CENTRAL VALLEY REGIONAL
WATER QUALITY CONTROL BOARD

A Compilation of
Water Quality Goals

August 2003
with tables updated August 2007

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

State of California
Arnold Schwarzenegger, Governor

California Environmental Protection Agency
Linda S. Adams, Secretary for Environmental Protection

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DISCLAIMER

This publication is a technical report by staff of the California Regional Water Quality Control Board, Central Valley Region. No policy or regulation is either expressed or intended.

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CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

PREFACE TO THE AUGUST 2007 UPDATE EDITION

This edition of the Central Valley Water Board staff report, *A Compilation of Water Quality Goals*, supersedes the August 2003 edition and all other editions and updates published prior to August 2003. Earlier editions and updates should be discarded, as they contain outdated information. This new edition contains water quality limit information that is current as of mid-August 2007.

While the text of the August 2007 Update Edition is the same as in the August 2003 Edition, the tables contain new and updated numerical water quality limits from a variety of sources, including:

- California Maximum Contaminant Levels for drinking water from the California Department of Public Health (CDPH), formerly the Department of Health Services (CDHS);
- State Notification Levels for drinking water (formerly called Action Levels) (CDPH);
- California Public Health Goals for drinking water from the California Environmental Protection Agency (Cal/EPA), Office of Environmental Health Hazard Assessment (OEHHA);
- Cancer risk estimates from the Cal/EPA Toxicity Criteria Database, maintained by OEHHA;
- Drinking Water Standards (MCLs) and Health Advisories from USEPA;
- Reference doses and cancer risk limits from the Integrated Risk Information System (IRIS) database, maintained by USEPA;
- Proposition 65 Safe Harbor Levels—No Significant Risk Levels for carcinogens and Maximum Allowable Dose Levels for chemicals causing reproductive toxicity;
- National Recommended (Ambient) Water Quality Criteria published by USEPA;
- Water quality objectives from the 2001 edition of the California Ocean Plan, adopted by the State Water Resources Control Board; and
- Hazard Assessments and Water Quality Criteria for pesticides, from the California Department of Fish and Game CDFG.

While not updated since the August 2003 Edition, the narrative *Selecting Water Quality Goals* contains information designed to help users to understand and select the most appropriate limits to implement California's water quality standards to protect the beneficial uses of surface water and groundwater resources. **To use this report correctly, it is necessary to read the enclosed narrative *Selecting Water Quality Goals* carefully before selecting numerical water quality limits from the tables.**

A Compilation of Water Quality Goals is a technical report by staff of the Central Valley Regional Water Quality Control Board. It is intended to assist in the appropriate interpretation of narrative water quality objectives. **This report does not, nor is it intended to, establish policy or regulation.**

The August 2007 Update Edition of *A Compilation of Water Quality Goals* and related information on water quality limits are available on the Central Valley Regional Water Board's internet web site at:

www.waterboards.ca.gov/centralvalley/
available_documents/

under the link "Water Quality Standards & Limits." Hard copies of *Water Quality Goals* are available in person or by mail from the Reception Desk at

Central Valley Regional Water Quality Control Board
11020 Sun Center Drive #200
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Public agencies may receive a copy free of charge. A charge to private entities covers the cost of reproduction, shipping and handling. Please call for cost information. Payment, if applicable, must accompany all requests. Checks are to be made payable to the Central Valley Regional Water Quality Control Board.

This staff report is not copyrighted. Persons are free to make copies of all or portions of this report. However, the author cautions that copies of the tables of numerical water quality limits without the accompanying text *Selecting Water Quality Goals* may result in misuse of the information.

If you have questions regarding this edition of the *Water Quality Goals* staff report, please contact me by telephone at (916) 464-4723 or by email at jmarshack@waterboards.ca.gov.

—Jon B. Marshack

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USING THIS REPORT

The remainder of this report is divided into five sections:

- Selecting Water Quality Goals
- Cross Reference of Chemical Names
- Water Quality Limits for Constituents and Parameters
- Footnotes
- References

Selecting Water Quality Goals — This section describes California's water quality standards that are designed to protect beneficial uses of groundwater and surface water resources. A process by which numerical limits from the published literature may be used to implement those standards is also presented. A ***glossary*** of commonly used terms is included at the end of this section.

Cross Reference of Chemical Names — This section provides an alphabetical listing of synonyms for the over 820 chemical constituents and parameters covered by this report. Many chemical constituents and parameters are commonly referred to by more than one name. **Look here first to find your chemical constituent or parameter of interest.** This section shows which name to use to find the constituent or parameter in the *Water Quality Limits* tables and indicates whether the constituent or parameter is organic (those chemicals for which their chemistry is dominated by that of the carbon atom) or inorganic (all other chemicals and parameters). Chemical Abstracts Service (CAS) Registry Numbers are also provided to help clarify the identity of most constituents.

To avoid incorrect use of the numerical water quality limits contained in this report, the author strongly recommends that the section* Selecting Water Quality Goals *be carefully reviewed.

Water Quality Limits — This section contains tables of numerical water quality limits. Constituents and parameters are presented on groups of six consecutive pages, beginning with pages "***1a***" through "***1f***." The first five pages of the group contain tables of water quality limits for the constituents and parameters. The sixth page is a table of CAS Registry Numbers, common synonyms and abbreviations. The next six pages, "***2a***" through "***2f***," repeat these tables for the next set of constituents and parameters. This section contains sixteen sets of these tables. For any constituent or parameter of interest, **be sure to review all six pages containing listings for that constituent or parameter before selecting numerical limits**. The numerical value of some water quality limits varies with the hardness, temperature, pH, or other characteristics of the waters to which they are applied. These variable limits for the protection of aquatic life from ammonia, heavy metals, and pentachlorophenol are presented in special tables and graphs on pages ***17*** through ***30*** of the *Water Quality Limits* section. Where a numerical limit varies in this manner, the number of the page which presents the variable limit is listed in the tables on pages ***1a*** through ***16f***.

Footnotes — Many listings in the tables contain footnotes within parentheses, e.g., "(122)." These footnotes, listed near the end of this report, explain limitations on how the numerical water quality limits apply and provide other useful information.

References — Literature sources, from which the numerical water quality limits were obtained, are provided at the end of this report. Where the reference information may be obtained on the internet, web addresses are also presented.

Selecting Water Quality Goals

California clearly values its water resources, which are significantly limited in quantity and quality. Recurring periods of drought have demonstrated the magnitude and severity of these limits. At the same time, improper waste management practices and contaminated sites pose significant threats to the quality of California's usable groundwater and surface water resources. The state population is expected to increase by fifty percent over the next quarter century, while the population of the Central Valley is expected to double over the next twenty years. At the same time, there is a growing realization that additional water is also needed in-stream to restore and protect our valuable fisheries. Therefore, it is imperative that California manage the quality of its water resources to be able to serve the growing needs of agriculture, cities, and industries without impairing in-stream beneficial uses.

The purpose of this staff report of the Central Valley Regional Water Quality Control Board is to introduce California's water quality standards and to outline a system for selecting numerical water quality limits, consistent with these standards. The resulting numerical limits may be used to assess impacts from waste management activities or releases on the quality of waters of the state and the beneficial uses that they are able to support.

To determine whether a particular waste management activity or release has caused or threatens to cause adverse effects on water quality, it is necessary to apply California's water quality standards. These standards are found in the *Water Quality Control Plans* adopted by the State Water Resources Control Board and each of the nine Regional Water Quality Control Boards. At concentrations equal to or greater than these standards, constituents are considered to have unreasonably impaired the beneficial uses of the state's water resources; that is, pollution has occurred.

In many cases, water quality standards include narrative, rather than numerical, water quality objectives. In such cases, numerical water quality limits from the literature may be used to ascertain compliance with these standards.

Terminology

This report uses several terms that may not be familiar or may have different meanings in their common usage. Differences in legal definitions necessitate using these terms in specific ways in this report.

Water Quality Standards — Pursuant to the federal Clean Water Act, water quality standards are composed of two parts: (1) the designated uses of water and (2) criteria to protect those uses. Water quality standards are enforceable limits in the bodies of water for which they have been established.

Beneficial Uses — This is the California term for designated uses of water that are components of water quality standards. California law defines beneficial uses as uses of surface water and groundwater that must be protected against water quality degradation. Beneficial uses of water may be found in the *Water Quality Control Plans* adopted by the State Water Resources Control Board and the nine Regional Water Quality Control Boards.

Water Quality Criteria — These are numerical or narrative limits for constituents or characteristics of water designed to protect specific uses of the water under the authority of the federal Clean Water Act. This term has two separate meanings. Water quality criteria promulgated by the U.S. Environmental Protection Agency (USEPA) under Section 303(c) of the Clean Water Act are enforceable water quality limits that, when combined with designated uses of water, become water quality standards. Water quality criteria published under Section 304(a) of the act are advisory limits, used by states and tribes to develop their own water quality standards or to interpret narrative water quality standards.

Water Quality Objectives — Under the California Water Code, these are numerical or narrative limits for constituents or characteristics of water designed to protect beneficial uses of a body of groundwater or surface water. Water Quality Objectives for surface water have the same legal status as Section 303(c) water quality criteria under the federal Clean Water Act. Water quality objectives may be found in the *Water*

Quality Control Plans adopted by the State and Regional Water Boards.

Water Quality Limit — As used in this report, this term refers to a numerical water quality limit from the literature designed to protect specific uses of water. Water quality limits may be used to interpret narrative water quality objectives or criteria.

Beneficial Use Protective Water Quality Limit — As used in this report, this term refers to the most stringent of a set of applicable water quality criteria and objectives and relevant water quality limits used to interpret narrative criteria and objectives for a constituent or parameter of concern in a specific body of water. This limit is chosen to comply with all applicable water quality objectives and Section 303(c) criteria so as to protect all beneficial uses designated for the body of water in question. In no case is this limit more stringent than the natural background concentration of the constituent.

Additional information about these terms is presented below.

California's Water Quality Control System

Realizing the limits on its water resources, California has developed a unique system to protect and control the quality of its most valuable resource. Our present system of water quality control was established in 1969, when the state legislature passed the Porter-Cologne Water Quality Control Act. Found in Division 7 of the California Water Code, the Porter-Cologne Act (on the web at http://www.swrcb.ca.gov/water_laws) provides for ten water quality control agencies: the State Water Resources Control Board and nine Regional Water Quality Control Boards. The Act instructs these boards to preserve and enhance the quality of California's water resources for the benefit of present and future generations.

The State Water Board carries out its water quality protection authority through the adoption of *Water Quality Control Plans*. These plans establish water quality standards for particular bodies of water. California's water quality standards are composed of the beneficial uses of water plus water quality objectives to protect those uses. Implementation plans are also adopted to achieve and maintain compliance with the water quality objectives. *Water Quality Control Plans* adopted by the State Water Resources Control Board include:

- The Ocean Plan
- The Thermal Plan (temperature control in coastal and interstate waters and enclosed bays and estuaries)
- The Delta Plan (Sacramento-San Joaquin Delta and Suisun Marsh)
- The Lake Tahoe Basin Water Quality Plan

In the year 2000, State Water Board adopted the *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California*. This policy, also known as the State Implementation Policy or SIP, provides implementation measures for numerical criteria contained in the *California Toxics Rule*, promulgated by the U.S. Environmental Protection Agency (USEPA) also in 2000. When combined with the beneficial use designations in the *Water Quality Control Plans* adopted by the Regional Water Boards (*Basin Plans*; see below), these documents establish statewide water quality standards for toxic constituents in surface waters that are not covered by the *Ocean Plan*. This combined Water Board/USEPA action is the first phase in the development of new *Water Quality Control Plans* for California's inland surface waters and enclosed bays and estuaries.

The State Water Board also adopts regulations and other "policies for water quality control," which have the enforceability of regulation, to protect water quality from discharges of waste to water or to land where water quality could be adversely affected.

To account for the great diversity of California's waterscape, the Porter-Cologne Act divided the state, along major drainage divides, into nine Water Quality Control Regions (see the map on the inside back cover of this report). Nine Regional Water Quality Control Boards act to protect water quality within these regions through the adoption of region-specific *Water Quality Control Plans*, also called *Basin Plans*. The *Basin Plans* contain water quality standards that are specific to surface waters and groundwater within a particular region or a portion thereof. As with the State Water Board's *Water Quality Control Plans*, the *Basin Plans* contain beneficial use designations, water quality objectives, and implementation programs.

Through voluntary compliance, the use of best management practices to control discharges of waste, and the issuance of waste discharge requirements (permits), water quality monitoring and reporting programs, and other enforceable orders, the State and Regional Water Boards implement the statewide and regional *Water Quality Control Plans*, policies for water quality control, and water quality regulations. Under delegation from USEPA, the State and Regional Water Boards also administer most of the federal clean water laws as they apply to California.

The focus of State and Regional Water Boards' water quality control programs is to prevent and correct conditions of pollution and nuisance. The Porter-Cologne Act defines "pollution" as "an alteration of the quality of the waters of the state by waste to a degree which unreasonably affects:

(1) such waters for beneficial uses, or
(2) facilities which serve such beneficial uses."

"Nuisance" is defined as "anything which:

(1) is injurious to health, or is indecent or offensive to the senses, or an obstruction to the free use of property so as to interfere with the comfortable enjoyment of life or property, and
(2) affects at the same time an entire community or neighborhood, or any considerable number of persons, although the extent of the annoyance or damage inflicted upon individuals may be unequal, and
(3) occurs during or as the result of the treatment or disposal of wastes."

WATER QUALITY STANDARDS

The term "water quality standards" is defined in regulations that implement the federal Clean Water Act. That definition reads:

"Water quality standards are provisions of state or federal law which consist of a designated use or uses for the waters of the United States and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the Act." [40 Code of Federal Regulations (CFR) Section 130.2(c) and 131.3(I)]

So, federal water quality standards must contain at least two critical components:

a) the designation of beneficial uses of water, and
b) the establishment of water quality criteria designed to protect those uses.

Antidegradation policies are also considered to be an integral part of federal water quality standards.

In California, the *Water Quality Control Plans* designate the beneficial uses of waters of the state and water quality objectives (the "criteria" under the Clean Water Act) to protect those uses. The *Water Quality Control Plans* are adopted by the State and Regional Water Boards through a formal administrative rule-making process and, thereby, have the force and effect of regulation. As mentioned above, the California Toxics Rule criteria, adopted by USEPA, when combined with beneficial use designations in the *Water Quality Control Plans*, are also water quality standards. One critical difference between the state and federal programs is that while the Clean Water Act focuses on surface water resources, the term "waters of the state" under the Porter-Cologne Act includes both surface waters and groundwaters. Therefore, California has water quality standards that apply to groundwater as well as water quality standards that apply to surface waters. Another difference is that California's *Water Quality Control Plans* include implementation programs to achieve and maintain compliance with water quality objectives.

California's water quality standards are enforceable by the State and Regional Water Boards. To protect both existing and future beneficial uses, they normally apply throughout the bodies of surface water and groundwater for which they were established, rather than at points of current water use or withdrawal.

BENEFICIAL USES

Section 13050(f) of the Porter-Cologne Act defines beneficial uses as follows:

"'Beneficial uses' of waters of the state that may be protected against quality degradation include, but are not necessarily limited to, domestic, municipal, agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves."

The State and Regional Water Boards' *Water Quality Control Plans* list the specific beneficial uses established for each of California's surface water and groundwater bodies. For example, the Central Valley Region's *Basin Plans* lists the following beneficial uses of water:

- Municipal and Domestic Supply
- Agricultural Supply
- Industrial Supply (both Service and Process)
- Groundwater Recharge
- Freshwater Replenishment
- Navigation
- Hydropower Generation
- Recreation (both Water Contact and Non-Water Contact)
- Commercial & Sport Fishing
- Aquaculture
- Freshwater Habitat (both Warm and Cold)
- Estuarine Habitat
- Wildlife Habitat
- Preservation of Biological Habitats of Special Significance
- Preservation of Rare, Threatened, or Endangered Species
- Migration of Aquatic Organisms
- Spawning, Reproduction, and/or Early Development
- Shellfish Harvesting

The *Water Quality Control Plans* specify which beneficial uses apply to each body of surface water and groundwater within each region of the state. Under the Porter-Cologne Act, the discharge of waste is not a right, but a privilege, subject to specific permit conditions. The discharge of waste is also not a beneficial use of water. The Water Boards' mission is to protect the quality of the State's waters from discharges of waste that could cause impairment of designated beneficial uses.

SOURCES OF DRINKING WATER POLICY

Also included within California's system of water quality standards are the "policies for water quality control" adopted by the State Water Board and incorporated into each of the Basin Plans. The SIP, discussed above, is an example. Another policy for water quality control is critical to the designation of beneficial uses.

In 1988, the State Water Board adopted Resolution No. 88-63, *Adoption of Policy Entitled "Sources of Drinking Water."* This policy specifies that, except under specifically defined circumstances, all surface water and groundwater of the state are to be protected as existing or potential sources of municipal and domestic supply, unless this beneficial use is explicitly excepted in a *Water Quality Control Plan*. The policy lists specific circumstances under which waters may be excluded from this beneficial use, including:

- waters with existing high total dissolved solids concentrations (greater than 3000 mg/l);
- waters having low sustainable yield (less than 200 gallons per day for a single well);
- water with contamination, unrelated to a specific pollution incident, that cannot reasonably be treated for domestic use;
- waters within particular wastewater conveyance and holding facilities; and
- regulated geothermal groundwaters.

These exceptions to the general municipal and domestic supply beneficial use designation are applied to specific water bodies through formal Basin Plan amendments by the appropriate Regional Water Board.

WATER QUALITY OBJECTIVES

The second component of California's water quality standards is water quality objectives. The Porter-Cologne Act defines "water quality objectives" as "the limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area." Since pollution is defined as an alteration of water quality to a degree which unreasonably affects beneficial uses, pollution is considered to occur whenever water quality objectives are exceeded.

Water quality objectives designed to protect beneficial uses and prevent nuisance are also found in the *Water Quality Control Plans*. As with beneficial uses, water quality objectives are established either for specific bodies of water, such as the Sacramento River between Shasta Dam and the Colusa Basin Drain, or for protection of particular beneficial uses of surface waters or groundwaters throughout a specific basin or region. In addition, the water quality criteria for toxic pollutants in the *California Toxics Rule* apply to nearly all of the state's surface waters which are not covered by the *Ocean Plan*, i.e., to inland surface waters, enclosed bays and estuaries. These limits are called "criteria" (rather than "objectives") because they were promulgated by USEPA pursuant to the federal Clean Water Act.

Water quality objectives may be stated in either numerical or narrative form. Where numerical objectives are listed in the *Water Quality Control Plans*, their values are enforceable numerical limits for the indicated constituent(s) or parameter(s). If not exceeded, they are intended to provide reasonable protection for beneficial uses of the specified body of water. However, in many cases, water quality objectives are stated in narrative form. Narrative objectives describe a requirement or a prohibition. Examples of narrative objectives, established in the Central Valley Region's *Water Quality Control Plan for the Sacramento River and San Joaquin River Basins*, include:

- Chemical Constituents —
  "Waters shall not contain chemical constituents in concentrations that adversely affect beneficial uses.
  "At a minimum, water designated for use as domestic or municipal supply (MUN) shall not contain concentrations of chemical constituents in excess of the maximum contaminant levels (MCLs) specified in … Title 22 of the California Code of Regulations [California's drinking water standards] …
  "To protect all beneficial uses, the Regional Water Board may apply limits more stringent than MCLs."
- Tastes and Odors —
  "Water shall not contain taste- or odor-producing substances in concentrations that impart undesirable tastes or odors to domestic or municipal water supplies or to fish flesh or other edible products of aquatic origin, or that cause nuisance, or otherwise adversely affect beneficial uses."
- Toxicity —
  "… waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life associated with designated beneficial use(s). This objective applies regardless of whether the toxicity is caused by a single substance or the interactive effects of multiple substances."

The Central Valley Region's Basin Plans also contain water quality objectives for the following constituents and parameters:

- Bacteria
- Biostimulatory Substances
- Color
- Dissolved Oxygen
- Floating Material
- Oil and Grease
- Pesticides
- pH
- Radioactivity
- Salinity
- Sediment
- Settleable Material
- Suspended Material
- Temperature
- Turbidity

Some are expressed as numerical objectives, while others are in narrative form. Narrative water quality objectives may be interpreted through the selection of numerical limits, as further described below.

ANTIDEGRADATION POLICY

Water is a multiple-use resource. That is, the same water may be used many times between where it falls as rain or snow in the mountains and where it eventually flows into the ocean. Each use of water causes some change or degradation in its quality. Water quality can also be degraded by discharges of waste and other human activities. The combined effect of multiple water uses and waste discharges on water quality must be considered. If the Board allows a single use or discharge to degrade water quality to a level just sufficient to protect beneficial uses, then no capacity exists for further degradation by succeeding water uses or other human activities. The ability to beneficially use the water has been impaired, even though water quality objectives have not been exceeded.

In addition, our understanding of the health and environmental effects of chemicals and combinations of chemicals in water is constantly evolving. What is considered safe at 10 ug/L (ppb) today may be found to be harmful at 1 ug/L tomorrow. For these reasons, it is often desirable to prevent or to minimize the degradation of water quality to preserve a higher quality than that which will just support the next beneficial use, that is, to preserve water quality better than applicable water quality objectives.

Realizing this need in 1968, the State Water Resources Control Board adopted Resolution No. 68-16, *Statement of Policy With Respect to Maintaining High Quality of Waters in California*. This established an

Antidegradation Policy for the protection of water quality in California. Under this policy, whenever the existing quality of water is better than that needed to protect existing and probable future beneficial uses, such existing high quality is to be maintained until or unless it has been demonstrated to the state that any change in water quality:

- will be consistent with the maximum benefit to the people of the state;
- will not unreasonably affect present or probable future beneficial uses of such water; and
- will not result in water quality less than prescribed in state policies.

Unless these three conditions are met, background water quality—the concentrations of substances in natural waters that are unaffected by waste management practices or contamination incidents—is to be maintained.

If the State or a Regional Water Board determines that some water quality degradation is in the best interest of the people of California, some incremental increase in constituent concentrations above background levels may be permitted under the Policy. However, in no case may such degradation cause unreasonable impairment of beneficial uses that have been designated for a water of the state.

The effect of this policy is to define a range of water quality—between natural background levels and the water quality objectives—that must be maintained. Within this range, the Water Boards must balance the need to protect existing high quality water with the benefit to California as a whole of allowing some degradation to occur from the discharge of waste.

The policy also specifies that discharges of waste to existing high quality waters are required to use "best practicable treatment or control," thereby imposing a technology-based limit on such discharges.

In more recent actions, the State Water Board further delineated implementation of the *Antidegradation Policy*. These include the adoption of monitoring and corrective action regulations and a cleanup policy.

CHAPTER 15, ARTICLE 5 REGULATIONS

In July 1991, the State Water Board adopted revised regulations for water quality monitoring and corrective action for waste management units—facilities where wastes are discharged to land for treatment, storage or disposal. These regulations, contained in Title 23 of the California Code of Regulations, Division 3, Chapter 15, Article 5, contain the only interpretation of the state's *Antidegradation Policy* that has been promulgated in regulations. Article 5 requires the Regional Water Board to establish water quality protection standards for all waste management units. Water quality protection standards include concentration limits for constituents of concern, which must be met in groundwater and surface water that could be affected by a release from the waste management unit.

Section 2550.4 of these regulations requires that, in most cases, concentration limits be established at background levels. However, in a corrective action program for a leaking waste management unit where the discharger of waste has demonstrated that it is technologically or economically infeasible to achieve background levels, the Regional Water Board may adopt concentration limits greater than background. The regulations require that these limits be set:

- at the lowest concentrations for the individual constituents which are technologically and economically achievable;
- so as not to exceed the maximum concentrations allowable under applicable statutes and regulations for individual constituents [including water quality objectives];
- so as not to result in excessive exposure to a sensitive biological receptor [as shown, for example, through health and ecological risk assessments]; and
- so that theoretical risks from chemicals associated with the release shall be considered additive across all media of exposure and shall be considered additive for those constituents that cause similar toxicologic effects or have carcinogenic effects.

CLEANUP POLICY

In June 1992, the State Water Board adopted Resolution No. 92-49, *Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304*. This policy for water quality control, which was modified in April 1994 and October 1996, states that the *Antidegradation Policy* of Resolution No. 68-16 is applicable to the cleanup of contaminated sites, and that criteria in Section 2550.4 of the Chapter 15 regulations are to be used to set cleanup levels for such sites. *[For cleanup of leaking underground fuel tank sites, Section 2550.4 criteria are to be considered in setting cleanup levels* *under Chapter 16 of Title 23, Division 3 of the California Code of Regulations.]* In determining cleanup levels for polluted water and for contaminated soils which threaten water quality, background constituent concentrations in water are the initial goal. If attainment of background concentrations is not achievable, cleanup levels must be set as close to background as technologically and economically feasible. They must, at a minimum, restore and protect all applicable beneficial uses of waters of the state, as measured by the water quality objectives, and must not present significant health or environmental risks.

Numerical Water Quality Limits

To determine whether a particular waste management activity or constituent release has caused or threatens to cause pollution—a degradation in water quality severe enough to impair present or probable future beneficial uses—one must refer to California's water quality standards. As described earlier, the standards consist of a beneficial use or uses of water and water quality objectives to protect those uses. According to the *Policy for Application of Water Quality Objectives* contained in the implementation chapter of both of the Central Valley Region's Basin Plans, narrative objectives must be interpreted and a numerical limit selected to implement the narrative objective. Once all beneficial uses, water quality objectives and numerical limits have been identified, those water quality limits that protect all applicable beneficial uses are selected for comparison with measured or projected constituent concentrations in the water body of interest. By such comparison, compliance with water quality standards may be determined.

The first step in selecting beneficial use protective water quality limits is to identify the bodies of groundwater and/or surface water that have been or have the potential to be affected by the particular waste management activity or constituent release. Under California's *Antidegradation Policy*, water quality limits are initially set equal to natural background levels in the body of water. Constituent concentrations in excess of these background levels in the water body, caused or threatened to be caused by a discharge of waste, indicate that water quality *degradation* has occurred or is threatened.

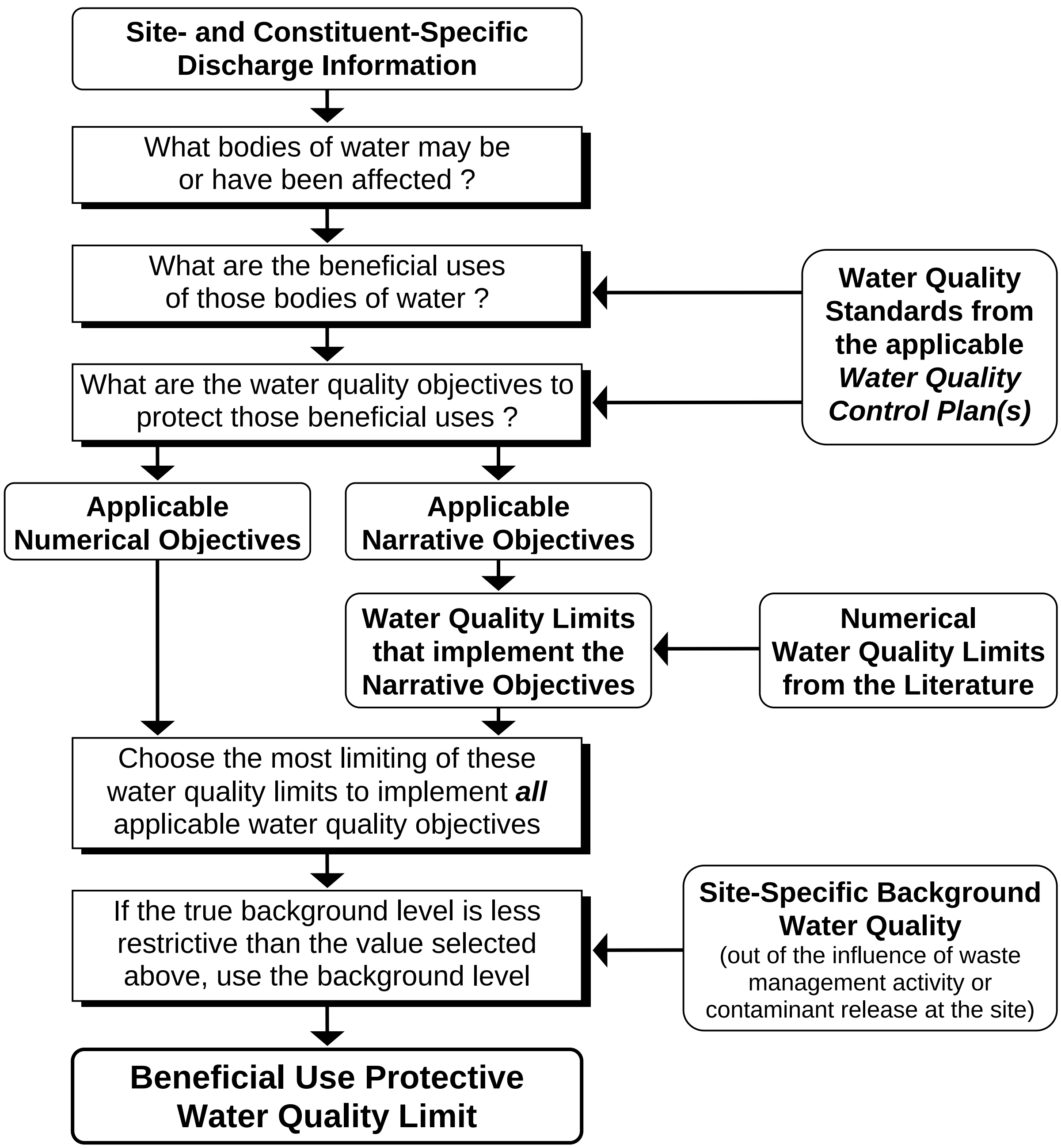
If degradation has already occurred, water quality limits should also be selected to determine whether *pollution* has occurred or is threatened. In this case, water quality limits are selected so as to ascertain compliance with all applicable water quality objectives for the protection of the beneficial uses designated for the water body in question. Designated beneficial uses and applicable water quality objectives to protect those uses are contained in the relevant *Water Quality Control Plan(s)*. The process of selecting beneficial use protective water quality limits to interpret these standards is shown in Figure 1.

Water quality objectives are numerical or narrative. The numerical objectives are a subset of the applicable beneficial use protective water quality limits. If narrative water quality objectives also apply to the constituent or parameter of interest in the water body, compliance with those objectives may be determined through measurement (e.g., toxicity testing) or other direct evidence of beneficial use impacts. Alternatively, relevant numerical water quality limits may be selected from the literature and used to interpret the narrative objectives. Water quality limits from the literature include drinking water standards, ambient water quality criteria, cancer risk estimates, health advisories, and other numerical values that represent concentrations of chemicals that would limit specific uses of water. An example of a water quality limit is the taste and odor threshold for ethylbenzene of 29 ug/L, published by USEPA. This water quality limit could be used to interpret compliance with the narrative water quality objective for Tastes and Odors, discussed above.

For each constituent, all applicable numerical objectives along with water quality limits selected to interpret each applicable narrative objective are collected. Then the most limiting (most stringent) of these values is selected. Below this most limiting value, compliance with all applicable water quality objectives is expected to occur and the most sensitive beneficial use should be protected. This most limiting value becomes the beneficial use protective water quality limit for the constituent of interest in the water body. If the concentration of the constituent exceeds the beneficial use protective water quality limit, one or more water quality objectives have been violated and pollution has occurred.

The one exception to this is where the site-specific natural background condition in water is a higher concentration than the beneficial use protective water quality limit. The State and Regional Water Boards authority for protection of water quality from waste discharges is limited to the regulation of “controllable water quality factors”—those actions, conditions, or circumstances resulting from human activities that may influence the quality of waters of the state and that may be reasonably controlled. Where the natural background level is higher than the beneficial use protective water quality limit, the natural background level is considered to be the applicable water quality objective. In such cases, other controllable factors are not allowed to cause any further degradation of water quality.

FIGURE 1. SELECTING BENEFICIAL USE PROTECTIVE WATER QUALITY LIMITS



TYPES OF WATER QUALITY LIMITS

The literature contains many useful water quality limits designed to protect specific beneficial uses of water. Some of these limits directly apply to constituents and parameters in California waters. If properly applied, the remaining limits may be used to interpret narrative water quality objectives. The following is a summary of available types of water quality limits that are presented in this document. The Reference section at the end of this report lists the sources of these limits, including internet addresses where available.

Drinking Water Standards, Maximum Contaminant Levels (MCLs)

MCLs are components of the drinking water standards adopted by the California Department of Health Services (DHS) pursuant to the California Safe Drinking Water Act. California MCLs may be found in Title 22 of the California Code of Regulations (CCR), Division 4, Chapter 15, *Domestic Water Quality and Monitoring*. USEPA also adopts MCLs under the federal Safe Drinking Water Act. DHS drinking water standards are required to be at least as stringent as those adopted by the USEPA. If USEPA adopts a federal MCL that is lower than the corresponding state MCL, the state is required by statute to revise its MCL to at least as low as the federal MCL. Some California MCLs are more stringent than USEPA MCLs.

Primary MCLs are derived from health-based criteria (by USEPA from MCL Goals; by DHS from Public Health Goals or from one-in-a-million [10^{-6}] incremental cancer risk estimates for carcinogens and threshold toxicity levels for non-carcinogens). MCLs also include technologic and economic considerations based on the feasibility of achieving and monitoring for these concentrations in drinking water supply systems and at the tap. It should be noted that the balancing of health effects with technologic and economic considerations in the derivation of MCLs may result in MCLs that are not fully health protective. As such, MCLs may not be appropriate for protection of the quality of raw surface water or groundwater resources, as will be discussed below.

Secondary MCLs are derived from human welfare considerations (e.g., taste, odor, laundry staining) in the same manner as Primary MCLs.

Drinking water MCLs are directly applicable to water supply systems and at the tap and are enforceable by DHS and local health departments. California MCLs, both Primary and Secondary, are directly applicable to groundwater and surface water resources when they are specifically referenced as water quality objectives in the pertinent *Water Quality Control Plan*. In such cases, MCLs become enforceable limits by the State and Regional Water Boards. When fully health protective, MCLs may also be used to interpret narrative water quality objectives prohibiting toxicity to humans in water designated as a source of drinking water (municipal and domestic supply) in the *Water Quality Control Plan*.

Maximum Contaminant Level Goals (MCL Goals or MCLGs)

MCL Goals are promulgated by USEPA as part of the National Primary Drinking Water Regulations. MCL Goals represent the first step in establishing federal Primary MCLs and are required by federal statute to be set at levels that represent no adverse health risks. They are set at “zero” for known and probable human carcinogens, since theoretically a single molecule of such a chemical could present some degree of cancer risk. Threshold levels posing no risk of health effects are used for non-carcinogens and for possible human carcinogens. Because they are purely health-based, non-zero MCL Goals may be useful to interpret narrative water quality objectives which prohibit toxicity to human consumers.

California Public Health Goals (PHGs)

The California Safe Drinking Water Act of 1996 requires the Cal/EPA, Office of Environmental Health Hazard Assessment (OEHHA) to perform risk assessments and to adopt Public Health Goals for contaminants in drinking water based exclusively on public health considerations. PHGs represent levels of contaminants in drinking water that would pose no significant health risk to individuals consuming the water on a daily basis over a lifetime. For carcinogens, PHGs are based on 10^{-6} incremental cancer risk estimates. OEHHA and DHS consider the 10^{-6} risk level to represent a *de minimis* level of cancer risk for involuntary exposure to contaminants in drinking water. For other contaminants, PHGs are based on threshold toxicity limits, with a margin of safety.

PHGs adopted by OEHHA are used by DHS to develop and revise primary drinking water MCLs. Where PHGs are to be based solely on scientific and public health considerations without regard to economic considerations, drinking water MCLs are to consider economic factors and technical feasibility. Each MCL adopted by DHS is to be set at a level that is as close as feasible to the corresponding PHG, placing emphasis on the protection of public health. Because they are purely health-based, PHGs are also appropriate to use in interpreting narrative toxicity objectives with respect to human exposures from constituents in water bodies that have been designated as existing or potential sources of municipal and domestic supply. In addition, where water quality objectives require compliance with drinking water MCLs, the PHGs may provide an indication of whether MCLs are likely to be revised in the future. The State and Regional Water Boards must protect both existing and future water uses.

California State Action Levels

Action levels are published by DHS for chemicals for which there is no drinking water MCL. State Action Levels are based mainly on health effects—an incremental cancer risk estimate of 10^{-6} for carcinogens and a threshold toxicity limit for other constituents. As with MCLs, the ability to quantify the amount of the constituent in a water sample using readily available analytical methods may cause action levels to be set at somewhat higher concentrations than purely health-based values. State Action Levels are advisory to water suppliers. If exceeded, DHS urges the supplier to correct the problem or to find an alternative raw water source. When they are purely health-based, State Action Levels may also be used to interpret narrative water quality objectives that prohibit toxicity to humans that beneficially use the water resource.

Cal/EPA Cancer Potency Factors

OEHHA has lead responsibility within Cal/EPA for the assessment of human health risks associated with exposures to toxic substances in environmental media. OEHHA also performs health risk assessments for California state agencies outside Cal/EPA, such as developing Public Health Goals for use by the Department of Health Services in deriving primary drinking water standards. OEHHA maintains an on-line database of health risk information for chemicals called the Cal/EPA Toxicity Criteria Database. The health based criteria presented in this database have been used as the basis for California state regulatory actions. The majority of these criteria has undergone peer review and in many cases rigorous regulatory review. The database includes cancer potency factors for inhalation and oral exposures to many chemicals. These Cal/EPA cancer potency factors may be used to calculate concentrations in drinking water associated with specific cancer risk levels, using standard exposure assumptions (see *Threshold Risk Characterization*, below.).

Integrated Risk Information System (IRIS)

The USEPA Office of Research and Development, National Center for Environmental Assessment maintains a chemical database called the Integrated Risk Information System. IRIS contains USEPA's most current information on human health effects that may result from exposure to toxic substances found in the environment. Two types of criteria are presented in IRIS. Reference doses (RfDs) are calculated as safe exposure levels for health effects other than cancer. They are presented in units of milligrams of chemical per kilogram body weight per day of exposure (mg/kg-day). RfDs may be converted into concentrations in drinking water (ug/L or ppb) using standard exposure assumptions (see *Threshold Risk Characterization*, below.). IRIS also presents concentrations of chemicals in drinking water that would be associated with specific levels of cancer risk.

Drinking Water Health Advisories and Water Quality Advisories

Health Advisories are published by USEPA for short-term (1-day exposure or less or 10-day exposure or less), long-term (7-year exposure or less), and lifetime human exposures through drinking water. Health advisories for non-carcinogens and for possible human carcinogens are calculated for chemicals where sufficient toxicologic data exist. Incremental cancer risk estimates for known and probable human carcinogens are also presented.

USEPA Water Quality Advisories contain human health related criteria that assume exposure through both drinking water and consumption of contaminated fish and shellfish harvested from the same water. Some Water Quality Advisories also contain criteria that are intended to be protective of aquatic life.

Suggested No-Adverse-Response Levels (SNARLs)

SNARLs are human health-based criteria that were published by the National Academy of Sciences (NAS) in the nine volumes of *Drinking Water and Health* (1977 to 1989). USEPA health advisories were also formerly published as "SNARLs." SNARLs do not reflect the cancer risk that may be posed by chemical exposure. Incremental cancer risk estimates for carcinogens are also presented in these NAS and USEPA documents. NAS criteria from *Drinking Water and Health* may not contain the most recent toxicologic information. They should only be used to interpret narrative water quality objectives where more recent health-based criteria are absent.

Proposition 65 Safe Harbor Levels

Safe harbor levels are established pursuant to the California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) for known human carcinogens and reproductive toxins. Proposition 65, an initiative statute, made it illegal to expose persons to significant amounts of these chemicals without prior notification or to discharge significant amounts of these chemicals to sources of drinking water. These "significant amounts" are adopted by the Office of Environmental Health Hazard Assessment in regulations contained in Title 22 of the California Code of Regulation, Division 2, Chapter 3. The intent of Proposition 65 was not to establish levels in water that are considered to be "safe."

For carcinogens, No Significant Risk Levels (NSRLs) are set at concentrations associated with a one-in-100,000 (10^{-5}) incremental risk of cancer. These are the only California health-based limits derived from risk levels greater than 10^{-6}. As such, they are not as protective of human health as many other published criteria (see *Which Cancer Risk Level?*, below). For reproductive toxicants, Maximum Allowable Dose Levels (MADLs) are set at $\frac{1}{1000}$ of the no-observable-effect level (NOEL).

Proposition 65 levels are doses, expressed in units of micrograms per day of exposure (ug/d). Dose levels may be converted into concentrations in water by assuming 2 liters per day water consumption and 100 percent exposure to the chemical through drinking water, under regulations contained in Title 22 of CCR, Sections 12721 and 12821.

California Toxics Rule (CTR) and National Toxics Rule (NTR) Criteria

The federal Clean Water Act requires all states to have enforceable numerical water quality criteria applicable to priority toxic pollutants in surface waters. California lacked many of these standards, in part due to the State Water Board's rescission of the *Inland Surface Waters Plan* and *Enclosed Bays and Estuaries Plan*, resulting from a legal challenge. In May 2000, USEPA promulgated water quality criteria for priority toxic pollutants for California's inland surface waters and enclosed bays and estuaries in federal regulations called the "California Toxics Rule." Included are criteria to protect both human health and aquatic life, similar to those published in the *National Ambient Water Quality Criteria*, discussed below.

The human health criteria are derived for drinking water sources (those designated in *Basin Plans* as municipal and domestic supply or MUN) considering exposure from consumption of both water and fish that had lived in the water. For waters that are not drinking water sources (non-MUN waters), human health criteria consider contaminated fish consumption only. Freshwater and saltwater aquatic life criteria are included for multiple averaging periods to protect against both acute and chronic toxicity.

The California Toxics Rule reiterated several criteria that USEPA had promulgated in December 1992 for California waters and those of other states in the National Toxics Rule (NTR).

The CTR criteria, along with the beneficial use designations in the *Basin Plans*, are directly applicable water quality standards for these toxic pollutants in these waters under Section 304(c) of the federal Clean Water Act. Implementation provisions for these standards may be found in the *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California* (SWRCB Resolution No. 2000-015), adopted by the State Water Board in March 2000. The policy includes time schedules for compliance, provisions for mixing zones, analytical methods and reporting levels.

California Ocean Plan Objectives

One of the statewide *Water Quality Control Plans* adopted by the State Water Resources Control Board, the *Water Quality Control Plan for Ocean Waters of California* (the *Ocean Plan*) includes numerical water quality objectives to protect both human health and marine aquatic life from potentially harmful constituents and parameters in marine waters of California. When combined with beneficial use designations, these objectives become directly applicable water quality standards pursuant to Section 304(c) of the federal Clean Water Act. Objectives to protect human health assume exposure through ingestion of fish that lived in water containing the constituent of concern. Marine aquatic life objectives are included for multiple averaging periods to protect against acute and chronic toxic effects.

National Ambient Water Quality Criteria

These criteria, also called the National Recommended Water Quality Criteria, are developed by USEPA under Section 304(a) of the federal Clean Water Act to provide guidance to the states in developing water quality standards under Section 304(c) of the Act and to interpret narrative toxicity standards (water quality objectives in California). These criteria are designed to protect human health and welfare and aquatic life from pollutants in freshwater and marine surface waters.

As with CTR and NTR criteria, discussed above, the human health protective criteria assume two different exposure scenarios. For waters that are sources of drinking water, exposure is assumed both from drinking the water and consuming aquatic organisms (fish and shellfish) that live in the water. For waters that are not sources of drinking water, exposure is assumed to be from the consumption of aquatic organisms only. Aquatic organisms are known to bioaccumulate certain toxic pollutants in their tissues, thereby magnifying human exposures. Because these human health based criteria assume exposure through fish and shellfish consumption, they should not be used to interpret water quality objectives for groundwater where human exposure would only occur from municipal and domestic supply uses. The criteria also include threshold health protective criteria for non-carcinogens. Incremental cancer risk estimates for carcinogens are presented at a variety of risk levels. Organoleptic (taste- and odor-based) levels are also provided for some chemicals to protect human welfare. Some organoleptic criteria are based on adverse taste or odor of chemicals in water, while others are based on the tainting of the flesh of fish and shellfish from chemicals in ambient water.

As with CTR and NTR criteria, National Ambient Water Quality Criteria also include criteria that are intended to protect freshwater and saltwater aquatic life. Normally, two types of limits are presented for each. Criteria Maximum Concentrations (CMCs) protect aquatic organisms from short-term or acute exposures (expressed as 1-hour average or instantaneous maximum concentrations) to pollutants. Criteria Continuous Concentrations (CCCs) are intended to protect aquatic organisms from long-term or chronic exposures (expressed as 4-day or 24-hour average concentrations). To be able to derive recommended criteria, the USEPA method requires toxicity data for species representing a minimum of eight families of organisms, including both vertebrate and invertebrate species. Important aquatic plant species are also considered. Fundamental to the method is protection of all species, even at sensitive life stages, for which there are reliable measurements in the data set. Criteria derived by this method are also intended to protect species for which those in the data set serve as surrogates. Toxicity information, in the form of lowest observed effect levels, is often presented in the USEPA criteria documents where there is insufficient toxicologic information with which to develop recommended criteria.

The National Ambient Water Quality Criteria are found in a number of USEPA documents:

- *Quality Criteria for Water, 1986*, with updates in 1986 and 1987, also known as the “Gold Book”;
- *Ambient Water Quality Criteria* volumes on specific pollutants or classes of pollutants (various dates beginning in 1980);
- *Quality Criteria for Water* (1976), also known as the “Red Book”;
- *Water Quality Criteria, 1972*, also known as the “Blue Book.”

In December 1992, USEPA promulgated the *National Toxics Rule*, which updated many of these criteria and made them directly applicable standards for surface waters in many states, including some

California waters. These regulations, found in 40 CFR Section 131.36, specify that “[t]he human health criteria shall be applied at the State-adopted 10^{-6} risk level” for California. To ascertain compliance with the aquatic life protective criteria for metallic constituents, water quality samples were to be analyzed for “total recoverable” concentrations. In May 1995, USEPA amended these regulations to convert most of these aquatic life criteria to dissolved concentrations.

In April 1999 and November 2002, USEPA published tables of *National Recommended Water Quality Criteria*, which summarize criteria from the sources discussed above and more recent updates. Due to their age and changes in methods used to derive the criteria, Blue Book criteria no longer appear in these summary tables. USEPA may no longer support their use.

Agricultural Water Quality Limits

Water Quality for Agriculture, published by the Food and Agriculture Organization of the United Nations in 1985, contains limits protective of various agricultural uses of water, including irrigation of various types of crops and stock watering. Above these limits, specific agricultural uses of water may be adversely affected. These limits may be used to translate narrative water quality objectives that prohibit chemical constituents in concentrations that would impair agricultural uses of water.

Taste and Odor Thresholds

Consumers of water do not want to drink water that tastes or smells bad. Therefore, water that contains substances in concentrations that cause adverse tastes or odors may be considered to be impaired with respect to beneficial uses associated with drinking water use (municipal or domestic supply). Adverse tastes and odors may also be associated with nuisance conditions. Taste and odor thresholds are used to translate narrative water quality objectives that prohibit adverse tastes and odors in waters of the State and prohibit nuisance conditions. Taste and odor thresholds form the basis for many secondary drinking water Maximum Contaminant Levels (MCLs) and are also published by the U.S. Environmental Protection Agency in the National Ambient Water Quality Criteria and Drinking Water Contaminant Fact Sheets. An extensive collection of odor thresholds was published by J.E. Amoore and E. Hautala in the Journal of Applied Toxicology (1983).

Other Numerical Limits

Other sources of numerical water quality limits include:

- *Hazard Assessments* and *Water Quality Criteria*, published by the California Department of Fish and Game, which contain criteria that are protective of aquatic life from exposure to several pesticides. CDFG uses the same methods employed by USEPA to derive the National Ambient Water Quality Criteria for freshwater and saltwater aquatic life protection, discussed above. CDFG may modify the data requirements of the USEPA methods, depending on data availability.
- *Water Quality Criteria, Second Edition*, written by McKee and Wolf and published by the State Water Resources Control Board in 1963 and 1978, which contains criteria for human health and welfare, aquatic life, agricultural use, industrial use, and various other beneficial uses of water. This document is available from the National Technical Information Service (NTIS; 1-800-553-6847) as Publication No. PB 82188244.

The numerical water quality limits discussed above are summarized in the tables and graphs that make up the remainder of this report.

Risk Characterization Methods for Drinking Water

The methods by which the USEPA and other agencies derive lifetime health advisories and concentration-based cancer risk estimates for constituents in drinking water may be used to calculate water quality limits from other published toxicologic criteria. These methods are based on the following toxicologic principles.

Threshold Toxins vs. Non-Threshold Toxins

Relationships between exposure to toxic chemicals and resulting health effects may be roughly divided into two categories, threshold and non-threshold. It is important to recognize that it is not the chemical itself, but the dose (the concentration of the chemical multiplied by the duration of exposure), that is responsible for the toxic effect. Below a particular threshold dose, many chemicals cause no toxic effects. These chemicals are called threshold toxins. Cyanide, mercury, and the pesticide malathion fall into this category. Some threshold chemicals, like Vitamin A, are beneficial to human health at low doses, but toxic at high doses.

On the other hand, some chemicals have no toxicity threshold; they may pose some degree of health risk at any concentration. Most carcinogens are thought to fall into this non-threshold category. Essentially, exposure to one molecule is considered to have the potential to cause some finite risk of getting cancer. Health risks for non-threshold toxins are characterized by probabilities. The higher the dose, the higher the probability of experiencing the toxic effect. For example, according to OEHHA, 0.15 microgram of benzene per liter of drinking water is associated with the probability of causing one additional cancer case in a million persons who are exposed through in-home use of this water over their lifetimes. The value of 0.15 ug/L is the estimated drinking water concentration associated with a 1-in-a-million (10^{-6}) incremental cancer risk, also known as the 10^{-6} cancer risk estimate for benzene. Because cancer risk is a probabilistic event, the level of cancer risk is directly proportional to the dose, or the concentration in water if all other factors are held constant. Therefore, the 10^{-5} cancer risk level (1 extra case of cancer in 100,000 exposed persons) for benzene would be 1.5 ug/L.

USEPA has assigned chemicals into five categories, by considering the weight of cancer risk evidence that exists in the toxicologic record:

Class A chemicals are known human carcinogens (there is sufficient evidence relating human exposure to cancer);

Class B chemicals are probable human carcinogens (limited human evidence, but sufficient animal evidence);

Class C chemicals are possible human carcinogens (no human evidence and limited animal evidence);

Class D chemicals have insufficient cancer risk data to assign them to another category; and

Class E chemicals have sufficient evidence to indicate that they are not carcinogens.

Because toxicologic experiments can not be carried out on humans, very few chemicals fall into Class A. Epidemiologic evidence from industrial and accidental human exposures are used to place chemicals in this category. Arsenic, benzene, vinyl chloride and radioactive substances are examples of Class A carcinogens. Unlike experimental animal studies, there is no need to extrapolate the evidence linking chemical exposure and cancer risk to humans. So the highest degree of association between chemical exposure and human cancer risk exists for chemicals in this class.

USEPA publishes cancer risk estimates for Class A, Class B, and sometimes for Class C chemicals. They publish threshold health advisories for lifetime exposure for Class C, Class D and Class E chemicals.

Because of the different ways in which chemicals are believed to cause adverse health impacts, the characterization of health risks for non-threshold toxins is different from that for threshold toxins.

Non-Threshold Risk Characterization

For non-threshold chemicals, including most carcinogens, the *risk* of a toxic effect is considered to be proportional to the amount or *dose* of the chemical to which a population is exposed. For each carcinogen, risk and dose are related by a cancer potency or slope factor (often abbreviated q_1*) which is equal to the risk of getting cancer per unit dose of the chemical. The potency factor is expressed in units of inverse milligrams of chemical per kilogram body weight per day of exposure $(mg/kg/day)^{-1}$. The cancer risk level, dose, and cancer potency factor are related by equation [1] in Figure 2. Potency factors for carcinogens are calculated by extrapolation from dose-response relationships often developed in laboratory animal exposure studies. For a few chemicals, they are based on human epidemiologic data. Potency factors may be found in the Cal/EPA Toxicity Criteria Database maintained by OEHHA, the USEPA Integrated Risk Information System (IRIS) database, USEPA health advisory documents, and the Drinking Water and Health publications of the National Academy of Sciences (NAS).

If one assumes a drinking water consumption rate of 2 liters per day and an average human body weight of 70 kg, dose and concentration in drinking water may be related by equation [2]. These are standard assumptions used by federal and state drinking water regulatory and advisory programs and by OEHHA in regulations that implement Proposition 65. By combining equations [1] and [2] and rearranging, we obtain equation [3]. This equation allows calculation of a concentration in drinking water associated with a given cancer risk level, if the potency factor is known.

FIGURE 2. CALCULATION OF HEALTH BASED LIMITS

[1] Risk Level = Dose $\times$ Potency Factor

[2] Dose (mg/kg/day) = Concentration (mg/l) $\times$ 2 liters/day $\div$ 70 kg

[3] $$\text{Concentration (mg/l)} = \frac{\text{Risk Level} \times 70 \text{ kg}}{\text{Potency Factor} \times 2 \text{ liters/day}}$$

[4] $$\text{RfD} = \frac{\text{NOAEL}}{\text{Uncertainty Factor}}$$

[5] $$\text{DWEL} = \frac{\text{RfD} \times 70 \text{ kg}}{2 \text{ liters/day}}$$

[6] $$\text{Lifetime Health Advisory (mg/l)} = \frac{\text{DWEL} \times 20\% \text{ RSC}}{\text{Additional Uncertainty Factor}}$$

For example, the Cal/EPA cancer potency factor for the pesticide 1,2-dibromo-3-chloropropane or DBCP is 7 $(\text{mg/kg/day})^{-1}$. Using equation [3], the concentration in drinking water associated with a 1-in-a-million (10^{-6}) lifetime cancer risk level may be calculated as 0.000005 mg/l or 0.005 ug/L. This 10^{-6} cancer risk estimate along with other similarly calculated cancer risk estimates for other chemicals may be found in the tables of this report.

Volatile chemicals in water may cause exposures other than through direct water ingestion. Use of water in the home can volatilize these chemicals into indoor air which people breathe. Bathing with contaminated water may cause chemical exposure through skin absorption. In recent years, OEHHA has accounted for these added exposures to volatile carcinogens in drinking water in the derivation of Public Health Goals. Assuming greater exposure means that a lower concentration in water is associated with the same level of cancer risk. For example, if exposure to the solvent trichloroethylene (TCE) is assumed only to occur through ingestion of contaminated water, the concentration associated with the 1-in-a-million lifetime cancer risk is 2.3 ug/L, according to OEHHA. If vapor inhalation and dermal exposure are also assumed to occur, the 1-in-a-million risk level drops to 0.8 ug/L. For this reason, Public Health Goals are often lower than cancer risk levels from other sources.

Which Cancer Risk Level?

There is often confusion about which cancer risk level to use in selecting human health-based water quality limits. The one-in-a-million (10^{-6}) incremental cancer risk level has historically formed the basis of human health protective numerical water quality limits in California. It is generally recognized by California and federal agencies as the *de minimis* or negligible level of risk associated with involuntary exposure to toxic chemicals in environmental media.

The 10^{-6} risk level has long formed the basis of water-related health-protective regulatory decision-making in California. The following are some of the more significant instances:

- DHS *Statement of Reasons* documents that justify Primary MCL regulations for carcinogenic substances use the 10^{-6} risk level for lifetime exposure as the basis from which the MCLs were derived. In these documents DHS describes the 10^{-6} risk level as "the *de minimis* excess cancer risk value" which is "typically assumed by federal and state regulatory agencies for involuntary exposures to environmental pollutants." MCLs for carcinogens deviate from the 10^{-6} risk level only where technologic or economic factors prevent the use of this level.
- DHS State Action Levels for drinking water are also set at the 10^{-6} risk level unless technologic or economic factors prevent using that level, as with the Primary MCLs.
- The *Preliminary Endangerment Assessment Guidance Manual* published by the Department of Toxic Substances Control (DTSC) [page 2-26] states that "[i]n general, a risk estimation greater that [sic] 10^{-6} or a hazard index greater than 1 indicate the presence of contamination which may

pose a significant threat to human health."

- Clean Water Act water quality criteria promulgated for California waters by USEPA in the National Toxics Rule and the California Toxics Rule state that "[t]he human health criteria shall be applied at the State-adopted 10^{-6} risk level." These criteria, when combined with beneficial use designations in state *Water Quality Control Plans* are water quality standards for California's inland and estuarine surface waters.
- *Functional Equivalent Documents* adopted by the State Water Board that provide background and justification for the *California Ocean Plan* and the former *California Inland Surface Waters* and *Enclosed Bays and Estuaries Plans* cite the 10^{-6} risk level as the basis of human health protective water quality objectives for carcinogens.
- Public Health Goals for drinking water, adopted by OEHHA, are based on the 10^{-6} risk level for carcinogens, "a level that has been considered negligible or *de minimis*," and a 70-year exposure period.
- In enforcement decisions regarding an off-site chlorinated solvent plume from Mather Air Force Base, the Central Valley Regional Water Quality Control Board required that replacement water supply be provided when the level of carcinogenic chemicals is detected and confirmed at or above concentrations that represent 10^{-6} lifetime cancer risk levels in individual wells. This decision implements the narrative toxicity objective for groundwater from the *Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins*.
- Cleanup and Abatement Order No. 92-707 adopted by the Central Valley Regional Water Quality Control Board established cleanup levels for groundwater at the Southern Pacific Transportation Company, Tracy Yard, San Joaquin County at the 10^{-6} lifetime cancer risk levels for carcinogens, based on the narrative toxicity objective for groundwater from the *Basin Plan for the Sacramento River and San Joaquin River Basins*.

For consistency, the 10^{-6} risk level should govern the selection of human health-based limits to interpret narrative toxicity objectives.

Regulations implementing Proposition 65 cite the one-in-a-hundred-thousand (10^{-5}) risk level for carcinogens. However, the intent of this initiative statute is public notice prior to exposure to certain chemicals and the prohibition of specific discharges of these chemicals. It is not the intent of Proposition 65 to establish levels of involuntary environmental exposure that are considered "safe." Therefore, Proposition 65 does not provide a relevant precedent for determining the level of cancer risk for compliance with the narrative toxicity objectives.

Threshold Risk Characterization

To determine the concentration of a threshold toxin that is safe for humans to consume in drinking water, toxic and safe dose information is first derived from animal studies or, if available, epidemiologic studies. In the laboratory studies, animals are exposed to a chemical at specific dose levels. For epidemiologic studies, measured or estimated human exposures are divided into various dose levels. USEPA and other agencies choose one of two dose level results from these studies from which to calculate safe levels for humans in drinking water. The no observed adverse effect level (NOAEL) is the highest dose that caused no toxic effect in the study. The lowest observed adverse effect level (LOAEL) is the lowest dose that did cause a measurable toxic effect. The LOAEL is a higher dose than the NOAEL. Because the toxic dose of a chemical is usually related to the body weight of the animal or human studied, doses are often reported in units of milligrams of chemical per kilogram of body weight per day of exposure (mg/kg/day or mg/kg-day). Both NOAELs and LOAELs are expressed in these units.

USEPA and other agencies use the NOAEL or LOAEL to calculate a reference dose or RfD for a toxic chemical, using equation [4] in Figure 2. The uncertainty factor in the equation accounts for unknowns in the extrapolation of study data into "safe" levels for human exposure. The minimum uncertainty factor is 10, which accounts for the fact that some people (e.g., children, the elderly, those with compromised immune systems) are more sensitive to toxic chemicals than the average person. The minimum uncertainty factor is normally multiplied by additional factors of 3 to 10 for each of the following conditions, if they apply:

- Extrapolation from animal toxicity studies to human toxicity (not used with human exposure data);

- Using a LOAEL in place of a NOAEL in equation [4], above;
- Using a dose (NOAEL or LOAEL) from a study which examined a less appropriate route of exposure to the chemical (the route of exposure most relevant to drinking water is ingestion);
- Using a dose from a study which exposed test animals for a period of time that is not a significant fraction of the animals' lifetime (subchronic exposure);
- Potential synergism among chemicals (the toxicity of two or more chemicals is greater than additive —the sum of their individual toxicities); and
- Any other toxicologic data gaps.

RfDs have the same units as the NOAELs and LOAELs from which they are derived, mg/kg/day. The USEPA IRIS database contains reference doses for many threshold toxins.

The next step, equation [5], is the calculation of a drinking water equivalent level (DWEL) from the reference dose. This step is derived from equation [2] by assuming an average human body weight of 70 kilograms and an average drinking water consumption rate of two liters per day. As with the calculation of cancer risk criteria in water, these are standard assumptions used by federal and state drinking water regulatory and advisory programs.

One last step, equation [6] in Figure 2, is required to turn the DWEL into the equivalent of a lifetime health advisory concentration. Two additional factors are used. The first is the relative source contribution or RSC. It accounts for the fact that people are usually exposed to chemicals from sources other than drinking water (e.g., in foods and in the air we breathe). The combined exposure from all sources forms the overall dose that may cause toxicity. The default relative source contribution normally used by USEPA in deriving lifetime health advisories for threshold constituents is 20%. This means that 20% of the exposure is assumed to come from drinking water and 80% from all other sources combined. Information on chemical exposure to specific chemicals through other media may cause a RSC to be used that is different than the default value. State Action Levels from DHS may differ from health based limits published by USEPA, due to differing assumptions about relative source contribution.

The second factor in equation [6] is an additional uncertainty factor, used to provide an extra margin of safety for those chemicals for which limited evidence of cancer risk exists (Class C carcinogens). This uncertainty factor is equal to 10 for Class C carcinogens, and 1 for chemicals in Classes D and E. Lifetime health advisories are usually not calculated for chemicals in cancer Classes A and B. Cancer risk estimates are calculated instead.

With equations [5] and [6], one can calculate health protective water quality limits for threshold toxins from RfD values published in the IRIS database and elsewhere in the literature. For example, acetone is a Class D chemical (no evidence of cancer risk) with an RfD of 0.10 mg/kg/day in IRIS. From equation [5], a DWEL of 3.5 mg/l may be calculated. By equation [6], this DWEL may be converted into an expected lifetime-exposure safe limit in drinking water of 0.7 mg/l or 700 ug/L. This and other similarly calculated limits are presented in the tables of this report.

Selecting From Among Available Numerical Limits

To protect all designated beneficial uses of water, the most protective (lowest), appropriate (to implement the water quality objectives in the *Water Quality Control Plans*) limit should be selected as the beneficial use protective water quality limit for a particular water body and constituent. Due to the rapid evolution of data on the health and environmental effects of chemicals, caution should be observed in selecting from among the various water quality limits to be sure that the most current limits are used. The original literature should be consulted whenever possible to determine the appropriateness and limitations of the water quality limits being considered. Other government agencies, such as the California Department of Health Services, the California Department of Fish and Game, the Office of Environmental Health Hazard Assessment, and the U.S. Environmental Protection Agency may be consulted for up-to-date information.

In some cases, multiple human health-based limits are available for a particular chemical. A decision must be made as to which of these limits is the most appropriate to implement narrative toxicity objectives to protect human health. In May of 1994, representatives of the State Water Board and the Central Valley Regional Water Board met with toxicologists and other representatives of DTSC and OEHHA to discuss the use of toxicologic criteria in contaminated site assessment and cleanup. The group agreed to use guidance parallel to that given on page 2-20 of DTSC's *Preliminary Endangerment Assessment Guidance Manual* (January 1994). When selecting numerical limits from the literature to interpret health-based narrative water quality objectives or when selecting criteria for use in health risk assessments, limits should be used in the following hierarchy:

(1) Cancer potency slope factors and reference doses promulgated into California regulations.

(2) Cancer potency slope factors and reference doses used to develop environmental criteria promulgated into California regulations. The entirely health-based dose criteria should be used, and not necessarily the resulting risk management environmental concentration criteria (e.g., the RfD rather than the MCL).

(3) Cancer potency slope factors and reference doses from USEPA's Integrated Risk Information System (IRIS).

(4) Cancer potency slope factors or reference doses from USEPA's Health Effects Assessment Summary Tables (Health Advisories), the most current edition.

Limits in the first two categories may be found in the Cal/EPA Toxicity Criteria Database maintained by OEHHA.

MCLs May Not Protect Water Resources

It has been common practice to rely on Primary MCLs as "enforceable standards" for human health protection from chemicals in water. However, MCLs are designed to apply to water within a drinking water distribution system and at the tap. Care should be taken when relying on Primary MCLs to implement water quality objectives that protect sources of drinking water (groundwater or surface water resources).

A common example of incorrect MCL application is the use of the total trihalomethane (THM) MCL to protect groundwater quality from chloroform, bromoform, bromodichloromethane and dibromochloromethane, the four chemicals covered by the term "trihalomethanes." These probable and possible human carcinogens are formed in drinking water by the action of chlorine, used for disinfection, on organic matter present in the raw source water. The total THM federal Primary MCL of 80 ug/L is 19 to 296 times higher than one-in-a-million incremental cancer risk estimates for the individual chemicals published by OEHHA and USEPA. USEPA has stated that the MCL for total THMs was based mainly on technologic and economic considerations. Therefore, this drinking water standard is not fully health protective. It does not clearly implement the language of the narrative water quality objective for toxicity that prohibits toxic substances in toxic amounts.

Most municipal drinking water systems chlorinate their water to remove pathogens, such as bacteria and viruses. The MCL for total THMs was derived by balancing the benefit provided by the chlorination process—elimination of pathogens in drinking water—with the health threat posed by the trihalomethane by-products of this process. The cost associated with converting to non-chlorine disinfection methods was also considered. In the case of groundwater protection, this type of cost/benefit balancing—accepting some cancer risk from chloroform and other THMs in order to eliminate the health risk from pathogens and avoid disinfection process conversion costs—is not germane. The water has not been and may not need to be chlorinated to allow domestic consumption. Therefore, the total THM MCL is not sufficiently protective of the ambient quality of domestic water supply sources.

To ensure that drinking water system compliance can be ascertained, MCLs are required to be set at or above commonly achievable analytical quantitation limits. In several cases, DHS and USEPA have established MCLs at concentrations higher than health protective levels, where the health-based levels are below readily available analytical quantitation limits. It is clear from the *Statement of Reasons* documents for California drinking water regulations that the intent of DHS was to adopt one-in-a-million cancer risk values as MCLs for several chlorinated solvents (e.g., TCE, carbon tetrachloride) if analytical quantitation limits had been lower. Since the adoption of these MCLs, analytical quantitation limits have improved. The health-based levels for these chemicals can be reliably measured at reasonable cost. The technologic constraint posed by the older analytical quantitation limits is no longer germane. Therefore, it is no longer reasonable to rely on outdated analytical quantitation limits as substitutes for truly health-based criteria when interpreting the narrative water quality objective for toxicity.

In several cases, Public Health Goals adopted by OEHHA are more stringent than existing Primary MCLs. The intent of the legislation that mandated adoption of PHGs is to inform DHS when California MCLs are less than fully health-protective. The legislation requires DHS to periodically review the MCLs and revise them to be as close to PHG values as is technologically and economically achievable. So, compliance with health-based PHGs in ambient sources of drinking water not only prevents toxic amounts of chemicals, but also addresses compliance with probable future MCLs. This may be appropriate for protection of water resources for existing and future municipal and domestic supply uses.

MCLs are only a subset of the water quality objectives applicable to sources of municipal and domestic supply under most *Basin Plans*. Narrative objectives related to toxicity and general beneficial use protection from chemical constituents are also applicable to these waters under most *Basin Plans*. Due to the constraints discussed above, MCLs that are not fully health protective are not appropriate water quality limits to interpret these objectives. Purely health-based limits, such as one-in-a-million incremental cancer risk estimates and Public Health Goals, are appropriate to interpret these narrative objectives. They are more accurate measures of potential impairment by toxic chemicals of the beneficial use of groundwater and surface water for municipal and domestic supply.

Virtually all Primary MCLs are derived by balancing health effects information with the technologic and economic considerations involved in providing that water to customers through conventional drinking water supply systems. Thus, Primary MCLs are not always reliable indicators of the protection of beneficial uses of ambient groundwaters or surface waters. They may not be appropriate water quality limits to interpret narrative water quality objectives designed to prevent human toxicity or generally protect beneficial uses from chemical constituents.

There are additional instances where water quality limits more stringent than MCLs are applied to protect all of the beneficial uses of a water resource. For example, the Regional Water Boards require surface waters to comply with aquatic life protective criteria for metals where these criteria are more stringent than MCLs. Agricultural use protective limits for several constituents and parameters, including chloride and total dissolved solids, are more stringent than MCLs, indicating that sensitive agricultural use may be impaired at concentrations lower than MCLs. Several chemicals cause water to taste or smell bad at concentrations far lower than MCLs. The following are taste and odor thresholds and primary MCLs (in ug/L) for three common gasoline constituents:

	Taste & Odor Threshold	***Primary MCL***
Ethylbenzene	29	300
Toluene	42	150
Xylene(s)	17	1750

It is clear that water will be rendered unpalatable and beneficial uses will be impaired at concentrations of these chemicals that are significantly below MCLs. The taste and odor thresholds, used to implement narrative water quality objectives for taste and odor, would prevent such impairment.

Again, even though the MCL may be an applicable water quality objective for these waters, it may not be the most stringent water quality objective. Compliance with the MCL will not ensure compliance with all applicable water quality objectives. As such, MCLs may not be sufficiently protective of the most sensitive beneficial use.

As discussed above, the state's *Antidegradation Policy* requires water quality limits to be set below beneficial use protective concentrations, toward or equal to background levels, where feasible.

WATER QUALITY LIMIT SELECTION ALGORITHMS

The above discussion shows how numerical limits may be used to translate narrative water quality objectives into beneficial use protective water quality limits for surface water and groundwater. *[This report does not provide guidance on effluent limits, which are derived from water quality-based and technology-based considerations using discharge-specific factors and according to applicable regulations and policies.]* It is important that the selected limits fully implement all applicable water quality objectives and are defensible.

To increase consistency in the selection of water quality limits, this report recommends the use of default rules or algorithms for selecting numerical limits to comply with water quality objectives and promulgated water quality criteria. These algorithms are based on a few guiding principles designed to support the selection of appropriate water quality-based limits. Other policies and regulations, such as the *Antidegradation Policy*, the Site Assessment and Cleanup Policy, and NPDES regulations require that technology-based limits and background levels also be considered in determining the final water quality limits appropriate for a particular situation.

Guiding Principles

The following principles and steps guide the derivation of the recommended algorithms that follow. ***To be defensible, water quality limits should be chosen so as to implement all applicable water quality objectives and promulgated water quality criteria.*** For each constituent of concern, the process involves three steps:

(1) Select a single numerical limit to satisfy each water quality objective or relevant portion thereof.
(2) To satisfy all applicable objectives, select the lowest of the numerical limits from step (1).
(3) To account for the *Controllable Factors Policy*, discussed below, select the larger of
  (a) the numerical limit chosen in step (2) or
  (b) the natural background level of the constituent.

As an example of "portions" of an objective in step (1), compliance with the narrative toxicity objective for surface water normally involves selection of one limit to protect aquatic life and another limit to protect human health. *[Note: For the National Pollutant Discharge Elimination System (NPDES) program and for other situations where it is not clear that background conditions represent true "natural background," (i.e., not influenced by controllable water quality factors), the limit chosen in step (2) should be imposed even where background levels are less stringent. According to the SWRCB "Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California," the CTR or NTR criterion becomes the effluent limit in such cases.]*

The above steps should provide a numerical limit which, if equaled or exceeded in ambient water, indicates that pollution has occurred. This is the least stringent limit below which ambient water would be in compliance with applicable water quality standards, beneficial use designations plus water quality objectives or promulgated criteria to protect such uses. Antidegradation principles may require that more stringent limits be applied to ambient water quality, where the natural background level was not selected in step (3) above.

In step (1), especially with respect to toxicity information, ***there should normally be a preference for:***

- ***Purely risk-based limits*** over risk-management based limits, unless the water quality objective mandates the use of a risk-management based limit (e.g., the Chemical Constituent objectives mandates compliance, at a minimum, with California Primary and Secondary drinking water MCLs). Purely risk based limits are based only on the health risk or other risk to beneficial uses. Risk-management based limits include economic and/or technologic factors that may not be relevant to protecting beneficial uses of ambient water resources and may not comply with the language of narrative water quality objectives, as discussed above with respect to MCLs.
- ***Limits developed and/or published by California agencies***, over those developed by federal agencies or other organizations, to provide consistency within state government.
- ***Limits that reflect peer reviewed science***. Avoid using draft or provisional limits, unless nothing else is available.
- ***Limits that reflect current science*** (e.g., Public Health Goals are normally more recent than IRIS criteria, which are normally more recent than USEPA health advisories).

These principles are consistent with the manner in which DTSC and OEHHA select toxicity-based criteria for health risk evaluations.

Avoid using Proposition 65 limits to interpret narrative toxicity objectives. As discussed above, the intent of Proposition 65 is not to designate "safe" levels of chemicals in drinking water. Proposition 65 limits are in conflict with other health-based limits for drinking water in California (i.e., PHGs, other health-based criteria from which MCLs are derived, and CTR and NTR criteria to protect human health).

The above principles may be used to generate algorithms to help select the most applicable or relevant and appropriate water quality numerical limits. Because water quality standards for groundwater and surface water differ significantly, separate algorithms are presented below.

An Algorithm for Groundwater

For chemicals in groundwater, the following water quality objectives and numerical limits normally apply to the receiving water:

- ❖ Chemical Constituents Objective —
  each of the following three items apply separately
  - ➢ Drinking Water MCLs —
    select the lowest of the following
    - ▪ California Primary MCL
    - ▪ California Secondary MCL
  - ➢ Numerical water quality objective from the *Water Quality Control Plan*
  - ➢ Concentrations that indicate impairment of any designated beneficial use —
    select the lowest of the following
    - ▪ Agricultural use protective limit
    - ▪ Federal Primary MCL, if lower than California Primary MCL
      [Note: Statute requires that the California MCL will be lowered to at least as low as the Federal MCL. Compliance with the lower Federal MCL is needed to protect the MUN beneficial use in the long term.]
- ❖ Toxicity Objective
  - ➢ Human health-risk based limits for drinking water use —
    normally in the following hierarchy
    - ▪ OEHHA Public Health Goal
    - ▪ Cal/EPA cancer potency factor at the one-in-a-million risk level
      [Note: For volatile carcinogens, this limit is likely to be less stringent and less relevant to translating the toxicity objective than the Public Health Goal because it considers only ingestion exposure. PHGs consider ingestion, vapor inhalation and skin adsorption exposures that are likely to occur from the use of drinking water in the household.]
    - ▪ California Drinking Water Action Level based on toxicity
    - ▪ USEPA IRIS criteria —
      select the lowest of the following
      - • one-in-a-million cancer risk estimate
      - • reference dose for non-cancer toxicity
    - ▪ USEPA Health Advisory —
      select the lowest of the following
      - • one-in-a-million cancer risk estimate
      - • lifetime non-cancer limit
    - ▪ USEPA MCL Goals —
      non-zero values only
      [MCL Goals for carcinogens are set at "zero" to represent no health risk. No significant risk is used for PHGs.]
    - ▪ Other health-risk based limits —
      check dates and basis before using these
      - • National Academy of Sciences criteria
        select the lowest of
        - ♦ one-in-a-million incremental cancer risk estimate
        - ♦ drinking water health advisory
      - • Proposition 65 levels —
        use only if no other health risk-based limits are available
- ❖ Tastes and Odors Objective
  - ➢ Taste- and odor-based limits —
    normally in the following hierarchy
    - ▪ California Secondary MCL
    - ▪ Federal Secondary MCL
    - ▪ USEPA National Ambient Water Quality Criterion based on taste & odor —
      Do not use if limit is based on tainting of fish flesh.
    - ▪ Taste and odor thresholds published by other agencies or from the peer reviewed literature

First, select one limit for each of the items above that begins with an arrow (➢). Record your selections in a table, such as the one shown in Figure 3.

Second, select the limit with the lowest concentration. The result should be a limit that satisfies all applicable water quality objectives. *Consideration of natural background levels and antidegradation may require further modifications to this selection, as discussed below.*

An Algorithm for Inland and Estuarine Surface Waters

Different numerical limits apply to surface waters. Additional beneficial uses—for example, those that protect aquatic life—normally apply. There are additional standards that apply to surface waters. The California Toxics Rule and the National Toxics Rule contain promulgated numerical criteria for pollutants in California inland and estuarine surface waters. CTR and NTR criteria to protect human health or aquatic life normally have stronger legal standing than the use of an advisory limit to interpret the narrative Toxicity objective, also to protect human health or aquatic life. For example, if the CTR contains a human health protective criterion for the chemical of concern, it would have precedence over the use of the Public Health Goal to interpret the narrative Toxicity objective to protect human health. Similarly, if the CTR includes an aquatic life protective criterion, it would normally supersede use of a USEPA recommended aquatic life criterion for the same chemical, even if the latter is newer or more stringent. This CTR/NTR constraint does not apply to groundwater. In addition, the CTR, NTR and USEPA Recommended Ambient Water Quality Criteria for human health protection apply only to surface water, because they are derived assuming exposure through consumption of fish and shellfish from the water.

- ❖ California Toxics Rule and National Toxics Rule
  [Note: NTR criteria are listed in Water Quality Limits tables under "California Toxics Rule Criteria" and footnoted accordingly.]
  - ➢ Criteria for human health protection
    [Note: Use criteria for drinking water sources, consumption of water plus aquatic organisms, unless the MUN beneficial use has specifically been de-listed for the water body.]
  - ➢ Criteria for aquatic life protection
    [Note: Both the Criteria Continuous Concentration (CCC, 4-day average) and Criteria Maximum Concentration (CMC, 1-hour average) criteria apply. Sampling frequency should allow determination that both types of criteria are satisfied]
- ❖ Chemical Constituents Objective —
  each of the following three items apply separately
  - ➢ Drinking Water MCLs —
    select the lowest of the following
    - ▪ California Primary MCL
    - ▪ California Secondary MCL
  - ➢ Numerical water quality objective from the Basin Plan
    [Note: Objectives may supercede CTR or NTR criteria if approved by USEPA.]
  - ➢ Concentrations that indicate impairment of any designated beneficial use —
    select the lowest of the following
    - ▪ Agricultural use protective limits
    - ▪ Federal Primary MCL, if lower than California Primary MCL
      [See note under Groundwater Algorithm, above.]
- ❖ Toxicity Objective
  - ➢ Human health-risk based limits for drinking water use —
    normally in the following hierarchy
    [Note: Applies only if there are no CTR or NTR criteria for human health protection.]
    - ▪ OEHHA Public Health Goal
    - ▪ Cal/EPA cancer potency factor at the one-in-a-million risk level
      [See note under Groundwater Algorithm, above.]
    - ▪ California Drinking Water Action Level based on toxicity
    - ▪ USEPA IRIS criteria —
      select the lowest of the following
      - • one-in-a-million cancer risk estimate
      - • reference dose for non-cancer toxicity

FIGURE 3. GROUNDWATER ALGORITHM TABLE

Water Quality Objective / Criterion	Relevant Portion of Objective / Criterion	Source	Concentration	Units
Chemical Constituents	Drinking Water MCL (lowest)	DHS		
	Numerical Water Quality Objective	Basin Plan		
	Beneficial Use Impairment Limit			
Toxicity	Human Health – Drinking Water			
Tastes & Odors	Taste & Odor Based Limits for Water			

- USEPA Health Advisory —
  select the lowest of the following
  - one-in-a-million cancer risk estimate
  - lifetime non-cancer limit
- USEPA MCL Goals —
  non-zero values only
  [See note under Groundwater Algorithm, above.]
- Other health-risk based limits —
  check dates and basis before using these
  - National Academy of Sciences criteria *select the lowest of*
    - one-in-a-million incremental cancer risk estimate
    - drinking water health advisory
  - Proposition 65 levels —
    use only if no other health risk-based limits are available

➢ Human health-risk based limits that include fish consumption exposure
Note: Applies only if there are no CTR or NTR criteria for human health protection.]
- USEPA Recommended Ambient Water Quality Criteria (RAWQC) for human health protection *(Use criteria for drinking water sources, consumption of water plus aquatic organisms, unless the MUN beneficial use has specifically been de-listed for the water body. If based on cancer risk, check that current cancer risk factors are used.)*

➢ Aquatic life protective limits, *normally in the following hierarchy*
(applies only if there are no CTR or NTR criteria for aquatic life protection)
- California Department of Fish and Game hazard evaluation or water quality criteria *[If available, both the Criteria Continuous Concentration (CCC, normally 4-day average) and Criteria Maximum Concentration (CMC, normally 1-hour average) criteria apply. Sampling frequency should allow determination that both types of criteria are satisfied]*
- USEPA Recommended Ambient Water Quality Criteria (RAWQC)for aquatic life protection *[If available, both the Criteria Continuous Concentration (CCC, 4-day average or 24-hour average) and Criteria Maximum Concentration (CMC, 1-hour average or instantaneous maximum) criteria apply. Sampling frequency should allow determination that both types of criteria are satisfied.]*

❖ Tastes and Odors Objective

➢ Taste- and odor-based limits, *normally in the following hierarchy*
- California Secondary MCL
- Federal Secondary MCL
- USEPA National Ambient Water Quality Criterion based on taste & odor
- Taste & odor thresholds published by other agencies or from the peer reviewed literature

First, select one limit for each of the items above that begins with an arrow (➢). Record your selections in a table, such as the one shown in Figure 4.

Second, select the limit with the lowest concentration. (In the case of aquatic life criteria, both CCC and CMC limits apply, as noted above.) The result should be a limit that satisfies all applicable water quality objectives. Where aquatic life criteria vary with hardness, pH, or other factors, aquatic life criteria may be the most restrictive under some conditions while other limits in the above table may be more restrictive under other conditions. *Consideration of natural background levels and antidegradation may require further modifications to this selection, as discussed below.*

Limitations and Further Assistance

The above algorithms should be applied carefully, considering the factors of each specific case. Automatically selecting numerical limits according to these algorithms will not always generate the most appropriate limit. If specific beneficial uses do not apply, then limits protective of those uses should not be considered. It may be appropriate to deviate from the hierarchies listed above in specific cases. One may find that a particular limit is outdated or is in formal dispute at the agency that originally issued the limit (as was the case with the former Public Health Goal for chromium at OEHHA).

In another example, a California health-based limit may be less stringent than a comparable USEPA limit. Normally, we would prefer using the California limit over the one from USEPA. However, if the

California and USEPA limits are based on the same source of toxicologic information and the California limit is higher simply because it was "rounded off" from the USEPA limit, it may be appropriate to use the more precise USEPA limit. It may also be that a risk-management decision prevented the California limit from being set at the same level as the USEPA limit.

What these examples show is that, while an algorithm may be useful to guide the selection process, other information and good judgment need to be used in selecting the final water quality limits. To maintain defensibility, arbitrary selection of limits must be avoided. Selection should be based on sound rationale and should consider the circumstances of each case. Documentation of the rationale is very important, should the decision to use a particular limit be challenged or appealed.

Sufficiently similar circumstances should be addressed in the same manner. To that end, a table of applicable or relevant limits for commonly encountered chemicals has been generated, based on the above algorithms. The table *Recommended Numerical Limits to Translate Water Quality Objectives* may be found on the internet at http://www.swrcb.ca.gov/rwqcb5/available_documents/ under the subheading "Water Quality Goals." Limits appropriate for groundwater and inland surface waters are identified. The table does not include numerical water quality objectives from the Basin Plans, because these will vary from location to location and Region to Region. Make sure to consult the appropriate Basin Plan and add numerical objectives applicable to your particular situation. This table will be updated on a regular basis. In most cases, the most stringent applicable or relevant limit should be selected from the table to implement all applicable water quality objectives and promulgated criteria.

Controllable Factors and Antidegradation Policies

The selection of numerical limits, as discussed above, has only considered compliance with water quality objectives and promulgated water quality criteria (CTR/NTR). Additional factors govern the final selection of water quality limits. According to the *Controllable Factors Policy* in the implementation chapter of the Central Valley Region Basin Plans,

> "Controllable water quality factors are not allowed to cause further degradation of water quality in instances where other factors have already resulted in water quality objectives being exceeded. Controllable water quality factors are those actions, conditions, or circumstances resulting from human activities that may influence the quality of the waters of the State, that are subject to the authority of the State Water Board or Regional Water Board, and that may be reasonably controlled."

Natural background water quality is an example of a water quality factor that is not controllable or is "uncontrollable." Where natural background water quality exceeds a water quality objective or the numerical

FIGURE 4. SURFACE WATER ALGORITHM TABLE

Water Quality Objective / Criterion	Relevant Portion of Objective / Criterion	Source	Concentration	Units
California Toxics Rule / National Toxics Rule	Human Health Protection	CTR or NTR		
	Aquatic Life Protection – CCC	CTR or NTR		
	Aquatic Life Protection – CMC	CTR or NTR		
Chemical Constituents	Drinking Water MCL (lowest)	DHS		
	Numerical Water Quality Objective	Basin Plan		
	Beneficial Use Impairment Limit			
Toxicity	Human Health – Drinking Water			
	Human Health – Fish Consumption	USEPA, NAWQC		
	Aquatic Life Protection – CCC			
	Aquatic Life Protection – CMC			
Tastes & Odors	Taste & Odor Based Limits			

limit chosen to translate the objective, the Basin Plan does not require improvement over the natural condition. However, the policy prohibits controllable factors from making the condition worse. In other words, if the natural concentration of a substance exceeds the limit derived from the above algorithms, then the natural concentration should be chosen as the applicable water quality limit for the water body. If there is a chance that local background water quality has been influenced by controllable factors (e.g., an upstream or upgradient discharge of waste), then the water quality objective or numerical limit chosen to translate the objective must not be exceeded. This latter situation is the default assumption for setting effluent limits in the NPDES program, as discussed above.

State Water Board Resolution No. 68-16, the State's *Antidegradation Policy*, requires that the quality of high quality waters be maintained "to the maximum extent possible." High quality means that the water is of better quality than water quality objectives for the constituent in question. This is a constituent by constituent evaluation. The policy allows water quality to be lowered but only if the discharger demonstrates that any change will:

(1) be consistent with the maximum benefit to the people of the State;
(2) not unreasonably affect the water's present and anticipated beneficial uses; and
(3) not result in water quality less than applicable water quality objectives.

In addition, the policy requires that discharges of waste to high quality waters meet best practicable treatment or control prior to discharge. If reasonably available technology can achieve constituent concentrations that are better than water quality objectives, then the Regional Water Board must require that the lower technology-based concentrations be met. In the NPDES program, this is the same as the requirement that both technology based and water quality based effluent limits be met for each constituent of the discharge. In site cleanup, State Water Board Resolution No. 92-49 affirmed the applicability of the *Antidegradation Policy* to the process of setting site cleanup levels. Cleanup levels must meet all applicable water quality objectives and must be the lowest concentrations that are technologically and economically achievable. In cases where cleanup technology cannot meet water quality objectives, Resolution No. 92-49 allows the Regional Water Board to establish a containment zone to manage residual pollution. A further discussion on cleanup levels is presented below.

Detection and Quantitation Limits

Analytical detection and quantitation limits may provide additional technologic limitations. When the water quality limit is lower than what can be quantified with appropriate analytical methods, the laboratory should be required to submit both detection and quantitation limits and to report "trace" results—results that are able to be detected but not quantified. For normal analytical work, quantitation limits may be found in the following references:

(1) Minimum Levels (MLs), State Water Board, *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California* (2 March 2000), Appendix 4, available on the internet at http://www.swrcb.ca.gov/iswp.
(2) Detection Limits for Purposes of Reporting (DLRs), Department of Health Services, available on the internet at http://www.dhs.ca.gov/ps/ddwem/chemicals/DLR/dlrindex.htm.

Detection and quantitation limits may also be found in the method manuals from USEPA. Not all laboratories are equipped up to run all of the methods contained in these references.

(3) Method Detection Limits (MDLs) Practical Quantitation Limits (PQLs), USEPA analytical method documents, available on the internet at http://www.epa.gov/Standards.html.
    (a) SW-846, *Test Methods for Evaluating Solid Waste* (also contains water methods)
    (b) *Methods and Guidance for Analysis of Water*

If available methods cannot detect low enough concentrations to determine compliance with the water quality limit, then there is no choice but to assume that the constituent is not present in the sample. Methods with lower detection and quantitation limits may need to be specified for certain situations. The need for the information should balance the higher cost of such methods. For example, more expensive methods could be reserved for confirmation sampling or be required at a lower frequency. This is in keeping with Section 13267(b) of the California Water Code which instructs that Regional Water Boards, when requiring dischargers of waste to furnish technical reports, "[t]he burden, including costs, of these reports shall bear a reasonable relationship to the need for the report and the benefits to be obtained from the reports."

Justification

The selection of water quality limits for a particular case should be carefully documented. To be defensible, the limit selected for each constituent must be tied back to a numerical or narrative water quality objective from the Basin Plan or to a promulgated water quality criterion from CTR or NTR. Cite the factors used in selecting numerical limits to translate narrative objectives and to address uncontrollable factors and antidegradation. Include specific rationale in the documentation (e.g., that the selected limit is the most recently developed limit, that its use supports and is consistent with guidance from sister California agencies, that it has been peer reviewed, and that it addresses routes of exposure that are directly related to the beneficial use(s) being protected). The descriptions of the types of water quality limits, presented above, should be helpful in developing this documentation. The full justification for selected limits should be included in the findings and/or the Information Sheet of proposed permits, waste discharge requirements, and other Board orders.

An Example of Selecting Beneficial Use Protective Water Quality Limits

Suppose that you are investigating a site where a waste oil tank has leaked into the surrounding soils. Groundwater sampling results indicate that zinc, trichloroethylene (TCE), benzene, and xylene have reached groundwater. You want to know whether the levels of constituents detected in water samples are of significant concern.

The first step is to look at the *Water Quality Control Plan* (Basin Plan) for the particular Region in which your site is located. Upon examination of that document, you determine that the beneficial uses designated for groundwater beneath this site are municipal and domestic supply (MUN) and agricultural supply (AGR). No numerical groundwater quality objectives are listed in the Basin Plan for the constituents of concern. However, there are three narrative objectives that apply:

- *Chemical Constituents*
  Groundwaters shall not contain chemical constituents in concentrations that adversely affect beneficial uses.
  At a minimum, groundwaters designated for use as domestic or municipal supply (MUN) shall not contain concentrations of chemical constituents in excess of the maximum contaminant levels (MCLs) specified in Title 22 of the California Code of Regulations.
- *Toxicity*
  Groundwaters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life associated with designated beneficial use(s). This objective applies regardless of whether the toxicity is caused by a singled substance or the interactive effect of multiple substances.
- *Tastes and Odors*
  Groundwaters shall not contain taste- or odor-producing substances in concentrations that cause nuisance or adversely affect beneficial uses.

Together, these beneficial uses and water quality objectives constitute the water quality standards for the constituents in groundwater at the site. The next step is to select water quality limits to interpret these narrative objectives. The tables of this report contain an extensive list of such numerical limits. First we will review these limits to determine which are most appropriate to translate the above objectives. Second, we will apply the groundwater algorithm to see whether it achieves the same result.

The chemical constituents objective from the *Basin Plan* incorporates by reference California maximum contaminant levels (MCLs) for drinking water. The Basin Plans do not differentiate between Primary and Secondary MCLs, so both types of limits apply. These drinking water standards are:

Zinc	5000 ug/L
TCE	5 ug/L
Benzene	1 ug/L
Xylene	1750 ug/L

This objective also prohibits chemical constituents in concentrations that adversely affect beneficial uses. A review of available limits shows that one of the constituents of concern for our site could adversely affect the use of groundwater for agricultural supply. An agricultural water use limit for zinc is 2000 ug/L.

Agricultural use protective numerical limits are not available for the organic solvents. Note that this zinc limit is more stringent than the MCL. Agricultural uses of water are not necessarily protected by compliance with MCLs alone.

To protect long term municipal water use, federal drinking water MCLs that are lower than California MCLs are also relevant limits. However, federal MCLs for benzene (5 ug/L) and xylene (10,000 ug/L) are less stringent than California MCLs. Federal MCLs for zinc and TCE are the same as California MCLs.

The water quality objective for toxicity, stated above, requires that toxic substances not be present in water in toxic amounts. Human health-based limits for drinking water exposures are relevant because humans using the groundwater for municipal or domestic water supply could experience toxic effects if exposed to the chemicals of concern above these limits. Health-based National Ambient Water Quality Criteria and CTR/NTR criteria from USEPA are not appropriate to this case, because those limits assume that exposure occurs through ingestion of contaminated fish and shellfish. This exposure route is not relevant for groundwater.

Relevant health-based limits for zinc include:

USEPA IRIS Reference Dose	2100 ug/L
USEPA Health Advisory	2000 ug/L

IRIS values are usually preferred over health advisories, because they are intended to reflect USEPA's most recent health risk information. In this case, the health advisory was derived from the IRIS reference dose by rounding to one significant figure.

Health-based limits for TCE include:

Primary MCL	5	ug/L
California Public Health Goal	0.8	ug/L
Cal/EPA Cancer Potency Factor	2.3	ug/L
USEPA Health Advisory – cancer	3	ug/L
NAS cancer risk level	1.5	ug/L
Proposition 65 regulatory level	25	ug/L

The MCL is not purely health protective because it was based on quantitation limits of older analytical methods. The Proposition 65 regulatory level is based on the less-appropriate 10^{-5} cancer risk level. All of the remaining limits are based on the 10^{-6} cancer risk level. To be consistent with other California government agencies, the California-derived limits (the PHG and the Cal/EPA cancer potency factor) are preferred over USEPA and NAS limits for use in California. The PHG is more protective because it includes exposure through inhalation and dermal contact caused by in-home water use in addition to direct ingestion of water. The PHG is also a more recent limit than the Cal/EPA cancer potency factor. The NAS criterion from *Drinking Water and Health* is least relevant because it is much older than the other limits, and because it was "based on limited evidence," as indicated in a footnote in the *Water Quality Limits* tables.

Relevant health-based values for benzene include:

California Primary MCL	1	ug/L
USEPA Primary MCL	5	ug/L
California Public Health Goal	0.15	ug/L
USEPA IRIS Reference Dose	28	ug/L
10-day USEPA Health Advisory	200	ug/L
Cal/EPA Cancer Potency Factor	0.35	ug/L
IRIS Cancer Potency Factor	1 to 10	ug/L
USEPA Health Advisory – cancer	1	ug/L
Prop. 65 No Significant Risk Level	3.5	ug/L
Prop. 65 Max. Allowable Dose Level	12	ug/L

The USEPA Primary MCL is not purely health protective because it was based on the quantitation limits of older analytical methods. The Proposition 65 No Significant Risk Level is based on the less-appropriate 10^{-5} cancer risk level. The Proposition 65 Maximum Allowable Dose Level, the USEPA IRIS reference dose, and the 10-day USEPA health advisory are significantly higher than the cancer based limits, so they are not protective against significant cancer risks. The 10-day USEPA health advisory does not protect against health effects that could occur through longer-term water use. The California Primary MCL may not be purely health protective by comparison to the remaining health-based limits. Of the remaining limits, the PHG is the most recent California-derived value. The Cal/EPA cancer potency factor is less health protective because it does not account for inhalation and dermal exposures included in calculation of the PHG.

Health-based limits for xylene include:

California Primary MCL	1750 ug/L
USEPA Primary MCL	10,000 ug/L
USEPA MCL Goal	10,000 ug/L
California Public Health Goal	1800 ug/L

USEPA IRIS Reference Dose	1400 ug/L
USEPA Health Advisory	10,000 ug/L

The USEPA IRIS reference does is the most stringent and most recent limit. However, California derived limits are preferred for consistency within California government. The California Primary MCL and the PHG are virtually identical limits, with the PHG being published more recently. The difference between these two limits reflect only the number of significant figures assumed.

In summary, appropriate health-based numerical water quality limits for use in interpreting the toxicity objective for the constituents of concern at our site are:

Zinc	2100	ug/L	USEPA IRIS RfD
TCE	0.8	ug/L	Calif. Public Health Goal
Benzene	0.15	ug/L	Calif. Public Health Goal
Xylene	1800	ug/L	Calif. Public Health Goal

The third water quality objective stated above requires that water not contain substances that could impart objectionable tastes or odors to water supplies. Groundwater beneath our site is designated as municipal and domestic supply. Taste- and odor-based (organoleptic) levels include:

- California and federal Secondary MCLs;
- USEPA National Ambient Water Quality Criteria based on taste & odor or welfare; and
- Other taste and odor thresholds from the scientific and regulatory literature.

For the constituents of concern, taste- and odor- based numerical limits are:

Zinc	5000 ug/L
TCE	310 ug/L
Benzene	170 ug/L
Xylene	17 ug/L

Note that xylene can make water taste or smell bad at a concentration that is over 100-fold lower than the health-based MCL. The USEPA Secondary MCL for xylene, at 20 ug/L, was actually rounded from and is slightly higher than the taste and odor threshold. However, it is only a proposed value.

So far, we have reviewed the available water quality limits and selected those most appropriate to interpret each of the applicable narrative water quality objectives for each constituent of concern. Following the groundwater algorithm, presented above, achieves the same result. Selecting a limit for each constituent and for each arrow bullet in the algorithm leads to the list of limits in Figure 5.

The most stringent of these limits for each constituent of concern would ensure compliance with all water quality objectives and should protect all beneficial uses. Therefore, the beneficial use protective water quality limits for the constituents of concern in groundwater at our leaking waste oil tank site are:

Zinc	2000	ug/L	Agricultural Use Limit
TCE	0.8	ug/L	Calif. Public Health Goal
Benzene	0.15	ug/L	Calif. Public Health Goal
Xylene(s)	17	ug/L	Taste & Odor Threshold

Measured concentrations in groundwater which exceed these limits would be considered to violate applicable water quality standards.

The reader is cautioned that these values would apply to groundwater at the hypothetical site in this example, and not necessarily to water bodies in other locations. Water resources at other sites may have different beneficial use designations and water quality objectives than presented in this example.

In our example, the solvents (TCE, benzene and xylenes) are not normally present naturally in groundwater. So aquifer-specific background levels are not relevant to beneficial use protection. Where natural background concentrations are higher than the limits selected to determine compliance with all applicable water quality objectives, the Regional Water Board would not normally require the site owner or operator to improve upon these background conditions. In such cases, the background concentrations are considered to comply with the applicable water quality limits.

In addition, strict application of California's *Antidegradation Policy* would require that background levels of chemicals in groundwater ("zero" for man-made substances such as solvents, at most sites) be selected as appropriate water quality limits if some water quality degradation is not found to be consistent with maximum benefit to the people of the state or do not represent best practicable treatment or control. Cleanup of groundwater to meet background levels would be required unless attaining such levels is determined to be technologically or economically infeasible. If cleanup levels higher than background are selected, those levels may not exceed applicable water quality standards, i.e., they should not exceed the

FIGURE 5. WATER QUALITY LIMITS FOR CONSTITUENTS OF CONCERN (COCs)

COC	Water Quality Objective / Criterion	Relevant Portion of Objective / Criterion	Source	Concen-tration	Units
Zinc	Chemical Constituents	Secondary Drinking Water MCL	DHS, Title 22 of CCR	5000	ug/L
		Numerical Water Quality Objective	Basin Plan	none	
		Beneficial Use Impairment Limit	Water Quality for Agriculture	2000	ug/L
	Toxicity	Human Health -- Drinking Water	USEPA IRIS Reference Dose	2100	ug/L
	Tastes and Odors	Taste & Odor Based Limit	California Secondary MCL	5000	ug/L
TCE	Chemical Constituents	Primary Drinking Water MCL	DHS, Title 22 of CCR	5	ug/L
		Numerical Water Quality Objective	Basin Plan	none	
		Beneficial Use Impairment Limit		none	
	Toxicity	Human Health -- Drinking Water	California Public Health Goal	0.8	ug/L
	Tastes and Odors	Taste & Odor Based Limit	Amoore and Hautala	310	ug/L
Benzene	Chemical Constituents	Primary Drinking Water MCL	DHS, Title 22 of CCR	1	ug/L
		Numerical Water Quality Objective	Basin Plan	none	
		Beneficial Use Impairment Limit		none	
	Toxicity	Human Health -- Drinking Water	California Public Health Goal	0.15	ug/L
	Tastes and Odors	Taste & Odor Based Limit	Amoore and Hautala	170	ug/L
Xylene(s)	Chemical Constituents	Primary Drinking Water MCL	DHS, Title 22 of CCR	1750	ug/L
		Numerical Water Quality Objective	Basin Plan	none	
		Beneficial Use Impairment Limit		none	
	Toxicity	Human Health -- Drinking Water	California Public Health Goal	1800	ug/L
	Tastes and Odors	Taste & Odor Based Limit	USEPA	17	ug/L

beneficial use protective water quality limits selected above.

ADDITIVE TOXICITY CRITERION FOR MULTIPLE CONSTITUENTS

When multiple constituents have been found together in groundwater or surface waters, their combined toxicity should be evaluated. In the absence of scientifically valid data to the contrary, Section 2550.4(g) of the Chapter 15, Article 5 regulations, which is referenced in the State Water Board’s *Site Investigation and Cleanup Policy*, requires that theoretical risks from chemicals found together in a water body “shall be considered additive for all chemicals having similar toxicologic effects or having carcinogenic effects.” Some *Water Quality Control Plans*, including both Basin Plans for the Central Valley Region, also require that combined toxicological effects be considered in this manner. This requirement is also found in the California hazardous waste management regulations [Title 22 of CCR, Section 66264.94(f)], and in the USEPA Risk Assessment Guidance for Superfund (RAGS).

The commonly used toxicologic formula for assessing additive risk is:

$$\sum_{i=1}^{n} \frac{[\text{Concentration of Constituent}]_i}{[\text{Toxicologic Limit in Water}]_i} < 1.0$$

The concentration of each constituent is divided by its toxicologic limit. The resulting ratios—normalized concentrations—are added for constituents having similar toxicologic effects and, separately, for carcinogens. If the sum is less than one (1.0), no additive toxicity problem is assumed to exist. If the summation is equal to or greater than one, the combination of chemicals is assumed to present an unacceptable level of health risk.

For our leaking waste oil tank example discussed above, monitoring shows that groundwater quality beneath the site has been degraded by four constituents of concern in the following concentrations:

Zinc	1300	ug/L
TCE	0.7	ug/L
Benzene	0.1	ug/L
Xylene	9	ug/L

None of these concentrations exceeds beneficial use protective water quality limits for the individual constituents.

However, two of these constituents, TCE and benzene, are associated with cancer risk. The Public Health Goals for TCE and benzene were established at their respective one-in-a-million incremental cancer risk levels:

TCE	0.8	ug/L
Benzene	0.15	ug/L

Individually, no chemical exceeds its toxicologic limit. However, an additive cancer risk calculation shows:

$$\frac{0.7}{0.8} + \frac{0.1}{0.15} = 1.5$$

The sum of the ratios is greater than unity (>1.0); therefore, the additive toxicity criterion has been violated. The chemicals together present an unacceptable level of toxicity—in this case, an overall cancer risk greater than one-in-a-million.

CLEANUP LEVELS IN WATER

If contaminants are found to impair or threaten the beneficial uses of groundwater or surface water resources, cleanup levels in water must be chosen. To satisfy State Water Board Resolution No. 92-49, *Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304*, the *Antidegradation Policy*, and Section 2550.4 of Title 23 of CCR, cleanup levels for constituents in water are to be chosen at or below applicable water quality standards. Beneficial use protective water quality limits, selected using the procedures discussed above, may be used to determine that remaining constituents do not exceed these standards. In addition, such cleanup levels must also:

- not result in excessive exposure to sensitive biological receptors;
- not pose a substantial present or potential hazard to human health or the environment;
- not exceed the maximum concentration allowable under applicable statutes or regulations; and
- be the lowest concentration for each individual constituent that is technologically and economically achievable, toward background levels.

Conventional health and ecological risk assessment procedures can be used to satisfy the first and second of these additional requirements. Feasibility studies provide information that can be used to satisfy the last requirement.

CONCLUSION AND STATUS

This staff report has been developed to provide a uniform method and a convenient source of numerical limits for consistently determining compliance with California's water quality standards. It is referenced for this use in both *Water Quality Control Plans* for the Central Valley Region.

This report has been used by the State Water Board and the other Regional Water Boards as a reference for selecting numerical water quality limits. This report has also been referenced in the *Water Quality Control Plan* for the San Francisco Bay Region.

A Compilation of Water Quality Goals will be updated and expanded to account for newly developed numerical water quality information, as needed and as Regional Board staff resources are made available for that effort.