority be given to ODW or appropriate local authority to require the participation by any public water system that has been designated as a participant in a regional plan and/or as a designated satellite management agency.

Recommendation: Legislation should be enacted that prohibits the formation of a new public water system within or adjacent to the approved service area of an existing public water system, unless it has been demonstrated that it is technically or economically infeasible for the existing system to serve the area. Approved service areas should be defined by the Local Agency Formation Commission, the PUC for investor owned facilities, or the area defined in the existing public water system permit.

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CHAPTER XI

IMPLEMENTATION PLAN

The Office of Drinking Water has presented in the Safe Drinking Water Plan for California numerous conclusions and recommendations regarding the drinking water program in California. The conclusions and recommendations presented in this report address the major issues that need to be considered in making improvements to the drinking water program. Due to time and resource limitations, the Office of Drinking Water was unable to fully evaluate the specific details of many recommendations. Some recommendations, therefore, are presented in conceptual form. Further detailed study and evaluation may be needed before legislative action is taken with respect to some recommendations.

California has such a diverse and complex water supply and resource picture that it should, hand-in-hand with the utilities, lead the nation in aggressively pursuing new water technology to meet the present and future supply and demands for water by helping to ensure the health, safety, and potability of drinking water for all Californians. Whether these recommendations are enacted in whole or in part is important. Only by enacting these recommendations and providing the funding for these programs will the legislature ensure that California's drinking water program will lead the nation.

Implementation of these recommendations and the direction of the drinking water program into the 21st century is dependent upon future legislative action.

APPENDIX 1

CHARACTERISTICS OF A "TYPICAL WATERSYSTEM

Table A.1 Characterization of Five "Typical" Community Water Systems

	Very Small	Small	Intermediate	Medium	Large
Service Connections	15	100	500	3,500	33,500
Population	53	350	1,950	13,650	130,650
Number of Sources	1	2	4	8	26
Ground water	1	1	3	7	24
Surface Water	0	1	1	1	2

The average size water system for the Intermediate, Medium, and Large "typical" water systems were determined from the Department's Water Quality Monitoring database. For these three systems, it was assumed that there were 3.9 persons per service connection as was determined from the Survey of Community Water Systems in California (CDHS 1991). For the Very Small and Small "typical" water systems, it was assumed that there were 3.5 persons per service connection, which has been used by the Department to determine cost impacts of proposed regulations on the small water systems. The estimated number of sources was also determined from statistical averages from the Department's Water Quality Monitoring database.

APPENDIX 2

MAXIMUM CONTAMINANT LEVELS AND ACTION LEVELS

Constituent	**MCL**	**AL**
Inorganic Chemicals		
Aluminum	1.	
Arsenic	0.05	
Barium	1.	
Cadmium	0.010	
Chromium	0.05	
Lead	0.05	
Mercury	0.002	
Nitrate *(as NO_3)*	45.	
Selenium	0.01	
Silver	0.05	
Fluoride		
≤53.7 Degrees Fahrenheit	2.4	
53.8 to 58.3	2.2	
58.4 to 63.8	2.0	
63.9 to 70.6	1.8	
70.7 to 79.2	1.6	
79.3 to 90.5	1.4	
Radioactivity		
Gross Alpha particle activity[1]	15 *(pCi/l)*[2]	
Gross Beta particle activity	50 *(pCi/l)*	
Combined Radium-226 and Radium-228	5 *(pCi/l)*	
Strontium-90	8 *(pCi/l)*	
Tritium	20,000 *(pCi/l)*	
Uranium	20 *(pCi/l)*	
Total Trihalomethanes		
(Sum of bromodichloromethane, dibromochloromethane, bromoform, and chloroform)	0.10	

[1]Including Radium-226 but excluding Radon and Uranium
[2]pCi/l = pico Curies per liter

Organic Chemicals[3]		
Alachlor *(Alanex)*	Unregulated (b)	0.0002
Aldicarb *(Temik)*	Unregulated (b)	0.010
Aldrin		0.00005
Atrazine *(AAtrex)*	0.003	
Baygon		0.090
Bentazon *(Basagran)*	0.018	
Benzene	0.001	
a-Benzene Hexachloride *(a-BHC)*		0.0007
b-Benzene Hexachloride *(b-BHC)*		0.0003
Bromobenzene *(Monobromobenzene)*	Unregulated (a)	
Bromochloromethane *(Chlorobromomethane)*	Unregulated (b)	
Bromacil *(Hyvar X, Hyvar XL)*	Unregulated (b)	
Bromodichloromethane *(Dichlorobromomethane)*	Unregulated (a)	
Bromoform *(Tribromomethane)*	Unregulated (a)	
Bromomethane *(Methyl Bromide)*	Unregulated (a)	
n-Butylbenzene *(1-Butylpropane)*	Unregulated (b)	
Sec-butylbenzene *(2-Phenylbutane)*	Unregulated (b)	
Tert-butylbenzene *(2-Methyl-2-phenylpropane)*	Unregulated (b)	
Captan		0.350
Carbaryl		0.060
Carbofuran *(Furadan)*	0.018	
Carbon Tetrachloride	0.0005	
Chlordane	0.0001	
Chloroethane *(Ethyl Chloride)*	Unregulated (a)	
2-Chloroethylvinyl Ether	Not Regulated	
Chloroform *(Trichloromethane)*	Unregulated (a)	
Chloromethane *(Methyl Chloride)*	Unregulated (a)	
Chloropicrin		0.050 (0.037)[4]
Chlorothalonil *(Bravo, Daconil)*	Unregulated (b)	
2-Chlorotoluene *(o-Chlorotoluene)*	Unregulated (a)	
4-Chlorotoluene *(p-Chlorotoluene)*	Unregulated (a)	
2, 4-D	0.1	
Diazinon *(Basudin, Neocidol)*	Unregulated (b)	0.014
Dibromochloromethane *(Chlorodibromomethane)*	Unregulated (a)	
1,2-Dibromo-3-chloropropane *(DBCP)*	0.0002	
Dibromomethane *(Methylene Bromide)*	Unregulated (a)	
1,2-Dichlorobenzene *(o-Dichlorobenzene)*	Unregulated (a)	0.130 (0.010)[5]
1,3-Dichlorobenzene *(m-Diclorobenzene)*	Unregulated (a)	0.130 (0.020)[5]

[3]Not Regulated: monitoring not required. No MCL or Action Level established.
Unregulated (a): monitoring required for all community and non-transient, non-community water systems.
Unregulated (b): monitoring required for all community and non-transient, non-community water systems if determined vulnerable.

[4]Taste and Odor Threshold
[5]Taste and Odor Threshold - Action level for 1,2-Dichlorobenzene and 1,3-Dichlorobenzene is either for a single isomer or for the sum of the 2 isomers.

1,4-Dichlorobenzene *(p-DCB)*	0.005	
Dichlorodifluoromethane *(Difluorodichloromethane)*	Unregulated (a)	
1,1-Dichloroethane *(1,1-DCA)*	0.005	
1,2-Dichloroethane *(1,2-DCA)*	0.0005	
1,1-Dichloroethylene *(1,1-DCE)*	0.006	
cis-1,2-Dichloroethylene	0.006	
trans-1,2-Dichloroethylene	0.01	
1,2-Dichloropropane *(Propylene Dichloride)*	0.005	
1,3-Dichloropropane	Unregulated (a)	
2,2-Dichloropropane	Unregulated (a)	
1,1-Dichloropropene	Unregulated (a)	
1,3-Dichloropropene	0.0005	
Dieldrin		0.00005
Di(2-ethylhexyl)phthalate *(DEHP)*	0.004	
Dimethoate *(Cygon)*	Unregulated (b)	0.140
2,4-Dimethylphenol		0.406[6]
Diphenamide		0.040
Diuron *(Karmex, Krovar)*	Unregulated (b)	
Endrin	0.0002	
Ethion		0.035
Ethylbenzene *(Phenylethane)*	0.680	
Ethylene Dibromide *(EDB)*	0.00002	
Formaldehyde		0.030
Glyphosate	0.7	
Heptachlor	0.00001	
Heptachlor Epoxide	0.00001	
Hexachlorobutadiene *(Perchlorobutadiene)*	Unregulated (b)	
Isopropyl N (3-chlorophenyl) carbamate *(CIPC)*		0.350
Isopropylbenzene *(Cumene)*	Unregulated (b)	
p-Isopropytoluene *(p-Cymene)*	Unregulated (b)	
Lindane *(gamma-BHC)*	0.004	
Malathion		0.160
Methoxychlor	0.1	
Methyl Ethyl Ketone *(MEK, Butanone)*	Not Regulated	
Methyl Isobutyl Ketone *(MIBK)*	Not Regulated	
Methyl Parathion		0.030
Methylene Chloride *(Dichloromethane)*	Unregulated (a)	0.040
Molinate *(Ordram)*	0.02	
Monochlorobenzene *(Chlorobenzene)*	0.030	
Naphthalene *(Naphthalin)*	Unregulated (b)	
Parathion		0.030
Pentachloronitrobenzene *(Terrachlor)*		0.0009
Pentachlorophenol		0.030
Phenol		0.0050[7]

[6]Taste and Odor Threshold
[7]Taste and Odor Threshold - For chlorinated systems

n-Propylbenzene *(1-Phenylpropane)*	Unregulated (b)	
Prometryn *(Caparol)*		
Simazine *(Princep)*	0.01	
Styrene *(Vinylbenzene)*	Unregulated (a)	
2, 4, 5-TP *(Silvex)*	0.01	
1,1,2,2-Tetrachloroethane	0.001	
1,1,1,2-Tetrachloroethane	Unregulated (a)	
Tetrachloroethylene *(PCE)*	0.005	
Thiobencarb *(Bolero)*[8]	0.07	
Toluene *(Methylbenzene)*	Unregulated (a)	0.10
Toxaphene	0.005	
1,2,3-Trichlorobenzene	Unregulated (b)	
1,2,4-Trichlorobenzene (*Unsym-trichlorobenzene)*	Unregulated (b)	
1,1,1-Trichloroethane *(1,1,1-TCA)*	0.200	
1,1,2-Trichloroethane *(1,1,2-TCA)*	0.032	
Trichloroethylene *(TCE)*	0.005	
Trichlorofluoromethane *(Freon 11)*	0.15	
1,2,3-Trichloropropane *(Allyl Trichloride)*	Unregulated (a)	
1,1,2-Trichloro-1,2,2-Trifluoroethane *(Freon 113)*	1.2	
1,2,4-Trimethylbenzene *(Pseudocumene)*	Unregulated (b)	
1,3,5-Trimethylbenzene *(Mesitylene)*	Unregulated (b)	
Trithion		0.0070
Vinyl Chloride *(VC)*	0.0005	
Xylenes *(single isomer or sum of isomers)*	1.750	
Secondary Drinking Water Standards		
Chloride	250-500-600 [9]	
Color	15 *units*	
Copper	1.0	
Corrosivity	Relatively Low	
Foaming Agents *(MBAS)*	0.5	
Iron	0.3	
Manganese	0.05	
Odor--Threshold	3 *units*	
Specific Conductance *(micromhos)*	900-1600-2200 [9]	
Sulfate	250-500-600[9]	
Thiobencarb *(Bolero)*[10]	0.001	
Total Dissolved Solids	500-1000-1500[9]	
Turbidity	5 *units*	
Zinc	5.0	

[8]Also listed as a Secondary Drinking Water Standard with MCL of 0.001 mg/l.
[9]Recommended-Upper-Short Term
[10]Also listed as a Primary Drinking Water Standard with MCL of 0.07 mg/l.

APPENDIX 3

PENNSYLVANIA INFRASTRUCTURE INVESTMENT AUTHORITY ACT

Act 16 SESSION OF 1988

PENNSYLVANIA INFRASTRUCTURE INVESTMENT AUTHORITY ACT

ACT NO. 1988–16

H.B.No. 1100

AN ACT Providing for the establishment, implementation and administration of the Pennsylvania Infrastructure Investment Authority; imposing powers and duties on a board of trustees; transferring the rights, powers, duties and obligations of the Water Facilities Loan Board to the Pennsylvania Infrastructure Investment Authority; providing for the issuance of notes and bonds; providing for financial assistance and for a comprehensive water facilities plan; authorizing a referendum to incur indebtedness; making an appropriation; and making repeals.

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Section

The General Assembly of the Commonwealth of Pennsylvania hereby enacts as follows:

Section 1. Short title[1]

This act shall be known and may be cited as the Pennsylvania Infrastructure Investment Authority Act.

Section 2. Legislative intent[2]

The General Assembly finds and declares that:

(1) The health of millions of citizens of this Commonwealth is at risk due to substandard and deteriorated water supply and sewage disposal systems.

(2) Many water and sewage systems in this Commonwealth are aging, outmoded, inadequate, deteriorating and operating above capacity, and many areas have to limit their growth solely due to lack of proper water supply and sewage disposal.

(3) The economic revitalization of this Commonwealth is being stifled by a lack of clean water and adequate sewage facilities.

(4) Financing of water and sewage projects at affordable cost is not currently available in many areas of this Commonwealth.

(5) In order to assist in financing projects to protect the health and safety of the citizens of this Commonwealth and to promote the economic development of Pennsylvania, the General Assembly has determined that it is necessary to establish the Pennsylvania Infrastructure Investment Authority and to provide funding of the authority programs.

Section 3. Definitions[3]

The following words and phrases when used in this act shall have the meanings given to them in this section unless the context clearly indicates otherwise:

"Authority." The Pennsylvania Infrastructure Investment Authority.

"Board." The board of directors of the authority.

"Bonds." Bonds, notes or other evidences of indebtedness issued by the authority pursuant to this act.

"Department." The Department of Environmental Resources of the Commonwealth.

"Eligible cost." The cost of all labor, materials, machinery and equipment, lands, property, rights and easements, plans and specifications, surveys or estimates of costs and revenues, pre-feasibility studies, engineering and legal services, and all other expenses necessary or incident to the acquisition, construction, improvement, expansion, extension, repair or rehabilitation of all or part of a project.

"Governmental unit." Any agency of the Commonwealth or any county, municipality or school district, or any agency, instrumentality, authority or corporation thereof, or any public body having local or regional jurisdiction or power.

"Project." The eligible costs associated with the acquisition, construction, improvement, expansion, extension, repair or rehabilitation of all or part of any facility or system, whether publicly or privately owned, for the collection, treatment or disposal of wastewater, including industrial waste, or for the supply, treatment, storage or distribution of drinking water.

"Secretary." The Secretary of Environmental Resources of the Commonwealth.

"Water Facilities Loan Board." The board established under 32 Pa.C.S. § 7504 (relating to Water Facilities Loan Board).

Section 4. Pennsylvania Infrastructure Investment Authority: board of directors[4]

(a) Establishment.—There is hereby established a body corporate and politic, with corporate succession, to be known as the Pennsylvania Infrastructure Investment Authority. The authority is constituted an instrumentality of the Commonwealth, and the exercise by the authority of the powers conferred by this act shall be deemed and held to be a public and essential governmental function.

(b) Membership.—The authority shall consist of a 13-member board of directors composed of the Governor; the Secretary of Environmental Resources; the Secretary of Commerce; the Secretary of Community Affairs; the Secretary of General Services; the Secretary of the Budget; two Senators, one each to be appointed by the President pro tempore of the Senate and the Minority Leader of the Senate; two members of the House of Representatives, one each to be appointed by the Speaker of the House of Representatives and the Minority Leader of the House of Representatives; and three persons to be appointed by the Governor, one of whom shall be a registered engineer in this Commonwealth, one of whom shall be a representative of water supply and sewage treatment system industries, and one of whom shall be a representative of a State local government association. The three members appointed by the Governor shall serve for a term of two years and shall be eligible for reappointment.

[3] 35 P.S. § 751.3.

[4] 35 P.S. § 751.4.

(c) Officers.—The Governor shall be the chairman and chief executive officer of the authority. The board shall biannually elect a vice chairman. The board shall select a secretary and treasurer who need not be members of the board, and the same person may be selected to serve as both secretary and treasurer.

(d) Vesting of powers.—The powers of the authority shall be vested in the board in office from time to time, and eight members of the board shall constitute a quorum at any meeting. Action may be taken and motions and resolutions adopted by the authority by the affirmative vote of at least seven members of the board. No vacancy on the board shall impair the right of a quorum of the members of the board to exercise the powers and perform the duties of the authority.

(e) Designees.—Each public officer member of the board may designate an officer or employee of the Commonwealth to represent him at meetings of the board. Each designee may lawfully vote and otherwise act on behalf of the member of the board for whom he constitutes the designee. The designation shall be in writing delivered to the authority and shall continue in effect until revoked or amended in writing delivered to the authority.

(f) Services.—Research, investigation and other services necessary for the operation of the board shall be carried out from resources and by employees from the various executive departments represented on the board. All applicable Commonwealth departments and agencies shall cooperate with, and provide assistance to, the board, which may, at its discretion, provide financial reimbursement.

(g) Dissolution.—The authority may be dissolved by law, provided that the authority has no bonds or other debts or obligations outstanding or that provision has been made for the payment or retirement of all such bonds, debts and obligations. Upon any dissolution of the authority, all property, funds and assets of the authority shall be vested in the Commonwealth.

Section 5. Revenues of authority[5]

(a) Sources of revenues.—The authority may receive money from sources of revenue, including, but not limited to, the following:

(1) State funds appropriated to the authority.

(2) Federal funds appropriated to or granted to the authority.

(3) Proceeds from the sale of bonds of the authority authorized under section 7.[6]

(4) Proceeds from the sale of bonds issued on or after the effective date of this act from the remaining unused authorization in addition to any other funds that remain unencumbered on the effective date of this act from the act of July 12, 1981 (P.L. 263, No. 88), entitled "An act authorizing the incurring of indebtedness, with approval of the electors, of $300,000,000 for the repair, construction, reconstruction, rehabilitation, extension and improvement of community water supply systems, and for the repair, reconstruction or rehabilitation of flood control facilities, dams and port facilities and providing the allotment of proceeds from borrowing hereunder," approved by the electorate on November 3, 1981.

(5) Proceeds from the sale of bonds not to exceed a total sum of $150,000,000 issued for site development under the provisions of Article XVI-B of the act of April 9, 1929 (P.L. 343, No. 176), known as The Fiscal Code.[7] This paragraph shall expire on December 31, 1989, except that the board may fund projects approved prior to December 31, 1989.

(6) Proceeds from the sale of any Commonwealth general obligation bonds issued under sections 16 and 17.

(7) Proceeds from the sale of authority assets.

(8) Repayment of loan principal.

[5] 35 P.S. § 751.5.
[6] 35 P.S. § 751.7.
[7] 72 P.S. § 1601-B et seq.

(9) Payment of interest on loans made by the authority.

(10) Interest earned on the investments of authority moneys.

(b) Control of revenues; investment of funds.—The board shall have exclusive control and management of all moneys of the authority and full power to invest moneys not required for immediate use in any securities or other investments in which funds of the Commonwealth are authorized to be invested and in any other type of security or investment if, prior to the acquisition of the securities or investments, the board determines by resolution that such type of security or investment is in the best interests of the authority and the State Treasurer approves of such type of security or other investment.

(c) General fund and other separate funds or accounts.—

(1) The board shall establish a general fund from which it may authorize expenditures for any of the purposes of this act.

(2) The board shall establish a Water Pollution Control Revolving Fund administered in accordance with the requirements of section 212 of the Water Quality Act of 1987 (Public Law 100–4, 101 Stat. 21), and may establish such other separate revolving funds and accounts when determined by the board to be necessary or convenient. The board may deposit no more than $375,000,000 in funds and accounts established under this paragraph from the sources specified in subsection (a)(4), (5) and (6). This limitation shall not apply to any Federal funds.

(3) The board may also establish such nonrevolving funds and accounts as it deems necessary or convenient. Any funds from sources specified in subsection (a)(4), (5) and (6) which are not deposited in the board's revolving funds and accounts shall be deposited into these nonrevolving funds and accounts.

(d) Loan repayment.—Subject to any agreement with the holders of bonds, repayments of loan principal, together with any interest thereon, shall be deposited with the authority. Repayments from loans made from revolving funds and accounts may be deposited in such funds and accounts as the board shall determine. Repayments from other loans shall be deposited in nonrevolving funds and accounts for the purpose of repayment of general obligation bonds of the Commonwealth issued under the authority of this act. Loans made by the Water Facilities Loan Board prior to the effective date of this act and repayment of the principal of and interest on those loans shall be controlled by the provisions of Title 32 of the Pennsylvania Consolidated Statutes (relating to forests, waters and State parks) and the regulations promulgated thereunder. The board shall maintain such separate funds and accounts as may be necessary for the deposit of payments made under authority or requirement of State or Federal law.

Section 6. Powers and duties of authority[8]

The authority shall have and may exercise all powers necessary or appropriate to carry out and effectuate the purposes of this act, including, but not limited to, the following:

(1) Conduct examinations and investigations and take testimony, under oath or affirmation, on any matter necessary to the determination and approval of project applications.

(2) Sue and be sued, implead and be impleaded, complain and defend in all courts.

(3) Adopt, use and alter at will a corporate seal.

(4)(i) Make bylaws for the management and regulation of its affairs, and make and, from time to time, adopt, amend and repeal rules and regulations governing the administrative procedures and business of the authority.

(ii) Notwithstanding subparagraph (i), and in order to facilitate the speedy implementation of this program, the board shall have the power and authority to promulgate, adopt and use guidelines which shall be published in the Pennsylvania Bulletin. The guidelines shall be subject to review pursuant to section 204(b) of the act of

[8] 35 P.S. § 751.6.

October 15, 1980 (P.L. 950, No. 164), known as the Commonwealth Attorneys Act,[9] and shall not be subject to review pursuant to the act of June 25, 1982 (P.L. 633, No. 181), known as the Regulatory Review Act,[10] and shall be effective for a period not to exceed one year from the effective date of this act.

(iii) After the expiration of the one-year period, all guidelines shall expire and shall be replaced by regulations which shall have been promulgated, adopted and published as provided by law.

(5) Make contracts of every name and nature and execute all instruments necessary or convenient for the carrying on of its business.

(6) Accept grants from and enter into contracts or other transactions with any Federal, State or local agency.

(7) Take title by foreclosure or otherwise to any project or other property pledged, mortgaged, encumbered or otherwise available as security for a project financed in whole or in part by the board, whether by loan, loan guarantee or otherwise, where such acquisition is necessary to protect the interests of the board with respect to a project; pay all costs arising out of such acquisition from moneys held in the trust fund; and sell, transfer and convey all or any portion of any such project to any responsible buyer. The board may require a dedicated source of revenue to be available for repayment of any loan.

(8) Provide financial assistance, including, but not limited to, loans, loan guarantees, bond guarantees and grants for projects fulfilling the purposes of this act.

(9) Collect fees and charges relating to projects funded under this act, as the board determines to be reasonable, relating to activities undertaken in furtherance of the purposes of this act.

(10) Borrow money and issue bonds and provide for the right of holders thereof in accordance with the provisions of this act.

(11) Pledge, hypothecate or otherwise encumber all or any of the revenues or receipts of the authority as security for all or any of the bonds of the authority.

(12) Receive appropriations and apply for and accept grants, gifts, donations, bequests and settlements from any public or private source.

(13) Acquire, own, hold, construct, improve, rehabilitate, renovate, operate, maintain, sell, assign, exchange, lease, mortgage or otherwise dispose of real and personal property or any interest therein in the exercise of its powers and the performance of its duties under this act.

(14) Procure insurance against any loss in connection with its property and other assets and operations in any amounts and from any insurers as it deems desirable.

(15) Contract for the services of attorneys, accountants and financial experts and any other advisors, consultants and agents as may be necessary in its judgment, subject to the requirement that the chairman shall ensure that minority-owned or minority-controlled firms shall have an opportunity to participate to a significant degree in the provision of any contractual services purchased by the authority.

(16) Subject to any agreement with holders of its bonds, notes or other obligations, purchase bonds, notes and other obligations of the authority.

(17) Subject to any agreement with holders of its bonds, notes or other obligations, obtain as security for payment of all or any part of the principal of and interest and premium on the bonds, notes and other obligations of the authority, lines of credit and letters of credit in any amounts and upon any terms as the authority may determine, and pay any fees and expenses required in connection therewith.

(18) Do any act necessary or convenient to the exercise of the powers enumerated in this section or reasonably implied therefrom.

(19) Serve as the Water Facilities Loan Board to satisfy any outstanding bond obligation and loan liabilities.

[9] 71 P.S. § 732-205.

[10] 71 P.S. § 745.1 et seq.

(20) Assume all the rights, powers, duties, obligations and liabilities of the Water Facilities Loan Board.

(21) Repay the General Fund any or all debt service due to be paid in any fiscal year from bonds used to fund projects under this act.

(22) Prepare plans and reports and provide for public participation as deemed appropriate.

(23) Fund prefeasibility studies from any of its sources of revenue.

Section 7. Specific power to issue bonds [11]

(a) Principal amounts.—The authority may issue its bonds, notes or other obligations in principal amounts as in the judgment of the authority shall be necessary to provide sufficient funds for any of its corporate purposes. Corporate purposes shall be deemed to include:

(1) The payment, funding or refunding of the principal of, or interest or redemption premiums on, any bonds issued by it, whether the bonds to be funded or refunded have or have not become due.

(2) The establishment or increase of reserves to secure or to pay the bonds or interest thereon.

(3) All other costs or expenses of the authority incident to and necessary to carry out its corporate purposes and powers.

(b) Negotiable instrument designation.—Whether or not the bonds are of a form and character as to be negotiable instruments under the terms of Title 13 of the Pennsylvania Consolidated Statutes (relating to commercial code), the bonds are made negotiable instruments within the meaning of and for the purposes of Title 13, subject only to the provisions of the bonds for registration.

(c) Resolution; terms of bonds.—Bonds shall be authorized by resolution of the board, may be issued in one or more series and shall bear any date or dates, mature at any time or times not later than 35 years from the date of issuance thereof, bear interest at any rate or rates or at variable rates, be in any denomination or denominations, be in any form, either coupon or registered, carry any conversion or registration privileges, have any rank or priority, be executed in any manner, be payable from such sources in any medium of payment at any place or places within or without this Commonwealth, and be subject to any terms of redemption, purchase or tender by the authority or the holders thereof, with or without premium, as the resolution or resolutions may provide. A resolution of the authority authorizing the issuance of bonds may provide that the bonds be secured by a trust indenture between the authority and a trustee, vesting in the trustee any property, rights, powers and duties in trust consistent with the provisions of this act as the authority may determine. Such resolution may further provide for the acquisition of credit enhancement devices such as bond insurance, letters of credit or any other instruments to carry out the provisions of this section.

(d) Public or private sale.—Bonds shall be sold initially at public sale at any price or prices and in any manner as the authority may determine, subject to the requirement that the chairman shall ensure that minority-owned or minority-controlled firms shall have an opportunity to participate to a significant degree in any bond sale activities. Any portion of any bond issue so offered and not sold or subscribed for may be disposed of by private sale by the authority in such manner and at such prices as the authority shall direct.

(e) No prior preconditions on bond issuance.—Bonds may be issued under the provisions of this act without obtaining the consent of any department, division, board, bureau or agency of the Commonwealth and without any other proceeding or the happening of any other conditions or other things than those proceedings, conditions or things which are specifically required by this act.

(f) Limitation on obligations.—Bonds issued under the provisions of this act shall not be a debt or liability of the Commonwealth or of any of its political subdivisions other

[11] 35 P.S. § 751.7.

than the authority and shall not create or constitute any indebtedness, liability or obligation of the Commonwealth or of any political subdivision. All bonds shall be payable solely from revenues or funds pledged or available for their payment as authorized in this act, including the proceeds of any issue of bonds. Each bond shall contain on its face a statement to the effect that the authority is obligated to pay the principal thereof or the interest thereon only from its revenues, receipts or funds pledged or available for their payment as authorized in this act, that neither the Commonwealth nor any political subdivisions are obligated to pay the principal or interest, and that neither the faith and credit nor the taxing power of the Commonwealth or any political subdivision is pledged to the payment of the principal of or the interest on the bonds.

(g) Nature of obligation and payment.—Each issue of bonds may, if it is determined by the authority, be general obligations of the authority payable out of any revenues, receipts or funds of the authority, or special obligations payable out of particular revenues, receipts or funds, subject only to agreements with the holders of the bonds. Bonds may be secured by one or more of the following:

(1) Pledges of revenues and other receipts to be derived from the payment of the interest on any principal of notes and bonds issued by one or more governmental units and purchased by the authority, and any other payment made to the authority pursuant to agreements with any governmental unit or a pledge or assignment of any notes and bonds of any governmental units, and the rights and interests of the authority therein.

(2) Pledges of loan payments, rentals, other revenues to be derived from loan agreements, leases or other contractual arrangements with any person or entity, public or private, or a pledge or assignment of any such loan agreements, leases or other contractual arrangements, and the rights and interests of the authority therein.

(3) Pledges of grants, subsidies, contributions, appropriations or other payments to be received from the Federal Government or any instrumentality thereof or from the Commonwealth, any Commonwealth agency or other governmental unit.

(4) Pledges of all moneys, funds, accounts, securities and other funds, including the proceeds of the bonds.

(5) Mortgages and security interests covering all or part of any project or other property of any person or entity, real or personal, then owned or thereafter to be acquired, or a pledge or assignment of mortgages and security interests made or granted to the authority by any person or entity, and the rights and interests of the authority therein.

(h) Exemption from taxation.—All bonds and notes issued under the provisions of this section shall be exempt from taxation for State and local purposes.

Section 8. Covenants and express conditions on obligations [12]

In any resolution of the authority authorizing or relating to the issuance of bonds, the authority, in order to secure payment of the bonds, and, in addition to its other powers, may, by provisions in the resolution which shall constitute covenants by the authority and contracts with the holders of the bonds, do the following:

(1) Secure the bonds.

(2) Make covenants against pledging all or part of its revenues or receipts to other parties.

(3) Make covenants limiting its right to sell, pledge or otherwise dispose of notes and bonds of governmental units, loan agreements of public or private persons or entities, or other property of any kind.

(4) Make covenants as to additional bonds to be issued, the limitations thereon, the terms and conditions thereof, and the custody, application, investment and disposition of the proceeds thereof.

(5) Make covenants as to the incurring of other debts by it.

[12] 35 P.S. § 751.8.

(6) Make covenants as to the payment of principal of or interest on bonds, the sources and methods of the payment, the rank or priority of bonds with respect to liens or security interests or the acceleration of maturity of bonds.

(7) Provide for replacement of lost, stolen, destroyed or mutilated bonds.

(8) Make covenants as to the redemption, purchase or tender of bonds by the authority, or the holders thereof, and the privileges of exchanging them for other bonds.

(9) Make covenants to create or authorize the creation of special funds or accounts to be held in trust or otherwise for the benefit of holders of bonds, or of reserves for other purposes and as to the use, investment and disposition of moneys held in those funds, accounts or reserves.

(10) Provide for the rights, liabilities, powers and duties arising upon the breach of a covenant, condition or obligation and prescribe the events of default and the terms and conditions upon which any or all of the bonds shall become or may be declared due and payable before maturity and the terms and conditions upon which the declaration and its consequences may be waived.

(11) Vest in a trustee or trustees within or without this Commonwealth in trust any property, rights, powers and duties as the authority may determine. These may include any or all of the rights, powers and duties of any trustee appointed by the holders of bonds or notes, including rights with respect to the sale or other disposition of notes and bonds of governmental units and other instruments and security pledged pursuant to a resolution or trust indenture for the benefit of the holders of bonds and the right, by suit or action, to foreclose any mortgage pledged pursuant to the resolution or trust indenture for the benefit of the holders of the bonds, notes or other obligations, and to limit the right of the holders of any bonds to appoint a trustee under this act and to limit the rights, powers and duties of the trustee.

(12) Pay the costs or expenses incident to the enforcement of the bonds or the provisions of the resolution authorizing the issuance of those bonds, or the trust indenture securing the bonds or any covenant or agreement of the authority with the holders of the bonds, notes or other obligations.

(13) Limit the rights of the holders of any bonds to enforce any pledge or covenant securing bonds.

(14) Make covenants other than or in addition to the covenants authorized by this act of like or different character and make covenants to do or refrain from doing any acts and things as may be necessary, or convenient and desirable, in order to better secure bonds or which, in the absolute discretion of the authority, will tend to make bonds more marketable, notwithstanding that the covenants, acts or things may not be enumerated herein.

Section 9. Nature and effect of pledges [13]

A pledge of revenues, receipts, moneys, funds or other property or instruments made by the authority shall be valid and binding from the time when the pledge is made. The revenues, receipts, moneys, funds or other property pledged and thereafter received by the authority shall be immediately subject to the lien of the pledge without its physical delivery or further act, and the lien of any pledge shall be valid and binding as against all parties having claims of any kind in tort, contract or otherwise against the authority irrespective of whether the parties have notice of the lien. Neither the resolution nor any other instrument by which a pledge under this section is created or evidenced need be filed or recorded except in the records of the authority.

Section 10. Financial assistance [14]

(a) Criteria for obtaining assistance.—In reviewing applications for financial assistance, the authority shall consider:

[13] 35 P.S. § 751.9. [14] 35 P.S. § 751.10.

(1) Whether the project will improve the health, safety, welfare or economic well-being of the people of this Commonwealth.

(2) Whether the proposed project will lead to an effective or complete solution to the problems experienced with the water supply or sewage treatment system to be aided, including compliance with State and Federal laws, regulations or standards.

(3) The cost-effectiveness of the proposed project in comparison with other alternatives, including other institutional, financial and physical alternatives.

(4) The consistency of the proposed project with other State and regional resource management and economic development plans.

(5) Whether the applicant has demonstrated its ability to operate and maintain the project in a proper manner.

(6) Whether the project encourages consolidation of water or sewer systems, where such consolidation would enable the customers of the systems to be more effectively and efficiently served.

(7) The availability of other sources of funds at reasonable rates to finance all or a portion of the project and the need for authority assistance to finance the project or to attract the other sources of funding.

(b) Financing priorities.—In assigning priorities for projects, the board shall consult with the Department of Commerce and the department. In addition to any requirements of Federal law imposed on the use of Federal funds, the board shall determine priorities based on factors which include, but are not limited to:

(1) Benefits to public health.

(2) The contribution to and impact of the project on economic development as well as social and environmental values.

(3) Benefits to public safety or welfare.

(4) Improvement in the ability of an applicant to come into compliance with State and Federal statutes, regulations and standards.

(5) Improvement in the adequacy or efficiency of the water supply or sewage treatment system.

(6) The cost-effectiveness of the project.

(7) Whether the governmental unit to be served by a sewage treatment system is subject to construction or connection limitations issued by the department and the date that any such limitation was issued.

(8) Whether the project encourages consolidation of water or sewer systems, where such consolidation would enable the customers of the systems to be more effectively and efficiently served.

(c) Decision of board.—Establishment of priority for financial assistance under subsection (b) shall not be deemed to be a final action under 2 Pa.C.S. (relating to administrative law and procedure), nor shall it confer a right or duty upon the board or any other person. A decision as to an applicant's eligibility under subsection (a) may be appealed pursuant to 2 Pa.C.S., but the priority assigned the project may not be raised in that appeal.

(d) Small projects.—The board shall establish a program of assistance to water supply and sewage disposal systems serving communities with a population of 12,000 people or less or systems having hookups of 1,000 or less.

(e) Grants.—Grants shall be made only when the board, in its sole discretion, determines that the financial condition of the recipient is such that repayment of a loan is unlikely and that the recipient will not be able to proceed with the project without a grant. In considering grant applications, the authority may recommend, either before or after the determination of the board, that the recipient pursue other State grant programs, including, but not limited to, the Site Development program, the Federal Small Communities Block Grant program and the Federal Urban Development Action Grant program.

Should the board determine that a grant is necessary from the authority, the board shall attempt to mix the grant funds with loan funds, if financially possible.

(f) Loans.—Subject to any agreements with the holders of bonds, the board shall have the power to set terms applicable to loans in any manner it deems appropriate, subject to the provisions of this subsection. The board may consider such factors as it deems relevant, including current market interest rates, the financial and economic distress of the area which the project serves, and the necessity to maintain the authority funds in a financially sound manner. Loans may be made based on the ability to repay the loan from future revenue to be derived from the project, by a mortgage or other property lien, or on any other fiscal matters which the authority deems appropriate. The board shall have the power to defer principal on loans for up to five years. In the event of a default on the repayment of a loan, the board may apply to the court of common pleas of the county where the project is located for the appointment of a receiver to assume operation and supervision of the facility under the supervision of the court. The minimum rate of interest to be paid on any loan made pursuant to this act shall be 1%.

The maximum rate of interest shall not exceed the following:

(1) For projects in counties whose unemployment rate exceeds the Statewide unemployment rate by 40% or more, 1% for the first five years and 25% of the bond issue rate for the remainder of the loan.

(2) For projects in counties whose unemployment rate exceeds the Statewide unemployment rate, but exceeds it by less than 40%, 80% of the bond issue rate for the first five years and 60% of the bond issue rate for the remainder of the loan.

(3) For all other projects, 60% of the bond issue rate for the first five years and 75% of the bond issue rate for the remainder of the loan.

(4) For projects located within municipalities for which unemployment rates exist which would qualify the project for lower interest rates than if the relevant county unemployment rate were used, the unemployment rate of that municipality may be used in determining the interest rate on the loan.

For purposes of this subsection, the phrase "unemployment rate of the county" shall mean the average unemployment rate for the county in the most recent calendar year for which data has been finalized. For the projects which serve multiple counties, the highest unemployment rate of the counties involved shall be used. The unemployment data utilized shall be data reported by the Department of Labor and Industry. For purposes of this subsection, the phrase "bond interest rate" shall be the rate of interest paid by the Commonwealth immediately preceding the date of the loan for the bonds issued under sections 16 and 17.

(g) Limitation on annual assistance.—The amount of assistance approved by the board under subsection (e) shall not in any fiscal year exceed the amount of interest earnings, State appropriations and any funds received specifically for grants which are deposited into the accounts of the authority. This limitation shall not apply to projects funded prior to January 1, 1989, but the total amount of assistance under subsection (e) prior to January 1, 1989, shall not exceed $15,000,000, excluding moneys specifically appropriated by the General Assembly for grants.

(h) Other assistance.—The board shall provide by regulation for the use of other methods of financial assistance, including, but not limited to, bond and loan guarantees, and purchase or insurance of bonds if the board deems this to be an appropriate method to accomplish the purposes of this act.

(i) Limitation.—The provisions of other law notwithstanding, all projects eligible for assistance under this act shall be determined to be site development projects as referenced in the act of April 9, 1929 (P.L. 343, No. 176), known as The Fiscal Code.[15] In no case shall total assistance to any single project total more than $11,000,000, or $20,000,000 if a project serves more than one municipality, except that the board by a vote of at least nine members may authorize loans in excess of $20,000,000 to comprehensive projects

[15] 72 P.S. § 1 et seq.

providing or proposing consolidated service to a region encompassing all or parts of four or more municipalities.

(j) **Continuing education of operators.**—No agreement with individuals or entities shall be valid in the absence of an agreement by the individuals or entities seeking assistance under this act to assure that the system operators are participating or will participate in continuing education programs developed by the Department of Environmental Resources. If the board determines that the system operator of a system receiving assistance is not participating in continuing education programs, the board shall take all steps necessary to cease all financial assistance and recover all prior payments, including, but not limited to, the immediate repayment of any outstanding loans and interest and any grants.

(k) **Inspection of project and records.**—

(1) The applicant shall allow the authority and its successors, agents and representatives the right, at all reasonable times during construction and after completion of the project, to enter upon and inspect the project and to examine and make copies of the applicant's books, records, accounting data and other documents pertaining to the project and the financial condition of the applicant.

(2) The applicant may be required by the board or its agent to have prepared independent audits of its financial documents and conditions and submit a certified copy of the audits to the board.

(l) **Financial analysis.**—The financial analysis used by the board to determine the need of all applicants for financial assistance shall include, but not be limited to, the following:

(1) Fair and reasonable costs of wastewater treatment or of supplying drinking water incurred by comparable systems.

(2) The incomes of affected ratepayers and their ability to pay increased rates necessary to complete the proposed projects.

(3) Other sources of financing available to individuals or entities seeking assistance under this act.

(4) A determination that any financial assistance provided by this act will not be used to supplant financial resources already available to the applicant.

(m) **Refinancing limitation.**—Financial assistance shall not be available under this act for refinancing of any project except that the Water Pollution Control Revolving Fund may be used to the extent authorized by the Water Quality Act of 1987 (Public Law 100-4, 101 Stat. 7) for projects commenced after March 7, 1985.

(n) **Steel procurement.**—Every application shall contain a certification that the applicant shall, in every contract for the acquisition, repair, construction, reconstruction, rehabilitation, extension, expansion, improvement, alteration or maintenance of any water supply or sewage treatment system, comply with the provisions of the act of March 3, 1978 (P.L. 6, No. 3), known as the Steel Products Procurement Act.[16]

Section 11. Comprehensive water facilities plan[17]

Not later than December 31, 1990, the department shall submit to the authority a comprehensive plan for wastewater disposal and piped drinking water facilities in this Commonwealth. In preparing the plan, the department shall consult with county commissioners, multicounty planning agencies and other applicable local officials and agencies. The plan should include, but not be limited to:

(1) An inventory of the existing facilities located within this Commonwealth, including, but not limited to, identification of the type, capacity, location, current condition and year constructed.

(2) An inventory of drinking water and sewage construction needs.

[16] 73 P.S. § 1881 et seq. [17] 35 P.S. § 751.11.

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(3) Identification of the major issues and problems that the Commonwealth must deal with in order to address its water infrastructure needs, including financial as well as nonfinancial issues.

(4) Recommendations for programs to encourage the construction of drinking water and sewage treatment facilities. This may include innovative financing mechanisms, alternative technology and ownership structures, and technical assistance.

(5) Identification of emerging issues, trends and problems that might affect these facilities.

The plan shall be updated at least every five years. The board shall consider the plan as a guide when evaluating applications considered for approval after the completion of the plan.

Section 12. Audits [18]

The accounts and books of the authority, including its receipts, disbursements, contracts, mortgages, investments and other matters relating to its finances, operation and affairs, shall be examined and audited by the Auditor General.

Section 13. Annual report [19]

The board shall provide the General Assembly with an annual report detailing all projects funded under section 10.

Section 14. Expedited approval of rate relief [20]

For the limited and special purpose of ensuring repayment of principal and interest on loans made pursuant to this act, the Pennsylvania Public Utility Commission shall approve such security issues, affiliated interest agreements and rate increase requests by applicants that are regulated utilities as are necessary and appropriate. For this purpose, the Pennsylvania Public Utility Commission shall establish such expedited practices, procedures and policies as necessary to facilitate and accomplish repayment of the loans. Nothing in this act shall be construed as to require approval of rate increases greater than that necessary to accomplish the repayment of loans made pursuant to this act.

Section 15. Transfer of Water Facilities Loan Board [21]

(a) Removal of members.—All existing members of the Water Facilities Loan Board shall cease to hold office on the day that the Governor certifies by publication in the Pennsylvania Bulletin the existence of a quorum on the board created under section 4.

(b) Board of directors to serve as Water Facilities Loan Board.—For purposes of satisfying all outstanding obligations of the Water Facilities Loan Board and for purposes of collecting loan and interest repayments, the board established in section 4 shall constitute the membership of the Water Facilities Loan Board.

(c) Transfer of function.—All remaining unencumbered funds, rights, powers, duties, obligations, liabilities, records and equipment of the Water Facilities Loan Board are transferred to the authority.

Section 16. Referendum [22]

(a) General rule.—Pursuant to the provisions of section 7(a)(3) of Article VIII of the Constitution of Pennsylvania, the question of incurring indebtedness of $300,000,000 for loans for the acquisition, repair, construction, reconstruction, rehabilitation, extension, expansion and improvement of water supply and sewage treatment systems, subject to implementation through this act, shall be submitted to the electors at the next primary, municipal or general election following the effective date of this act.

[18] 35 P.S. § 751.12.
[19] 35 P.S. § 751.13.
[20] 35 P.S. § 751.14.
[21] 35 P.S. § 751.15.
[22] 35 P.S. § 751.16.

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(b) **Certification.**—The Secretary of the Commonwealth shall forthwith certify the question to the county boards of elections.

(c) **Form of question.**—The question shall be in substantially the following form:

> Do you favor the incurring of indebtedness by the Commonwealth of $300,000,000 for use as loans to acquire, repair, construct, reconstruct, rehabilitate, extend, expand and improve water supply and sewage treatment systems?

Section 17. Bonds [23]

(a) **Issuance of general obligation bonds.**—As evidence of the indebtedness if authorized under section 16, general obligation bonds of the Commonwealth shall be issued from time to time to fund and retire notes issued pursuant to section 16 to carry out the purposes of this act, or both, for such total amounts, in such form, in such denominations and subject to such terms and conditions of issue, redemption and maturity, rate of interest and time of payment of interest as the issuing officials direct except that the latest stated maturity date shall not exceed 30 years from the date of the debt first issued for each series.

(b) **Execution of bonds.**—All bonds and notes issued under the authority of section 16 shall bear facsimile signatures of the issuing officials and a facsimile of the great seal of the Commonwealth and shall be countersigned by a duly authorized loan and transfer agent of the Commonwealth.

(c) **Direct obligation of Commonwealth.**—All bonds and notes issued in accordance with section 16 shall be direct obligations of the Commonwealth, and the full faith and credit of the Commonwealth are hereby pledged for the payment of the interest thereon as it becomes due and the payment of the principal at maturity. The principal of and interest on the bonds and notes shall be payable in lawful money of the United States of America.

(d) **Exemption from taxation.**—All bonds and notes issued under the provisions of this section shall be exempt from taxation for State and local purposes.

(e) **Form of bonds.**—The bonds may be issued as coupon bonds or registered as to both principal and interest as the issuing officials may determine. If interest coupons are attached, they shall contain the facsimile signature of the State Treasurer.

(f) **Bond amortization.**—The issuing officials shall provide for the amortization of the bonds in substantial and regular amounts over the term of the debt. The first retirement of principal shall be stated to mature prior to the expiration of a period of time equal to one-tenth of the time from the date of the first obligation issued to evidence the debt to the date of the expiration of the term of the debt. Retirements of principal shall be regular and substantial if made in annual or semiannual amounts, whether by stated serial maturities or by mandatory sinking fund retirements.

(g) **Refunding bonds.**—The issuing officials are authorized to provide, by resolution, for the issuance of refunding bonds for the purpose of refunding any bonds issued under this section and then outstanding, either by voluntary exchange with the holders of the outstanding bonds, or to provide funds to redeem and retire the outstanding bonds with accrued interest, any premium payable thereon and the costs of issuance and retirement of bonds, at maturity or at any call date. The issuance of the refunding bonds, the maturities and other details thereof, the rights of the holders thereof and the duties of the issuing officials in respect to the same shall be governed by the provisions of this section, insofar as they may be applicable. Refunding bonds may be issued by the issuing officials to refund bonds originally issued or to refund bonds previously issued for refunding purposes.

(h) **Quorum.**—Whenever any action is to be taken or decision made by the Governor, the Auditor General and the State Treasurer acting as issuing officials and the three officers are not able unanimously to agree, the action or decision of the Governor and either the Auditor General or State Treasurer shall be binding and final.

[23] 35 P.S. § 751.17.

(i) Public sale.—Whenever bonds are issued, they shall be offered for sale at not less than 98% of the principal amount and accrued interest and shall be sold by the issuing officials to the highest and best bidder or bidders after due public advertisement on such terms and conditions and upon such open competitive bidding as the issuing officials shall direct. The manner and character of the advertisement and the time of advertising shall be prescribed by the issuing officials.

(j) Private sale.—Any portion of any bond issue so offered and not sold or subscribed for may be disposed of by private sale by the issuing officials in such manner and at such prices, not less than 98% of the principal amount and accrued interest, as the issuing officials shall direct. No commission shall be allowed or paid for the sale of any bonds issued under the authority of this section.

(k) Bond series.—When bonds are issued from time to time, the bonds of each issue shall constitute a separate series to be designated by the issuing officials or may be combined for sale as one series with other general obligation bonds of the Commonwealth.

(*l*) Temporary bonds.—Until permanent bonds can be prepared, the issuing officials may in their discretion issue, in lieu of permanent bonds, temporary bonds in such form and with such privileges as to registration and exchange for permanent bonds as may be determined by the issuing officials.

(m) Disposition and use of proceeds.—The proceeds realized from the sale of bonds and notes, except funding bonds, refunding bonds and renewal notes, under the provisions of this section are specifically dedicated to the purposes of the referendum to be implemented by this act and shall be paid into the special funds established in the State Treasury in such amounts as may be specified by the board pursuant to section 5(c).[24] The proceeds shall be paid by the State Treasurer periodically to the board to expend them at such times and in such amounts as may be necessary to satisfy the funding needs of the board. The proceeds of the sale of funding bonds, refunding bonds and renewal notes shall be paid to the State Treasurer and applied to the payment of principal, the accrued interest and premium, if any, and costs of redemption of the bonds and notes for which such obligations shall have been issued.

(n) Investment of funds.—Pending their application to the purposes authorized, moneys held or deposited by the State Treasurer may be invested or reinvested as are other funds in the custody of the State Treasurer in the manner provided by law. All earnings received from the investment or deposit of such funds shall be paid into the State Treasury to the credit of the funds established by the board in section 5(c) in such amounts as may be specified by the board pursuant to that section.

(*o*) Registration of bonds.—The Auditor General shall prepare the necessary registry book to be kept in the office of the duly authorized loan and transfer agent of the Commonwealth for the registration of any bonds, at the request of owners thereof, according to the terms and conditions of issue directed by the issuing officials.

(p) Expenses of preparation for issue and sale of bonds and notes.—There is hereby appropriated to the State Treasurer from the proceeds of the bonds and notes issued as much money as may be necessary for all costs and expenses in connection with the issue of and sale and registration of the bonds and notes in connection with this act.

Section 18. Appropriations[25]

(a) Appropriation.—The sum of $500,000, or as much thereof as may be necessary, is hereby appropriated from the General Fund to the Pennsylvania Infrastructure Investment Authority as a continuing appropriation to carry out the provisions of this act. This appropriation shall lapse June 30, 1989.

(b) Continuing appropriation.—The General Assembly hereby appropriates on a continuing basis to the authority funds as authorized by section 5[26] in order to carry out the

[24] 35 P.S. § 751.5(c).
[25] 35 P.S. § 751.18.
[26] 35 P.S. § 751.5.

purposes of this act, including the payment of the administrative expenses of the authority.

Section 19. Severability[27]

The provisions of this act are severable. If any provision of this act or its application to any person or circumstance is held invalid, the invalidity shall not affect other provisions or applications of this act which can be given effect without the invalid provision or application.

Section 20. Repeals[28]

(a) Absolute.—On the date that the Governor certifies by publication in the Pennsylvania Bulletin the existence of a quorum on the board created under section 4, the following acts or parts of acts are repealed:

The definitions of "community water supply system," "department," "flood control facility," "port facility," "project" and "water facility" in section 7502 and sections 7503, 7504(b), (d) and (e), 7506, 7510, 7511, 7512, 7513, 7514, 7515 and 7516 of Title 32 of the Pennsylvania Consolidated Statutes (relating to forests, waters and State parks).

(b) Limited.—The following acts or parts of acts are repealed:

(1) Any project itemized in a capital budget which was funded by current revenues without the use of bond obligations.

(2) Sections 1, 1.1, 2 and 3 of the act of August 20, 1953 (P.L. 1217, No. 339), entitled "An act providing for payments by the Commonwealth to municipalities which have expended money to acquire and construct sewage treatment plants in accordance with the Clean Streams Program and the act, approved the twenty-second day of June, one thousand nine hundred thirty-seven (Pamphlet Laws 1987), and making an appropriation," as applied to projects funded under the provisions of this act.[29]

(c) Inconsistent.—All other acts and parts of acts are repealed insofar as they are inconsistent with this act.

Section 21. Effective date

This act shall take effect immediately.

Approved the 1st day of March A.D. 1988.

PENNSYLVANIA SCENIC RIVERS SYSTEM—SCHUYLKILL RIVER

ACT NO. 1988–17

H.B.No. 482

AN ACT Amending the act of November 26, 1978 (P.L. 1415, No. 333), entitled "An act designating a portion of the Schuylkill River as a component of the Pennsylvania Scenic Rivers System in accordance with the Pennsylvania Scenic Rivers Act; authorizing further classification; providing for cooperation, limitation of liability and protection of critical areas, and authorizing the expenditure of moneys," extending the designation to an additional portion of the Schuylkill River and to two of its tributaries.

The General Assembly of the Commonwealth of Pennsylvania hereby enacts as follows:

Section 1. Sections 2, 4, 7 and 8 of the act of November 26, 1978 (P.L. 1415, No. 333), known as the Schuylkill Scenic River Act, are amended to read:

[27] 35 P.S. § 751.19.
[28] 35 P.S. § 751.20.
[29] 35 P.S. § 701 et seq.

GLOSSARY

ACRE-FOOT - The quantity of water that will cover one acre of area with water one foot deep; also equal to approximately 326,000 gallons of water, or about the quantity of water used by a family of five in one year.

ACUTE - Occurring over a short period of time; used to describe brief exposures and effects which appear promptly after exposure.

ACUTE HEALTH EFFECT - A health effect occurring over a short period of time, and which appears promptly after exposure.

AD VALOREM - A direct tax based "according to value" of property. Counties and school districts and municipalities usually are, and special tax districts may be, authorized by law to levy ad valorem taxes on property other than intangible personal property. Local governmental bodies with taxing powers may issue bonds or short-term certificates payable from ad valorem taxation.

ADDITIVE EFFECT - Combined effect of two or more chemicals equal to the sum of their individual effects.

ANIMAL STUDIES - Investigations using animals as surrogates for humans, on the expectation that results in animal are pertinent to humans.

ANION - A negatively charged ion.

ATOMIZE - To reduce or separate into fine or minute particles.

BENTHIC - Plants and animals that live at or on the bottom of a water body.

BIOASSAYS - A laboratory procedure for measurement of the effect of a substance on a test specimen.

BIOFILM - A biological film that forms on the surface of pipes and tank linings in water distribution systems.

BOND - A written promise to pay a specified sum of money, called the face value or principal amount, at a specified date or dates in the future, called the maturity date(s), together with periodic interest at a specified rate. The difference between a note and a bond is that the latter runs for a longer period of time and requires greater legal formality.

Bond Anticipation Notes - Short-term interest-bearing notes issued by a governmental agency in anticipation of bonds to be issued at a later date. The notes are retired from proceeds of the bond issue to which they are related.

Cancer - A disease characterized by the rapid and uncontrolled growth of aberrant cells into malignant tumors.

Capital Improvement Plan - A plan for capital expenditures to be incurred each year over a fixed period of years to meet capital needs arising from the long-term work program or otherwise. It sets forth each project or other contemplated expenditure in which the entity is to have a part and specifies the full resources estimated to be available to finance the projected expenditures.

Carcinogen - A chemical which causes or induces cancer.

Central Nervous System (CNS) - The portion of the nervous system which consists of the brain and spinal cord.

Certificates Of Participation - A lease-purchase arrangement whereby the lessor issues certificates to third parties to finance property purchases, receives payment and retires debt in accordance with lease provisions, and incurs ownership liabilities. The local government lessee exercises control over the certificate features, makes payments for leased property, and may acquire the property through purchase options.

Chronic - Occurring over a long period of time, either continuously or intermittently; used to describe ongoing exposures and effects that develop only after a long exposure.

Chronic Health Effect - A health effect occurring over a long period of time, either due to continuous or intermittent exposure.

Coliform Bacteria - Aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose with gas and acid formation within 48 hours at 35 degrees Celsius.

Community Water System - A public water system which serves at least 15 service connections used by yearlong residents or regularly serves at least 25 yearlong residents.

CONNECTION CHARGE - The charge made by the utility to recover the cost of connecting the customer's service line to the utility's facilities. This charge is often considered as contribution of capital by the customer or other agency applying for service; although it is most often considered as a utility revenue source.

CREDIT ENHANCEMENT - The availability of additional outside support designed to improve an issuer's own credit standing. Examples include bank lines of credit or collateralized funds.

CUSTOMER CLASSIFICATION - The grouping of customers into homogeneous classes. Typically, water utility customers may be classified as residential, commercial, and industrial for rate making and other purposes.

DE MINIMUS - The negligible calculated individual lifetime risk level.

DERMAL EXPOSURE - Contact between a chemical and the skin.

DETECTION LIMIT FOR REPORTING PURPOSES - The lowest level of a contaminant that is reportable to the California Department of Health Service under conditions similar to the USEPA definition of practical quantitation limit.

DOSE - The actual quantity of a chemical to which an organism is exposed.

DOSE-RESPONSE - A quantitative relationship between the dose of a chemical and an effect caused by the chemical.

DOUBLE-BARRELED BOND - Traditionally, a bond secured by a defined source of revenue plus the full faith and credit of the issuer. The term is occasionally, although erroneously, used to refer to bonds secured by any two sources of pledged revenue.

DUAL WATER SYSTEM - A water distribution system that delivers potable water in one system for use inside a building or residence and a non-potable water in a separate system for nonconsumption use outside the building or residence.

ELEMENT - A pure substance that cannot be decomposed into any simpler pure substance.

ELUENT - The additional liquid mobile phase added after the sample in liquid chromatography to force the sample down the column.

Epidemiologic Study - Study of human populations to identify causes of disease. Such studies often compare the health status of a group of persons who have been exposed to a suspect agent with that of a comparable non-exposed group.

Equity - The net worth of a business, consisting of capital stock, capital (or paid in) surplus, earned surplus (or retained earnings), and, occasionally, certain net-worth reserves.

EUTROPHICATION - The addition of nutrients to the water.

Floating Or Variable Interest Rate - A method of determining the interest to be paid on a bond issue by reference to an index or according to a formula or other standard of measurement at intervals as stated in the bond contract. One common method is to calculate the interest rate as a percentage of the prime rate published by a named financial institution on specified dates. It may also be the interest rate determined by the remarketing agent to be necessary to allow all bonds to trade at par.

General Obligation Bonds - Bonds which are secured by the full faith and credit of the issuer. General obligation bonds issued by local units of government are secured by a pledge of the issuer's ad valorem taxing power. Such bonds constitute debts of the issuer and normally require approval by election prior to issuance. In the event of default, the holders of general obligation bonds have the right to compel a tax levy or legislative appropriation, by mandamus or injunction, in order to satisfy the issuer's obligation on the defaulted bonds.

Geographical Information Systems - A computer software program for evaluation of geographically related information.

Grant Anticipation Notes Or Gan's - Notes issued on the expectation of receiving grant monies, usually from the federal government. The notes are payable from the grant funds, when received.

Health Risk - The likelihood (or probability) that a given exposure or series of exposures may have or will damage the health of individuals experiencing the exposures.

High-To-Low-Dose Extrapolation - The process of prediction of low exposure risks to rodents from the measured high exposure/high risk data.

Hydride - A negatively charged hydrogen ion.

In-Vitro - A laboratory procedure for test the effect of a substance on a test specimen, isolated from the living organism, and artificially maintained.

Ingestion Exposure - Type of exposure through eating, drinking or otherwise consuming an agent.

Ingrowth - The production of a daughter product over a period of time through the decay of the parent radiochemical. For example, actinium-228 (daughter product) is produced by decay of radium-228 (parent radiochemical).

Inhalation Exposure - Type of exposure by inhalation of an agent into the lungs and the absorption of that agent into the lung tissue and throughout the rest of the body.

Inorganic Chemical - A chemical from a branch of chemistry dealing with compounds lacking carbon or containing it only in the form of carbonates, carbides, and most cyanides.

Investor-Owned Water Utility - A utility owned by an individual, partnership, corporation, or other qualified entity with the equity provided by shareholders. Regulation may take the form of local or state jurisdiction.

Ionic Emission Spectra - A series of discrete lines at wavelengths, in the ultraviolet or visible region, that are characteristic of a chemical element.

Large Water System - A public water system which serves 200 or more service connections.

Letter Of Credit - An irrevocable backup guarantee from a commercial bank on an issuer's credit in the form of a promise to stand behind the issuer's outstanding obligation if the issuer fails to provide sufficient funds for debt service.

LOAEL - Lowest-Observed-Adverse-Effect Level; the lowest dose in an experiment which produced and observable adverse effect.

Long-Term Debt - Debt with a maturity of more than one year after the date of issuance.

Maximum contaminant Level (MCL) - The maximum permissible level of a contaminant in water.

Method Detection Limit - The minimum concentration of a substance that can be measured and reported with 99% confidence that the true value is greater than zero; generally measured by a few of the most experienced labs under non-routine and controlled research type conditions.

μg/L - Micrograms per Liter, a weight to volume measure of the quantity of a substance in solution in water, approximately equal to one part of the substance in one billion parts of water.

mg/L - Milligrams per Liter, a weight to volume measure of the quantity of a substance in solution in water, approximately equal to one part of the substance in one million parts of water.

Microbial Agent - A microscopic organism such as bacteria, viruses, and *Giardia lamblia* cysts.

Microgram Per Liter - A unit of concentration; 1,000 micrograms per liter = 1 milligram per liter.

Milligram Per Liter - A unit of concentration; 1 milligram per liter = 0.00000833 pounds per gallon.

Milliliter - A unit of volume; 1 milliliter = 0.000264 gallons.

Modeling - Use of mathematical equations to simulate and predict real events and processes.

Mutagen - An agent that causes a permanent genetic change in a cell other than that which occurs during normal genetic recombination.

Nanogram Per Liter - A unit of concentration; 1 million nanograms per liter = 1 milligram per liter.

Nebulize - To convert a liquid to a fine spray.

Nephelometer - An instrument used to measure the amount of suspended material in a liquid medium. For drinking water analysis, the instrument is designed to measures light scattered at 90 degrees to the incident light path, not to exceed + 30 degrees variation from 90 degrees.

NOAEL - No-Observed-Adverse-Effect Level; the highest dose in an experiment which did not produce an observable adverse effect.

Non-Community Water System - A public water system which meets one of the following criteria: (1) serves at least 25 nonresident individuals daily at least 60 days of the year, but not more than 24 yearlong residents, or (2) serves 15 or more service connections and any number of nonresident individuals at least 60 days of the year, but no yearlong residents.

Non-Transient, Non-Community Water System - A public water system which is not a community system and that regularly serves at least the same 25 persons over six months per year.

Organic Chemical - A chemical from a branch of chemistry that related to the structure, formation, and properties of compounds containing carbon. May be identified as volatile (readily evaporated at a relative low temperature, e.g., industrial solvent) or synthetic (a "man-made" substance, e.g., herbicides and pesticides).

Overdraft - occurs when the quantity of water extracted from a ground water basin exceeds the natural recharge to that basin.

Parts Per Million - A unit of concentration; 1 part per million = 1 microgram per liter.

Pathogen - Any disease-causing agent, usually applied to living agents.

Picocuries Per Liter - A rate of disintegration per unit volume; 1 trillion picocuries = 1 curie = the amount of any nuclide that undergoes exactly 3.7×10^{10} radioactive disintegrations per second.

Picograms Per Liter - A unit of concentration; 1 billion picograms per liter = 1 milligram per liter.

Practical Quantitation Limit - The lowest measurement level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions.

Private Activity Bonds - One of two categories of bonds established under Tax Reform Act of 1986. Depending on meeting certain tests, such bonds can be issued as tax-exempt, generally subject to state volume caps.

Privatization - Private sector involvement in the design, financing, construction, ownership, and/or operation of a facility that will provide services to the public sector.

Public Water System - A water system for the provision of piped water to the public for domestic use if such a system has at least five service connections or regularly serves an average of at least 25 individuals daily at least 60 days of the year.

Publicly Owned Water Utility - A water utility created by the state or other governmental legislative action, with the mandate that the purposes of the utility are public purposes and that its functions are essential governmental proprietary functions. Its primary purpose is to provide its designated area with potable water in an adequate supply at reasonable costs so that people of the area may improve their health, safety, and welfare. A publicly owned water utility may be part of a municipal government operation, a county agency, a regional authority, or take such other forms as is appropriate for its service area.

Radiochemical - A chemical from the branch of chemistry dealing with the properties and reactions of radioactive substances.

Ratings - Evaluations of credit quality of notes and bonds usually made by independent rating services, although many financial institutions also rate bonds for their own purposes. Ratings generally measure the probability of the timely repayment of principal of and interest on municipal bonds. Ratings are initially made before issuance and are continuously reviewed and may be amended to reflect changes in the issuer's credit position. The information required by the rating agencies varies with each bond issue, but generally includes demographics, debt burden, economic base, finances, and management structure. The information is evaluated and the issued is assigned a letter rating which reflects the creditworthiness of the bonds. The higher the credit rating, the more favorable the effect on the marketability of the bond.

Recharge - The process, either natural or artificial, by which the ground water that has been extracted from a ground water basin is replaced.

Recommended Public Health Level - The Recommended Public Health Level is the maximum concentration of a contaminant in drinking water established pursuant to the criteria set forth in the California Health and Safety code, Section 4023.

Retention Time - The time required for a chemical to travel the length of a chromatographic column.

Revenue Anticipation Notes - Notes issued in anticipation of receiving revenues at a future date.

REVENUE BONDS - Bond payable from a specific source of revenue and which do not pledge the full faith and credit of the issuer. Revenue bonds are payable from identified sources of revenue, and do not permit the bondholders to compel taxation or legislative appropriation of funds not pledged for payment of debt service. Pledged revenues may be derived from operation of the financed project, grants, and excise or other specified non-ad valorem taxes. Generally, no election is required prior to issuance or validation of such obligations.

REVERSE OSMOSIS - Process for removing dissolved salts from solution in water.

RISK - The potential for realization of unwanted adverse consequences or events.

RISK ASSESSMENT - A qualitative or quantitative evaluation of the environmental and/or health risk resulting from exposure to a chemical or physical agent (pollutant); combines exposure assessment results with toxicity assessment results to estimate risk.

RISK MANAGEMENT - Decisions about whether an assessed risk is sufficiently high to present a public health concern and about the appropriate means for control of a risk judged to be significant.

ROUTE OF EXPOSURE - The avenue by which a chemical comes into contact with an organism (e.g., inhalation, ingestion, or dermal contact).

SCINTILLATION - The act or state of sparkling or flashing as a result of energy released during ionizing radiation.

SMALL WATER SYSTEM - A public water system which serves less than 200 service connections.

SPECIAL ASSESSMENT - Charges imposed against property in a particular locality because that property receives a special benefit by virtue of some public improvement, separate and apart from the general benefit accruing to the public at large. Special assessments must be apportioned according to the value of the benefit received, rather than the cost of the improvement, and may not exceed the value of such benefit. When the value of the benefit exceeds the cost of the improvement, however, the special assessment may not exceed the cost of the improvement.

Special Districts - Single or limited purpose units of government formed under state enabling legislation to meet certain local needs not satisfied by existing general purpose governments in a given geographical area. Special districts may be granted taxing powers. An independent special district is one whose governing body is an independent entity and whose budget is established independently of the local governing authority.

State Small Water System - A public water system which meets one of the following criteria: 1) serves from 5 to 14 service connections and less than 25 individuals any part of the year, 2) serves 15 or more service connections and any number of nonresident individuals less than 60 days per year, or 3) serves 5 to 14 service connections and 25 or more individuals less than 60 days per year.

Strawman Rule - A hypothetical rule to foster discussion in developing the actual proposed federal regulations.

Surplus Water - Surface water that is not subject to prior rights registered with the State Water Resources Control Board.

Synergism - An interaction of two or more chemicals that results in an effect that is greater than the sum of their effects taken independently.

Synthetic Organic Chemical - See organic chemical.

Tax Anticipation Notes - Notes issued in anticipation of future tax receipts, such as ad valorem taxes which are due and payable at a set time of the year. GAN's, RAN's and TAN's may be issued to finance capital projects or to alleviate cash flow problems of the issuer.

Tax Reform Act Of 1986 - Legislation enacted which among other major changes to federal tax provisions greatly affects ability of localities to issue tax-exempt securities.

Tax-Exempt Bond - Bonds whose interest is exempt from federal income taxation pursuant to Section 103 of the Internal Revenue Code, and may or may not be exempt from state income or personal property taxation in the jurisdiction where issued. If the bond is exempt from state income tax, it possesses "double exemption" status. "Triple exemption" bonds are exempt from municipal income tax, as well as federal and state income tax.

Teratogenesis - The induction of structural or functional development abnormalities by external factors acting during gestation; interference with normal embryonic development.

Threshold - The lowest dose of a chemical at which a specified measurable effect is observed and below which it is not observed.

TOC - is simply a measure of organic carbon and any carbon source, even those of biological origin, can contribute to the measured TOC.

Total Coliform - See coliform bacteria.

Turbidity - A measure of suspended material in raw and treated water; typically used as a form of process control to measure the efficiency of treatment (i.e., coagulation and filtration) provided at surface water treatment plants.

Variable-Rate Demand Bonds - An issue whose payable interest rate is allowed to rise or fall with market conditions. In addition, these bonds have "put" provisions, allowing the investor to redeem them at any time.

Volatile Organic Chemical - See organic chemical.

Zero Coupon Bond - A bond which pays no interest, but is issued at a deep discount from par, appreciating its full value at maturity.