California's Water Quality Standards

and Their Applicability to Waste Management and Site Cleanup

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California is significantly limited in the quantity and quality of its water resources. Improper waste management practices and contaminated sites pose significant threats to the quality of California's usable ground and surface water resources. The purpose of this narrative is to introduce California's water quality standards and to outline a system for selecting numerical water quality limits, consistent with these standards, that may be used to assess impacts from waste management activities and pollutant releases on the quality of waters of the state and the beneficial uses of these waters.

This paper summarizes information contained in two staff reports of the California Regional Water Quality Control Board, Central Valley Region entitled *A Compilation of Water Quality Goals* and *The Designated Level Methodology for Waste Classification and Cleanup Level Determination*. The first of these reports explains the state's water quality standards, while the second establishes a framework for classifying wastes so that water quality protective treatment, storage, and disposal practices may be selected and for determining water quality protective soil cleanup levels.

To determine whether a particular waste management activity or pollutant release has caused or threatens to cause adverse water quality impacts, staff of the Regional Water Quality Control Boards must apply California's water quality standards, contained in the *Water Quality Control Plans*, to select applicable numerical water quality limits for each pollutant involved. At concentrations equal to or greater than these numerical limits, California's water quality standards have been exceeded and the pollutants are considered to have unreasonably impaired the beneficial uses of the state's waters. To further assess the impact or potential impact of waste materials or contaminated soils, " designated levels" may be calculated from the water quality numerical limits, using information specific to the waste or pollutant and to the site of waste discharge or pollutant release. If the mobile concentration of a pollutant in a waste or soil exceeds its calculated designated level, the waste or soil may be assumed to pose a site-specific threat to water quality.

California's Water Quality Control System

Because it is a water-limited state, California possesses a unique system for the protection and control of the quality of its most valuable resource. Our present system of water quality control was established in 1969, with the adoption, by the legislature, of the Porter-Cologne Water Quality Control Act. Found in Division 7 of the California Water Code, the Porter-Cologne Act is implemented by the State Water Resources Control Board and nine Regional Water Quality Control Boards.

The State Water Board carries out its water quality protection authority through the adoption of specific *Water Quality Control Plans*, which establish water quality standards for particular bodies of water, comprised of the designation of beneficial uses of these waters and water quality objectives to protect those uses. Implementation programs needed to achieve and / or maintain compliance with the water quality objectives are also addressed in these plans. Existing *Water Quality Control Plans* adopted by the State Water Resources Control Board include:

- ❏ The Inland Surface Waters Plan
- ❏ The Enclosed Bays and Estuaries Plan
- ❏ 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

[NOTE: The Inland Surface Waters Plan and the most recent Enclosed Bays and Estuaries Plan are not currently enforceable, due to a recent court decision.] The State Water Board also adopts enforceable policies for water quality control and regulations 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 in California's waterscape, the Porter-Cologne Act separates the state, along major drainage divides, into nine Water Quality Control Regions. Nine Regional Water Quality Control Boards act to protect water quality within these regions through the adoption of region-specific *Water Quality Control Plans* or "Basin Plans". The Basin Plans contain water quality standards which are specific to waters within a particular region or a portion thereof. As with the State Water Board's *Water Quality Control Plans*, implementation programs are also included in the Basin Plans.

Through 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 regulations. The State and Regional Water Boards also administer most of the federal clean water laws in California.

The State and Regional Water Boards' water quality control programs are geared toward the prevention of water 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 which 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) §§130.2(c) and 131.3(i)]

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

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

In California, the *Water Quality Control Plans* contain the state's water quality standards because these plans set forth 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 rulemaking process and, thereby, have the force of regulation. 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 and ground waters. Therefore, California has water quality standards applicable to ground waters as well as to surface waters. Another difference is that California's *Water Quality Control Plans* include implementation programs to achieve compliance with water quality objectives.

California's water quality standards are enforceable by the State and Regional Water Boards on the bodies of surface and ground water for which they were established.

Beneficial Uses

§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; esthetic 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 and ground water bodies. For example, the Central Valley Region's *Water Quality Control Plan for the Sacramento River and San Joaquin River Basins* lists the following beneficial uses of surface and ground waters:

- ❏ Municipal and Domestic Supply
- ❏ Agricultural Supply
- ❏ Industrial Supply (both Service and Process)
- ❏ Ground Water 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 water within each region of the state. Under the Porter-Cologne Act, the discharge of waste is a privilege, subject to specific permit conditions, not a right. The discharge of waste is not a beneficial use of water. The Water Boards' mission is to protect these beneficial uses from discharges of waste that could cause use impairment.

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. One such policy is critical to the designation of beneficial uses.

In 1988, the State Water Board adopted Resolution No. 88-63, the "Sources of Drinking Water" policy. This policy specifies that, except under specifically defined circumstances, all surface and ground waters of the state are to be protected as existing or potential sources of municipal and domestic supply, unless this beneficial use is explicitly de-designated in a *Water Quality Control Plan*. The specific circumstances include: waters with existing high total dissolved solids concentrations (greater than 3000 mg / l); 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 municipal, industrial and agricultural wastewater conveyance and holding facilities; and regulated geothermal ground waters. These exemptions to the municipal and domestic supply use designation are applied to specific water bodies through formal actions of the appropriate Regional Water Board.

Water Quality Objectives

The second component of California's water quality standards are 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."

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 stated either for specific bodies of water, such as the Sacramento River between particular points, or for protection of particular beneficial uses of surface or ground waters throughout a specific basin or region.

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 become applicable numerical water quality limits for the indicated constituent(s) or parameter(s) to protect beneficial uses of the specified body of water. However in many cases, water quality objectives are stated in narrative form. Examples of narrative objectives, delineated 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.

Antidegradation Policy

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", establishing an Antidegradation Policy for the protection of water quality in California. This policy for water quality control is critical to the determination of numerical water quality limits. Under this policy, whenever the existing quality of water is better than that needed to protect all present and probable future beneficial uses of the water, such existing high quality shall 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 which are unaffected by waste management practices or contamination incidents—is to be maintained.

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

The effect of this policy is to designate a range of water quality—between 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 water quality with the benefit to California as a whole of allowing some degradation to occur.

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 two more recent actions, the State Water Board further delineated implementation of the Antidegradation 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 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 ground and surface waters that could be affected by a release from the waste management unit.

§2550.4 of the regulations require 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 (CLGBs). These limits must be set:

- ❏ At the lowest concentrations for the individual pollutants which are technologically and economically achievable;
- ❏ So as not to exceed the maximum concentrations allowable under applicable statutes and regulations for individual pollutants [including the Water Board's 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 pollutants which 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 and readopted in April of 1994, states that the Antidegradation Policy of Resolution No. 68-16 is applicable to cleanup of contaminated sites, and that criteria in §2550.4 of the Chapter 15 regulations also apply to setting cleanup levels for such sites. [For cleanup of leaking underground tank sites, §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.] Therefore, in determining cleanup levels for water and for contaminated soils which threaten water quality, background pollutant 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 and 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.

Water Quality Goals

To determine whether a particular waste management activity or pollutant release has caused or threatens to cause water quality degradation (adverse change from background water quality) or pollution (degradation in excess of water quality objectives), staff of the Regional Water Quality Control Boards use California's water quality standards to determine applicable numerical water quality limits or "water quality goals" for the pollutants involved. "Water quality goals" are numerical pollutant concentrations, above which pollutants are considered to have adversely impacted the quality of waters of the state.

The first step in selecting water quality goals is to identify the ground and / or surface waters which have been or have the potential to be affected by the particular waste management activity or pollutant release. Under California's Antidegradation Policy, water quality goals are initially set equal to true background levels of water quality constituents and parameters in the body of water. Any discharge of waste that results in pollutant concentrations in excess of background levels in the water body indicates that water quality *degradation* has occurred.

If degradation has already occurred, water quality goals may also be selected so as to determine whether *pollution* has occurred or is threatened. In that case, water quality goals (or beneficial use protective numerical limits) are set to implement all applicable water quality objectives for protection of the beneficial uses designated for the body of water in question. Applicable beneficial uses and water quality objectives to protect those uses are determined by referring to the appropriate *Water Quality Control Plan(s)*. The process of selecting beneficial use protective water quality goals is shown in Figure 1 on the next page.

SELECTING BENEFICIAL USE PROTECTIVE NUMERICAL LIMITS IN WATER

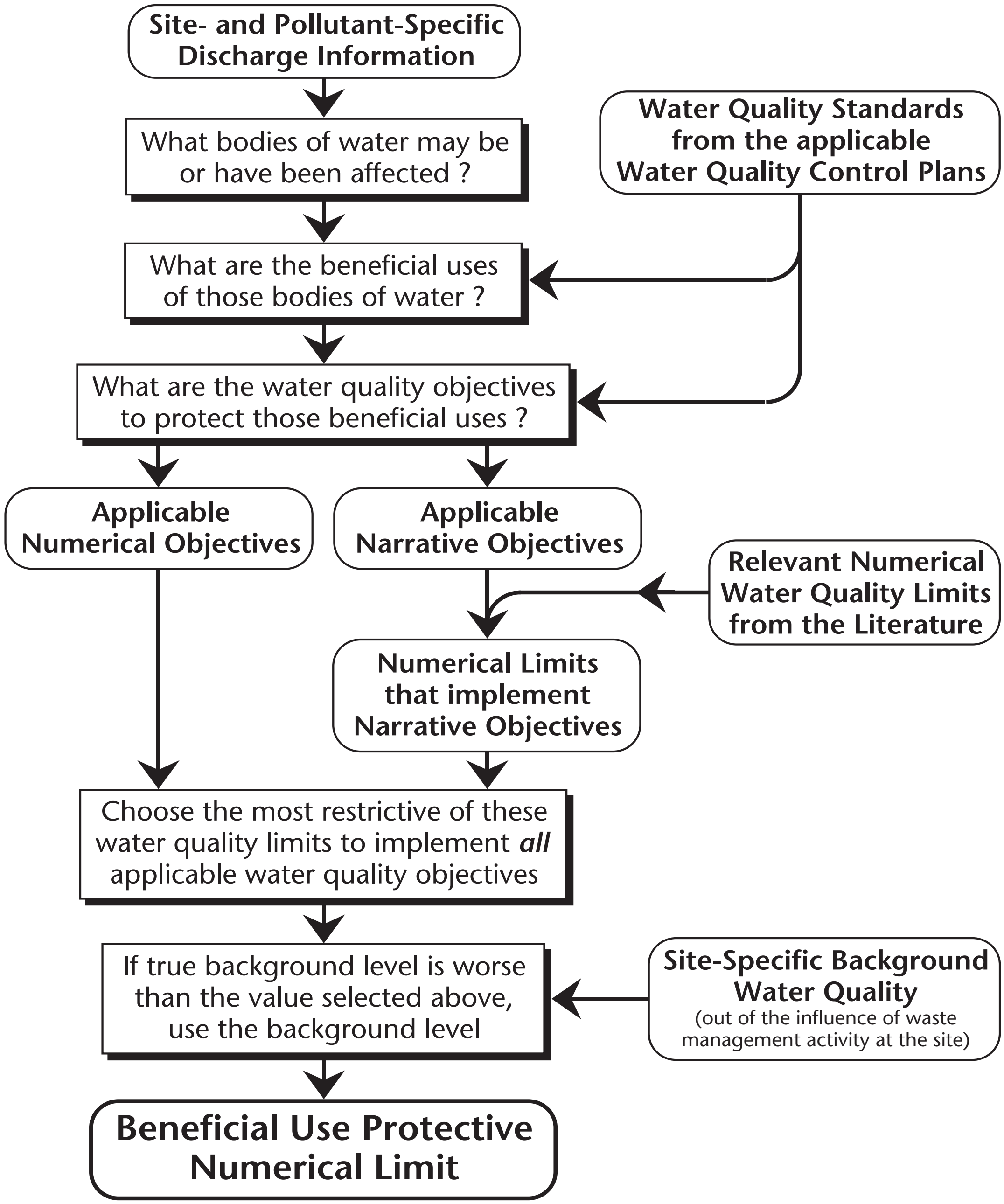

Figure 1

Some water quality objectives are stated in numerical form. These numerical objectives become a subset of the applicable beneficial use protective numerical limits. If narrative water quality objectives also apply to the water body in question, numerical water quality limits must be selected from the literature to implement these narrative objectives. Water quality limits from the literature include drinking water standards, water quality criteria, cancer risk estimates, health advisories, and other scientific numerical values which represent concentrations of chemicals that can limit certain uses of water. An example of such a limit is the taste and odor threshold for ethylbenzene of 29 µg/l, published by the U.S. Environmental Protection Agency (USEPA) in the Federal Register. This numerical limit could be used to implement the Central Valley

Region's narrative objective for taste and odor producing substances in ground or surface waters, discussed above.

For each pollutant, the applicable numerical objectives along with numerical limits selected to implement applicable narrative objectives are compared and the most limiting (most stringent) value is selected. That most limiting value should protect the most sensitive beneficial use. It becomes the beneficial use protective numerical limit for the pollutant in the body of water being impacted or threatened. If the concentration of the pollutant exceeds the beneficial use protective limit, pollution has occurred. The one exception is where the site-specific background level in water is less stringent (higher concentration) than the beneficial use protective limit. Where the true background level is less stringent, the background level becomes the beneficial use protective limit, since it is not necessarily the intent of the Water Boards to improve on naturally occurring water quality.

Types of Numerical Water Quality Limits

The literature contains many useful water quality limits designed to protect specific beneficial uses of water, which can be used to implement narrative water quality objectives. The following is a summary of several available types of numerical water quality limits.

Maximum Contaminant Levels (MCLs) —

MCLs are part of the drinking water standards adopted both by the California Department of Health Services (DHS), Office of Drinking Water in Title 22 of the California Code of Regulations (CCR), Division 4, Chapter 15, "Domestic Water Quality and Monitoring" and by the USEPA under the Safe Drinking Water Act. DHS's drinking water standards are required to be at least as stringent as those adopted by the USEPA. Some are more stringent.

Primary MCLs are derived from health-based criteria (by USEPA from MCL Goals; by DHS from one-in-a-million, or 10^{-6}, incremental cancer risk estimates for carcinogens and from threshold toxicity levels for non-carcinogens) in conjunction with technologic and economic factors relating to the feasibility of achieving and monitoring these concentrations in drinking water supply systems. It should be noted that the balancing of health effects with technologic and economic considerations in the derivation of MCLs may not be applicable to the protection of the quality of a raw surface or ground water resource, as will be discussed later in this narrative. 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 and enforceable by DHS and local health departments on water supply systems and at the tap. MCLs, both Primary and Secondary, are directly applicable to ground and surface water resources only when they are specifically referenced as water quality objectives in the pertinent *Water Quality Control Plans*. Where fully health protective, MCLs may also be used as water quality limits for other bodies of water designated as sources of drinking water in the *Water Quality Control Plans.*

Maximum Contaminant Level Goals (MCL Goals) —

MCL Goals are promulgated by USEPA as part of the National Primary Drinking Water Regulations. MCL Goals represent the first step in establishing Primary MCLs and are required by law to be set at levels which 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 cancer risk. Threshold levels posing no risk of health effects other than cancer are used for non-carcinogens and possible human carcinogens.

State "Action Levels" and Recommended Public Health Levels (RPHLs) —

Action levels are published by DHS's Office of Drinking Water and are based mainly on health effects. 10^{-6} incremental cancer risk estimates are used for carcinogens and threshold toxicity limits are used for other constituents. The ability to quantify the amount of the constituent in water using readily available analytical methods may cause action levels to be somewhat less stringent than purely health-based values. Organoleptic (taste- and odor-based) values are also included as action levels for some chemicals. Action levels are advisory to water suppliers. If exceeded, the supplier is urged to correct the problem or to find an alternative raw water source. In 1992, DHS proposed to adopt regulations in Title 22 of CCR that would establish RPHLs—health-based numerical limits that are similar to action levels—for several chemicals.

Health Advisories and Water Quality Advisories —

These advisories are published by USEPA's Office of Water. Short-term (10 days exposure or less), long-term (7years exposure or less), and lifetime exposure health advisories for non-carcinogens and possible human carcinogens are included where data sufficient for derivation of the advisories exist. Incremental cancer risk estimates for known and probable human carcinogens are also included. Some Water Quality Advisories also contain aquatic life protective criteria.

Suggested No-Adverse-Response Levels (SNARLs) —

These human health-related criteria were published by the National Academy of Sciences (NAS) in the nine volumes of *Drinking Water and Health* (1977 to 1989). USEPA's health advisories were also formerly published as "SNARLs." SNARLs do not reflect the cancer risk that may be posed by these chemicals. Incremental cancer risk estimates are presented separately in these NAS and USEPA documents for carcinogens.

Proposition 65 Regulatory Levels —

Proposition 65 levels are established under the California Safe Drinking Water and Toxic Enforcement Act of 1986 for known human carcinogens and reproductive toxins. Proposition 65 made it illegal to expose persons to significant amounts of these chemicals without prior notification. The "significant amounts" are developed by the California Environmental Protection Agency (Cal/EPA), Office of Environmental Health Hazard Assessment (OEHHA) and are found in Title 22 of CCR, Division 2, Chapter 3. For carcinogens, No-Significant-Risk Levels (NSRLs) are set equal to the one-in-100,000 (10^{-5}) incremental cancer risk estimate. $^{1}/_{1000}$ of the No-Observable-Effect Level (NOEL) is used for reproductive toxicants. Proposition 65 levels are established as a dose in units of micrograms per day of exposure (µg/d). These levels are 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, §§12721 and 12821.

National Ambient Water Quality Criteria —

These criteria are published by USEPA under the Clean Water Act to protect human health and welfare and freshwater and marine aquatic life. No-Adverse-Effect Levels are presented for non-carcinogens. Incremental cancer risk estimates for carcinogens are given at the 10^{-5}, 10^{-6}, and 10^{-7} (one-in-ten-million) risk levels. Organoleptic (taste- and odor-based) levels are provided for some chemicals. Freshwater and saltwater aquatic life criteria and toxicity information are included. These criteria are found in a number of USEPA documents:

- ❏ *Quality Criteria for Water, 1986* — the "Gold Book";
- ❏ the *Ambient Water Quality Criteria* volumes (1980, 1984, 1986, 1987, and 1989);
- ❏ *Quality Criteria for Water (1976)* — the "Red Book";
- ❏ *Water Quality Criteria, 1972* — the "Blue Book".

In December 1992, USEPA promulgated the "National Toxics Rule" (Federal Register, Vol. 57, No. 246, pp. 60848-60923), which updated many of these criteria and made them directly applicable to surface waters in many states, including California. These regulations, found in 40 CFR §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 (Federal Register, Vol. 60, No. 86, pp. 22228-22237) to be able to express many of these aquatic life criteria as dissolved concentrations.

Other sources of numerical water quality limits include:

- ❏ *Water Quality for Agriculture*, published by the Food and Agriculture Organization of the United Nations in 1985, which contains criteria protective of agricultural uses of water.
- ❏ *Water Quality Criteria*, 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. More recently, this document has been made available from the National Technical Information Service (NTIS) as Publication No. 188244.
- ❏ The California Department of Fish and Game and the U.S. Fish and Wildlife Service, which can also supply criteria for fish and wildlife protection.

Many of the numerical water quality limits discussed above as well as the numerical water quality objectives from the State Water Board's statewide *Water Quality Control Plans* are summarized in the tables and graphs which make up the remainder of the *Water Quality Goals* staff report.

$$[1] \quad \text{Risk Level} = \text{Dose} \times \text{Potency Factor}$$

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

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

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

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

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

Risk Characterization Methods for Drinking Water

The methods by which the USEPA and other agencies establish lifetime health advisories and concentration-based cancer risk estimates for pollutants in drinking water may be used to calculate additional numerical water quality limits. These methods are based on the following fundamental toxicologic concepts.

Threshold Toxins vs. Non-Threshold Toxins

The toxic effects of chemicals may be roughly divided into two categories, threshold and non-threshold. It is important to recognize that it isn't the chemical, but the dose of the chemical, which is responsible for the toxic effect. Below a particular threshold dose or level of exposure, many chemicals cause no toxicity. These chemicals are called threshold toxins. Cyanide, mercury, and 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 a quantifiable health risk at any concentration. Most carcinogens are thought to fall into this non-threshold category. Essentially one molecule is thought to have the potential of causing some risk of cancer. Health risks for non-threshold toxins are characterized by probabilities. For example, according to Cal/EPA- OEHHA, 0.35 µg of benzene per liter of drinking water is associated with the probability of one additional cancer case per million persons exposed at a 2liters per day water consumption rate over a lifetime of 70 years. The value of 0.35 µg/l is the estimated drinking water concentration associated with a 1-in-a-million cancer risk.

Chemicals are currently assigned by USEPA into five categories, based on the weight of cancer risk evidence that exists in the toxicologic record. Class A chemicals are *known human carcinogens*; Class B chemicals are *probable human carcinogens*; Class C chemicals are *possible human carcinogens*; Class D chemicals have insufficient cancer risk data to assign them to another category; and Class E chemicals have sufficient evidence which indicates that they are *not carcinogens*. USEPA does not calculate lifetime health advisories for Class A or Class B chemicals. Cancer risk estimates are calculated for Class A, Class B, and sometimes for Class C 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 than for threshold toxins.

Non-Threshold Risk Characterization

For non-threshold pollutants, 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 carcinogens, risk and dose are related by a cancer potency factor (often abbreviated q_1^*) which is equal to the risk of getting cancer per unit dose, and is expressed in units of $(mg/kg/day)^{-1}$. The risk level, dose, and potency factor are related by equation [1] above.

Potency factors for carcinogens are calculated by extrapolation from laboratory animal exposure studies, and may be found in USEPA's Integrated Risk Information System (IRIS) database and health advisory documents, and elsewhere in the literature. The IRIS database contains USEPA's most up-to-date chemical health risk information. A list of cancer potency factors has also been developed by Cal/EPA-OEHHA, based on information developed by certain state health-related programs or adopted by these programs for use as the basis for regulations.

Dose and concentration in water may be related as in equation [2], where we assume a drinking water consumption rate of 2 liters per day and an average human body weight of 70 kg. By combining equations [1] and [2] and rearranging, we obtain equation [3]. This equation allows calculation of concentrations in drinking water associated with a given cancer risk level, if the potency factor is known. For example, the Cal/EPA-OEHHA cancer potency factor for the pesticide 1,2-dibromo-3-chloropropane or DBCP is 7 $(mg/kg/day)^{-1}$. 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 µg/l. This 10^{-6} cancer risk estimate along with other similarly calculated cancer risk estimates may be found in the tables of the *Water Quality Goals* staff report.

Threshold Risk Characterization

To determine the concentration of a threshold toxin which is safe for humans to consume in drinking water, toxic dose information is first derived from animal studies. In these studies, laboratory animals are exposed to a chemical at specific dose levels. USEPA and other agencies choose one of two dose level results from these studies. The *no observed adverse effect level* (NOAEL) is the highest dose which caused no toxic effect to animals in the study. The *lowest observed adverse effect level* (LOAEL) is the lowest dose which did cause a measurable toxic effect in the study. 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 studied, doses are often reported in units of milligrams of chemical per kilogram of body weight per day of exposure (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 chemical, using the equation [4] on page 9. The uncertainty factor accounts for unknowns in the derivation of human risk levels from animal studies. The minimum uncertainty factor is 10, which accounts for the fact that some people (e.g., children and the elderly) are more sensitive to toxic chemical exposures than is the average person. The minimum uncertainty factor is normally multiplied by additional factors of 10 for each of the following conditions, if they apply:

- ❑ Extrapolation from animal toxicity studies to human toxicity;
- ❑ Using a LOAEL in place of a NOAEL in equation [4] on the previous page;
- ❑ 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 which 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); and
- ❑ Any other toxicologic data gaps.

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

The next step (equation [5] on page 9) is the calculation of a *drinking water equivalent level* or *DWEL* from the reference dose. This step factors in an assumed average human body weight of 70 kilograms and the assumed average drinking water consumption rate of two liters per day.

One last step (equation [6] on page 9) is required to turn the DWEL into a *lifetime health advisory*. Two additional factors are used. The first is the *relative source contribution* or *RSC*, which accounts for the fact that we are usually exposed to chemicals from sources other than in drinking water (e.g., in foods and in the air we breathe). The combined exposure from all sources forms the overall dose which may cause toxicity. The relative source contribution normally used by USEPA in deriving lifetime health advisories for threshold pollutants is 20%. This means that 20% of the exposure is assumed to come from drinking water and 80% from all other sources combined. The second factor 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. As stated above, lifetime health advisories are usually not calculated for chemicals in Classes A and B.

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 for cancer risk) and has an RfD of 0.10 mg / kg / day. 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 µg / l. This and other similarly calculated limits are presented in the tables of the *Water Quality Goals* staff report.

Selecting a Water Quality Goal From Among Available Numerical Limits

To protect all applicable beneficial uses, the most protective (lowest), applicable (under the beneficial use designations and water quality objectives in the *Water Quality Control Plans*) numerical water quality limit should be selected as the beneficial use protective numerical limit for a particular water body and pollutant. Due to the rapidly changing data base on the health and environmental effects of chemicals, caution should be observed in selecting among the various numerical water quality limits to be sure that the most current information is utilized. The original literature should be consulted whenever possible to determine the applicability and limitations of the limits being selected. 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-protective numerical limits are available for a particular chemical. A decision must be made as to which of these limits is the most appropriate. In May of 1994, representatives of the State and Regional Water Boards met with toxicologists and other representatives of the DTSC and OEHHA to discuss the use of toxicologic criteria in contaminated site assessment and cleanup. The group agreed to guidance parallel to that given to toxicologists within DTSC's Office of Scientific Affairs. When selecting numerical limits from the literature to implement health based narrative water quality objectives or when selecting criteria for use in health risk assessments, the following 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. Examples include criteria used in deriving State drinking water standards and Proposition 65 "no-significant-risk levels." 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 Service (IRIS).
4) Cancer potency slope factors or reference doses from USEPA's Health Effects Assessment Summary Tables (Health Advisories), the most current edition.

Cancer potency factors in the first two categories are summarized in *California Environmental Protection Agency Criteria for Carcinogens*, OEHHA (November 1994).

It has been common practice to rely on Primary MCLs as "enforceable standards" for human health protection. However, MCLs are designed to apply to water within a drinking water distribution system and at the tap. Care should be taken in the application of Primary MCLs to the protection of *sources* of drinking water (ground or surface water resources).

A common example of incorrect MCL application is the use of the total trihalomethane (THM) MCL for the protection of ground water 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 Primary MCL of 100 µg / l is 17 to 370 times higher than the 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, and does not clearly protect the beneficial use for municipal and domestic supply of waters of the state. 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 and the cost associated with conversion to other disinfection methods. In the case of ground water protection, this type of cost / benefit balancing—accepting some chloroform and other THMs in order to eliminate pathogens and avoid conversion costs—is not germane, since this water has not been and may not need to be chlorinated for domestic consumption. Therefore, the total THM MCL is not sufficiently protective of the ambient quality of domestic water supply source waters.

The published one-in-a-million incremental cancer risk estimates (ranging from 0.27 to 6 µg / l) are a more accurate measure of potential impairment by trihalomethanes of the beneficial use of ground water for domestic supply. Staff of USEPA, Region 9 (San Francisco), Water Management Division has supported the application of a one-in-a-million cancer risk estimate, instead of the total THM Primary MCL, as a numerical water quality limit for chloroform in ground water as consistent with the intent of the federal Clean Water and Safe Drinking Water Acts. In conclusion, the total THM drinking water standard is not appropriate for protection of the quality of a water resource.

Virtually all Primary MCLs are derived by balancing the technologic and economic considerations that are directly related to the use of water via conventional domestic and municipal water supply systems with the health effects information developed under the MCL Goal and state action level or RPHL process. Thus, Primary MCLs are not always reliable indicators of the protection of beneficial uses of ambient waters and should not be relied upon as appropriate numerical water quality limits without careful scrutiny.

There are additional instances where water quality limits more stringent than MCLs are applied to protect the beneficial uses of a water resource. For example, in conformance with the *Water Quality Control Plans*, the Regional Water Quality Control Boards require compliance with aquatic life criteria for heavy metal contaminants in surface waters and taste and odor thresholds for organic chemicals in ground waters where these limits are more stringent than MCLs for the same contaminants.

The state's Antidegradation Policy requires water quality limits to be set below beneficial use protective concentrations, toward or equal to background levels, when feasible. Water is a multi-use resource and some degradation in water quality occurs from each use. Water quality is also degraded by discharges of waste. Multiple water users and waste dischargers and the contribution to degradation of water quality imposed by each must be considered. If one user or discharger is permitted to degrade the quality of a water resource to just below the limit where beneficial uses are impaired, then no additional capacity exists for further degradation by other water users or discharges of waste. In addition, our understanding of the health and environmental effects of chemicals and combinations of chemicals is constantly evolving. What is considered to be safe at 10 µg / l today may be found to be harmful at 1 µg / l tomorrow.

An Example of Numerical Limit Selection

Suppose you are investigating a site where a fuel tank has leaked a petroleum product into the surrounding soils. Ground water sampling results indicate that benzene, ethylbenzene, toluene, xylenes and other gasoline-range petroleum hydrocarbons have entered ground water. No fuel additives were involved. You wish to know whether the levels of constituents detected in that water are of significant concern.

The first step would be 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 the ground water are municipal and domestic supply. No numerical water quality objectives are listed in the Basin Plan for benzene, ethylbenzene, toluene, xylene, or gasoline. However, there are three narrative objectives which appear to be applicable:

❏ Ground waters shall not contain chemical constituents in concentrations that adversely affect beneficial uses.

- ❑ At a minimum, ground waters 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, which are incorporated by reference into this plan…
- ❑ Ground waters shall not contain taste- or odor-producing substances in concentrations that cause nuisance or adversely affect beneficial uses.
- ❑ Ground 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 singled substance or the interactive effect of multiple substances.

Together, these beneficial uses and water quality objectives constitute the "water quality standards" for the chemical constituents in ground water at the site of your investigation. The next step is to select numerical water quality limits to interpret these narrative objectives. The tables of the *Water Quality Goals* staff report contain an extensive list of such numerical limits.

The second objective from the Basin Plan, stated above, references California maximum contaminant levels (MCLs). These applicable drinking water standards are:

Benzene	1	µg/l
Ethylbenzene	700	
Toluene	150	
Xylene(s)	1750	

No California MCL currently exists for gasoline.

The third water quality objective stated above requires that these waters not contain chemicals which could impart objectionable tastes or odors. Taste- and odor-based (organoleptic) levels include:

- ❑ California and federal Secondary MCLs;
- ❑ California State Action Levels, Taste & Odor;
- ❑ USEPA National Ambient Water Quality Criteria based on Taste & Odor or Welfare; and
- ❑ other taste and odor thresholds from the scientific literature.

For the constituents of concern, the most stringent of these listings are the taste and odor thresholds cited by USEPA in the Federal Register of 1989:

Ethylbenzene	29	µg/l
Toluene	42	
Xylene(s)	17	
Gasoline	5	

No taste- or odor-based limits are found for benzene.

The first applicable water quality objective stated above requires that chemical constituents are not to impair beneficial uses. Since the beneficial uses designated in the Basin Plan relate to consumption and other uses of water by humans, health- and welfare-related limits would apply. The fourth narrative water quality objective also indicates that human health-related limits would apply. Other than the values cited above, applicable values for benzene include a proposed Recommended Public Health Level, a number of 10^{-6} cancer risk estimates including one calculated from a Cal/EPA Cancer Potency Factor, a 10-day exposure USEPA health advisory, and a Proposition 65 Regulatory Level. 10-day advisories are not protective of human health in the long term and are, therefore, not applicable to protecting a ground water resource. The current Prop. 65 criterion for benzene is 3.5 µg/l. The cancer risk estimates, including the limit calculated from the Cal/EPA Cancer Potency Factor, range from 0.35 to 1 µg/l. The proposed Recommended Public Health Level is also 0.35 µg/l. The most limiting values for benzene appear to be the cancer risk-based limits. According to the hierarchy of health-based criteria agreed upon by staff of the Water Boards, DTSC and OEHHA discussed above, the Cal/EPA Cancer Potency Factor should be chosen as a reasonable beneficial use protective numerical limit for benzene. [It should be noted that the difference between this value the California Primary MCL is within the range of normal sampling and analytical error for benzene in water samples. For this reason, the choice of the Cal/EPA Cancer Potency Factor over the California Primary MCL may be insignificant.]

For ethylbenzene, other relevant human health- and welfare-related limits include a proposed Secondary MCL of 30 µg/l, a proposed Recommended Public Health Level of 680 µg/l, a USEPA Health Advisory of 700 µg/l (which is in agreement with the IRIS RfD), and a taste and odor threshold of 29 µg/l. In reviewing these limits, the most stringent applicable water quality numerical limit for ethylbenzene appears to be the taste and odor threshold of 29 µg/l, discussed above.

Similarly, a review of other relevant values shows that all limits for toluene and xylene are higher (less protective) than their taste and odor thresholds discussed above. Limits for gasoline other than the taste and odor threshold are not found. Therefore, relevant water quality numerical limits for toluene, xylenes, and gasoline appear to be the taste and odor thresholds of 42, 17, and 5 µg/l, respectively. [The proposed federal Secondary MCL for toluene is slightly lower, at 40 µg/l; however, it is very close to the taste and odor threshold and is currently a proposed value.]

In summary, the numerical limits chosen to implement the applicable water quality objectives for the protection of all beneficial uses of ground water at the site being studied are:

Benzene	0.35	µg/l	Cal/EPA Cancer Potency
Ethylbenzene	29		Taste & Odor Threshold
Toluene	42		Taste & Odor Threshold
Xylene(s)	17		Taste & Odor Threshold
Gasoline	5		Taste & Odor Threshold

The reader is cautioned that these values would apply to ground water at the hypothetical site in this example, and not necessarily to water resources in other locations. Water resources at other sites may have different beneficial use designations and applicable water quality objectives, which could alter the assessment of relevant beneficial use protective numerical limits for these chemicals.

In the above example, the constituents of concern are not normally found naturally in ground water, so aquifer-specific background levels are not relevant to beneficial use protective limit selection. Where background concentrations (out of the influence of waste management activities at the site) are higher than the limits selected to implement applicable water quality objectives, the Regional Water Board would not normally require the site owner or operator to improve upon the background conditions. In such cases, the background concentrations would become the applicable water quality numerical limits.

In addition, strict application of California's Antidegradation Policy would require that background levels of chemicals in ground water ("zero" for anthropogenic substances at most sites) be selected as appropriate water quality limits if some water quality degradation is not found to be consistent with the requirements of that policy, as discussed above.

Additive Toxicity Criterion for Multiple Pollutants

When multiple constituents have been found in ground or surface waters, their combined toxicity must be evaluated. In the absence of scientifically valid data to the contrary, §2550.4(g) of the Chapter 15, Article 5 regulations discussed above 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* also require that combined toxicological effects be considered in this manner. This requirement is also found in California's hazardous waste management regulations [Title 22 of CCR, §66264.94(f)], and in USEPA's *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 are added for constituents having similar toxicologic effects and, separately, for carcinogens. If such a sum of ratios is less than one, an additive toxicity problem is assumed not 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 example, monitoring shows that ground water beneath a site has been degraded by three volatile organic chemicals in the following concentrations:

Perchloroethylene	0.3	µg/l
Trichloroethylene	0.4	
1,1-Dichloroethylene	5	

One-in-a-million incremental cancer risk estimates, calculated from Cal/EPA cancer potency factors, are as follows:

Perchloroethylene	0.69	µg/l
Trichloroethylene	2.3	
1,1-Dichloroethylene	6.3	

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

$$\frac{0.3}{0.69} + \frac{0.4}{2.3} + \frac{5}{6.3} = 1.4$$

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, cancer risk).

Cleanup Levels In Water

If contaminants are found to threaten the quality of ground or surface water resources, cleanup levels in water must be chosen. To satisfy the antidegradation policy, State Water Board Resolution No. 92-49, *Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304* and §2550.4 of Title 23 of CCR, background concentrations of contaminants in water are to be chosen as cleanup levels unless background levels are either technologically or economically infeasible to achieve.

If background levels are determined to be unachievable, cleanup levels greater than background may be selected. As detailed in §2550.4 of Title 23 of CCR, such cleanup levels must:

❏ be the lowest concentrations for the individual pollutants which are technologically and economically achievable;
❏ not pose a substantial present or potential hazard to human health or the environment; and
❏ not exceed the maximum concentrations allowable under applicable statutes or regulations for individual pollutants, including applicable water quality standards.

Feasibility studies and conventional health and ecological risk assessment procedures can be used to satisfy the first and second of these requirements, respectively. Beneficial use protective water quality limits for the constituents, determined using the procedures discussed above, may be used to determine compliance with this last requirement, i.e., that remaining contaminants do not threaten to exceed California's water quality standards.

Waste Classification

In California, the classification of wastes is performed by two separate Cal/EPA state agencies with separate regulatory authority. The Department of Toxic Substances Control (DTSC; formerly the Toxic Substances Control Division of the Department of Health Services) classifies wastes as hazardous or non-hazardous based on their direct threat to public health. The State Water Resources Control Board, together with the nine Regional Water Quality Control Boards, classify non-hazardous wastes as "designated", "nonhazardous solid" or "inert", based on the threat that each waste poses to the beneficial uses of ground and surface waters, as required by the Porter-Cologne Water Quality Control Act and regulations, water quality control plans and policies set forth by the Water Boards.

As shown in Figures 2 and 3 on the next page, Water Board regulations divide wastes into four categories which, in turn, determine the classes of waste management units to which their discharge is permitted for treatment, storage or disposal. Detailed criteria are contained in Title 22 of the California Code of Regulations, Division 4.5, Chapter 11 for determining whether a waste falls into the hazardous category. These criteria fall under the headings of toxicity, ignitability, reactivity, corrosivity, and listing under the federal Resource Conservation and Recovery Act (RCRA). Hazardous wastes may be discharged only to Class I waste management units which provide both natural geologic and engineered containment features to isolate the wastes from the environment, unless a specific variance has been granted by DTSC from California's hazardous waste management requirements.

"Nonhazardous solid waste" is the regulatory (Title 23 of CCR) term for "municipal solid waste" or "refuse" and is characterized as having a significant proportion of putrescible (degradable) matter, stringent moisture limitations, and prohibitions against inclusion of "designated" or "hazardous" wastes. "Nonhazardous solid waste" may be discharged to Class III landfills that protect beneficial uses of nearby waters, but do not provide complete waste containment. The only threat to water quality posed by wastes in the "inert" category is siltation. Paving fragments and nondegradable construction debris are examples of "inert waste". Wastes in this category may be discharged to unclassified waste management units that are located and managed to keep the wastes from entering surface waters or drainage courses.

"Designated waste" is defined in §2522(a) of Title 23 of CCR, Division 3, Chapter 15 as:

"1) nonhazardous waste which consists of or contains pollutants which, under ambient environmental conditions at the waste management unit, could be released at concentrations in excess of applicable water quality objectives, or could cause degradation of waters of the State" or

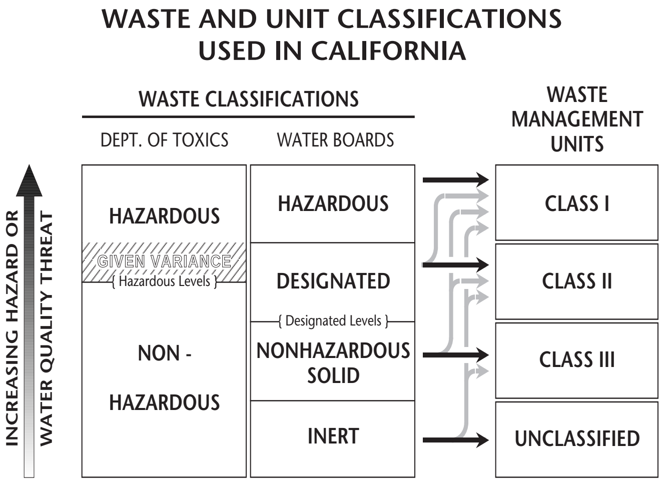

Figure 2

“2) hazardous waste which has been granted a variance from hazardous waste management requirements pursuant to Section 66310 of Title 22 of this code.” [In July 1991, §66310 of Title 22 of CCR was repealed and replaced with §66260.210.]

The second part of this definition pertains to those wastes granted a variance by DTSC from ClassI disposal, as discussed above. The first half of the “designated waste” definition includes non-hazardous wastes which have the potential to impair water quality at the site of discharge. Due to their threat to water quality, “designated wastes” are to be discharged to Class II waste management units which have engineered containment features—liners, leachate collection systems and caps—which act to isolate the wastes from ground and surface waters. The Chapter15 regulations, however, do not contain guidance on how to interpret the first part of the “designated waste” definition. The purpose of the Central Valley Regional Water Quality Control Board staff report, *TheDesignated Level Methodology* , is to provide an interpretation of this definition.

It may not be immediately apparent how a non-hazardous waste could pose a threat to water quality. A simple example will illustrate this point. Figure4 shows an unlined surface impoundment which con-

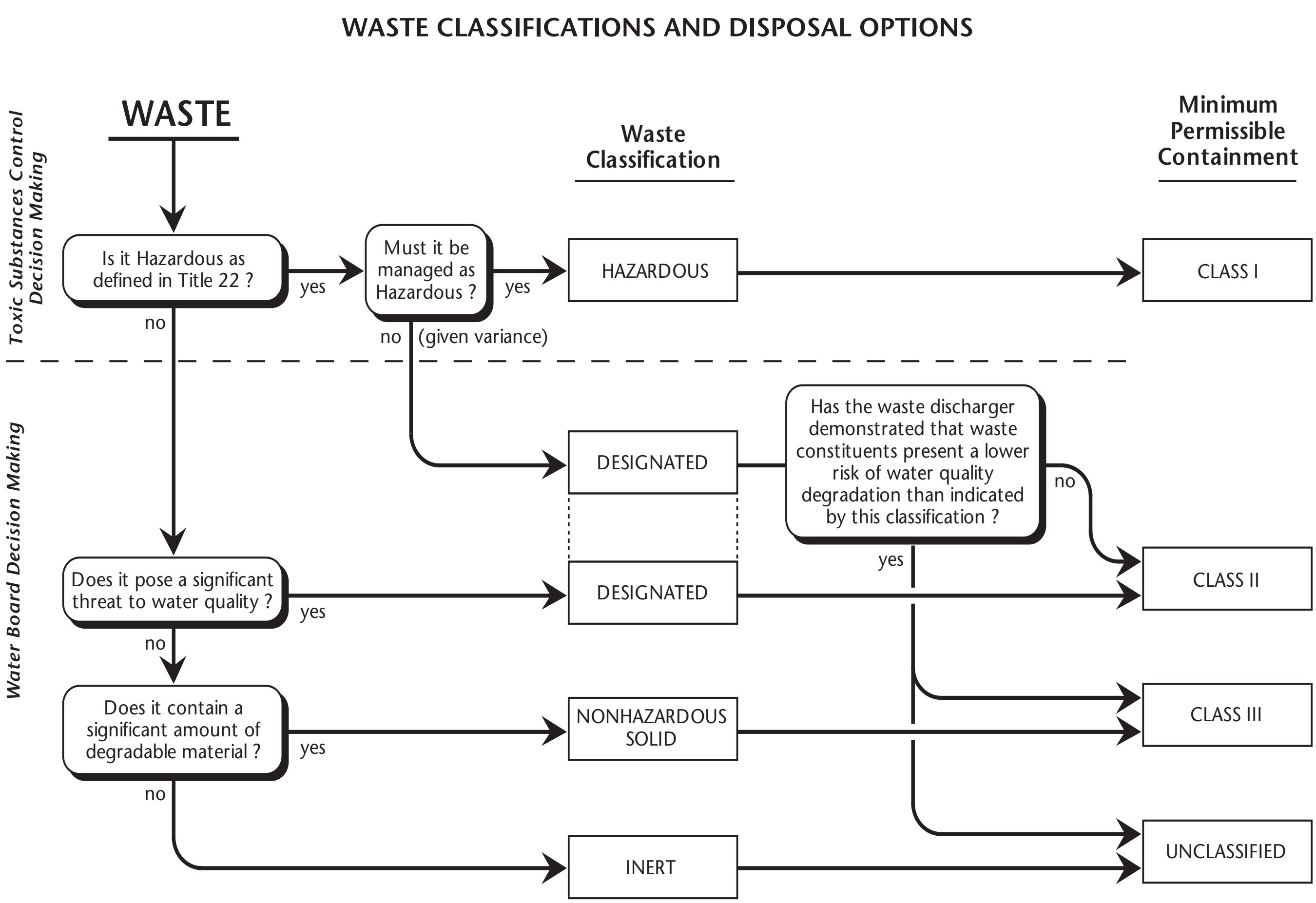

Figure 3

tains soluble arsenic at a concentration of 4.5mg/l. The hazardous STLC for arsenic, the level above which a liquid waste becomes hazardous under Title22 of CCR, is 5mg/l. Therefore, the waste in this example is not hazardous. The Proposition 65 (Safe Drinking Water and Toxic Enforcement Act of 1986) no-significant-risk level for arsenic is 0.005mg/l. If natural geologic materials between the base of the impoundment and the water table are unable to sufficiently filter out or attenuate the arsenic, the Proposition 65 regulatory level will be exceeded, adversely impacting the beneficial use of the water for domestic supply. Therefore, this waste at this site would be classified as a "designated waste", and the impoundment would have to be designed to meet Class II containment standards to isolate the waste from ground water.

The Designated Level Methodology

As shown by the above example, the determination of whether a waste poses a threat to water quality must take into account factors relating to the waste and to the site of proposed discharge. In *The Designated Level Methodology*, this is accomplished by determining "Designated Levels", concentrations of waste constituents which provide a site-specific indication of the waste's water quality impairment potential. If measured concentrations of constituents in a waste exceed these Designated Levels, the waste is assumed to pose a water quality threat at the site in question. Because of the site-specific nature of the determination, the same waste may be classified as "designated" in one location, but not in another location which provides a greater degree of protection for water quality.

Designated Levels are calculated by first determining the bodies of water which may be affected by the waste management activity in question and the present and probable future beneficial uses of these waters, as shown in Figure 5 on the next page. Next, site-specific water quality goals are selected, as discussed above, based on background water quality and California's water quality standards to protect beneficial uses. Finally, the applicable water quality goals are multiplied by factors which account for the magnitude of environmental attenuation expected to occur under reasonable worst-case conditions at the proposed site of discharge. The result is a set of Soluble Designated Levels for waste constituents of concern which are specifically applicable to both the waste and the site and which, if not exceeded, should protect the beneficial uses of waters of the state.

NON-HAZARDOUS WASTES CAN THREATEN WATER QUALITY

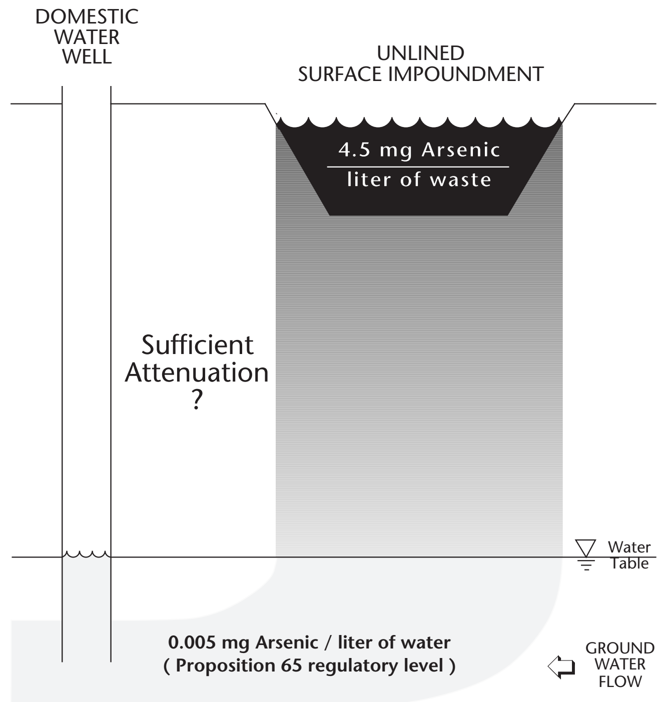

Figure 4

For the site in question, wastes having soluble constituent concentrations in excess of their calculated Designated Levels are assumed to pose a threat to water quality and are classified as "designated wastes". These wastes are required to be discharged to waste management units which isolate them from the environment.

Environmental Attenuation Factors

There are a variety of natural processes which act to attenuate (reduce the concentrations of) waste constituents as they migrate through the environment. These processes, which are collectively grouped under the term "environmental fate", include sorption, chemical binding, ion exchange, filtration, diffusion, dispersion, dilution, chemical reaction, biodegradation, and partitioning. By collecting data on the waste constituents and on the site in question, the amount or degree of attenuation which would be expected to occur as the constituents migrate from the location of waste discharge to either ground or surface water may be estimated. In *The Designated Level Methodology*, the

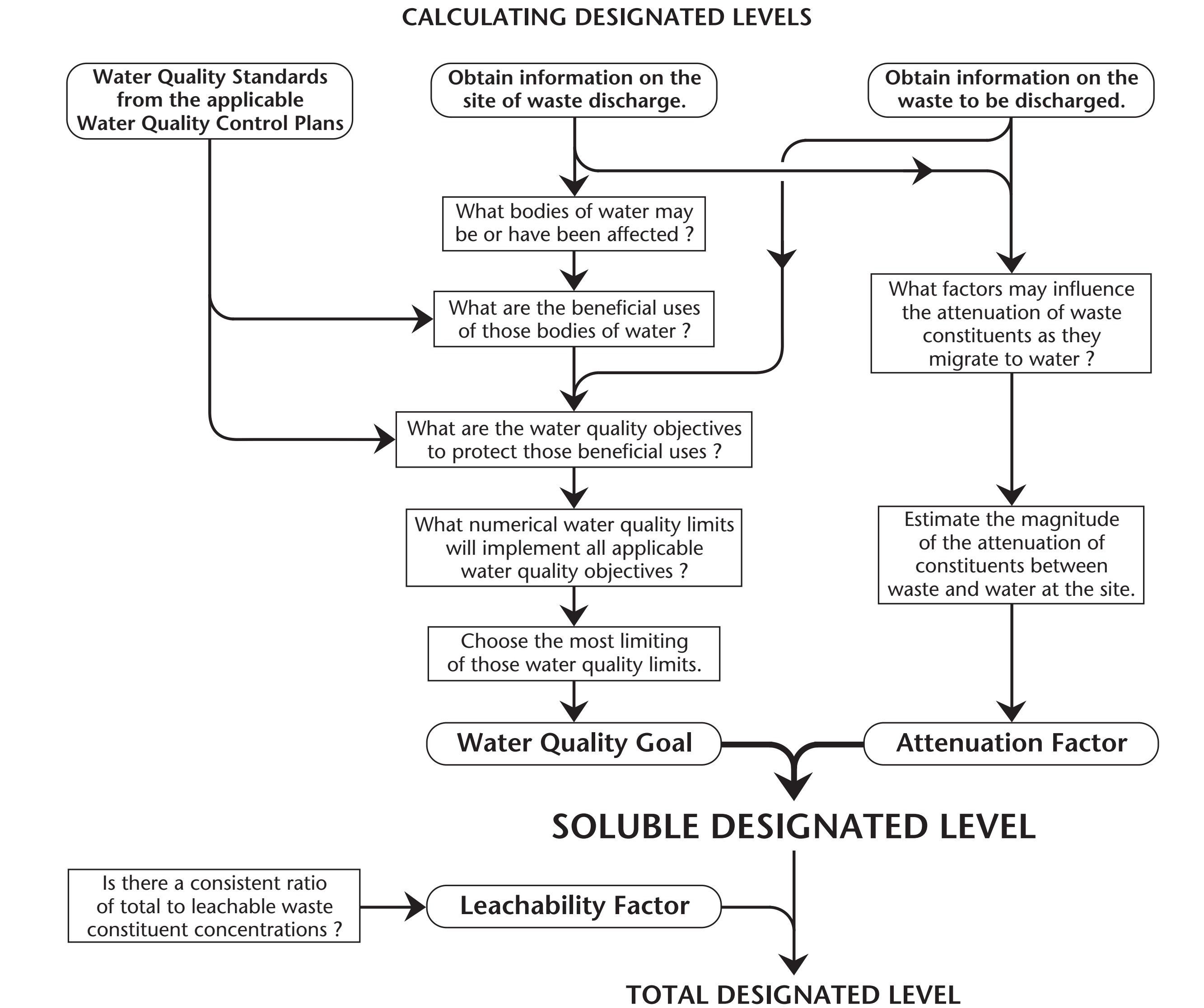

Figure 5

smallest degree of attenuation that would be expected to occur for the particular constituent at the specific site of discharge is approximated by an "environmental attenuation factor". The greater the amount of attenuation that is expected to occur, the larger the attenuation factor that would be assigned.

As shown in Figure 6, there are a variety of site-specific and constituent-specific characteristics which influence the magnitude of attenuation that may be expected to occur. Also shown are how increases in these environmental characteristics effect the magnitude of the anticipated attenuation and, therefore, the selection of environmental attenuation factors.

If ground water is threatened by waste constituents, increases in the depth to ground water (thickness of the vadose zone), in the clay content, organic matter content, ion exchange capacity or pH of vadose zone materials, and in the ionic strength, viscosity, degradability or octanol / water partition coefficient (the affinity of the chemical for octanol or soil organic matter versus its affinity for water) of the waste constituent will cause the attenuation factor to be larger (greater attenuation expected). Increases in the net recharge rate (a driving force for movement of waste constituents), in the permeability or porosity of vadose zone materials, in the polarity or volatility of the waste constituent, in the concentrations of solvents or other chemicals that can increase the permeability of soils or act as carriers for the constituent, or in the mass loading of waste constituents will cause the attenuation factor to be smaller (less attenuation expected as the constituent migrates to ground water).

If surface waters are threatened by constituents in a waste, increases in the distance of travel from the site of waste discharge to surface water, in the volatility, reactivity, degradability or octanol / water partition coefficient of the waste constituent, and in the amount of initial dilution that the waste or leachate would receive upon entering surface waters will cause the attenuation factor to be larger. Increases in the steepness of the terrain, in the polarity of the constituent, in the amount of interconnection between ground and surface waters, in the concentrations of solvents or other chemicals that can act as carriers for the constituent, and in the total constituent loading will lower the attenuation factor.

Undoubtedly the most important characteristic that must be evaluated in the derivation of environmental attenuation factors is the relative uncertainty of the data and assumptions used to quantify environmental fate processes. The more uncertainty involved in the estimation of environmental attenuation factors, the more the assumptions being used in their derivation should lean toward underestimating the amount of attenuation expected to occur. In this way, a greater assurance of water quality protection is provided. The degree of uncertainty in the estimation of environmental attenuation should also be reflected in the amount of vadose zone and ground water monitoring that is required for a waste management unit. Greater uncertainty necessitates a greater monitoring effort to assure that the attenuation factor setting process was sufficiently protective of water quality.

Site- and constituent-specific information regarding key environmental fate characteristics under reasonable worst-case conditions may be used to estimate attenuation factors for specific waste constituents at a site. Publications such as *The California Site Mitigation Decision Tree Manual* from DTSC, *The Soil Chemistry of Hazardous Materials* by James Dragun, the USEPA publications *Superfund Exposure Assessment Manual*, *Water Related Environmental Fate of the 129 Priority Pollutants* and *DRASTIC: A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings*, and the *Handbook of Environmental Data on Organic Chemicals* by Karel Verschueren contain information and / or procedures that can be used to assess the fate of chemicals in the environment and to estimate environmental attenuation factors for specific waste constituents and site conditions. Computer models which are applicable to the waste constituents of concern and to the site's hydrogeologic conditions may also be used.

EXAMPLES OF ENVIRONMENTAL FATE CHARACTERISTICS WHICH INFLUENCE ATTENUATION FACTORS

As the following characteristics increase…	EFFECT ON ATTENUATION FACTOR: INCREASE	EFFECT ON ATTENUATION FACTOR: DECREASE
FOR THE PROTECTION OF GROUND WATER —		
• Depth to Highest Ground Water (incl. capillary fringe)	■	
• Net Recharge (i.e., [rainfall] — [evaporation])		■
• Characteristics of the Vadose Zone:		
Permeability and Porosity		■
Clay Content	■	
Organic Matter Content	■	
Ion Exchange Capacity and pH	■	
• Pollutant Characteristics:		
Polarity		■
Ionic Strength (more positive)	■	
Volatility (potential for vapor transport)		■
Viscosity	■	
Degradability or Biologic Activity	■	
Octanol/Water Partition Coefficient (Kow)	■	
• Other Constituents that Could Increase Mobility		■
• Topography (steepness of terrain)	■	
• Total Pollutant Load (mass loading)		■
• Uncertainty of the Data and Assumptions		■
FOR THE PROTECTION OF SURFACE WATERS —		
• Distance from Drainage Courses	■	
• Topography (steepness of terrain)		■
• Pollutant Characteristics:		
Volatility (loss to atmosphere)	■	
Reactivity or Degradability	■	
Polarity		■
Octanol/Water Partition Coefficient (Kow)	■	
• Other Constituents That Could Increase Mobility		■
• Initial Dilution Upon Reaching Surface Waters (min. surface water flow vs. max. pollutant flow)	■	
• Interconnection of Ground and Surface Waters		■
• Total Pollutant Load (mass loading)		■
• Uncertainty of the Data and Assumptions		■

Figure 6

If a waste discharger is unable or unwilling to expend the resources necessary to develop detailed and specific attenuation factors for the site of waste discharge, the Central Valley Regional Water Board has provided guidelines for the selection of generic attenuation factors based on the depth to ground water and the clay content of unsaturated zone soils.

Designated Levels for Liquid Wastes

Once the water quality goal is selected and an environmental attenuation factor is estimated, their values are multiplied together to obtain a Designated Level applicable to the specific liquid waste constituent and site of proposed waste discharge. If the concentration of a constituent in the liquid waste exceeds this level, the waste is classified as a "designated waste" and Class II containment is required if the waste is to be discharged to land for treatment, storage, or disposal at

SOLUBLE DESIGNATED LEVEL FOR A CONSTITUENT OF A SOLID WASTE

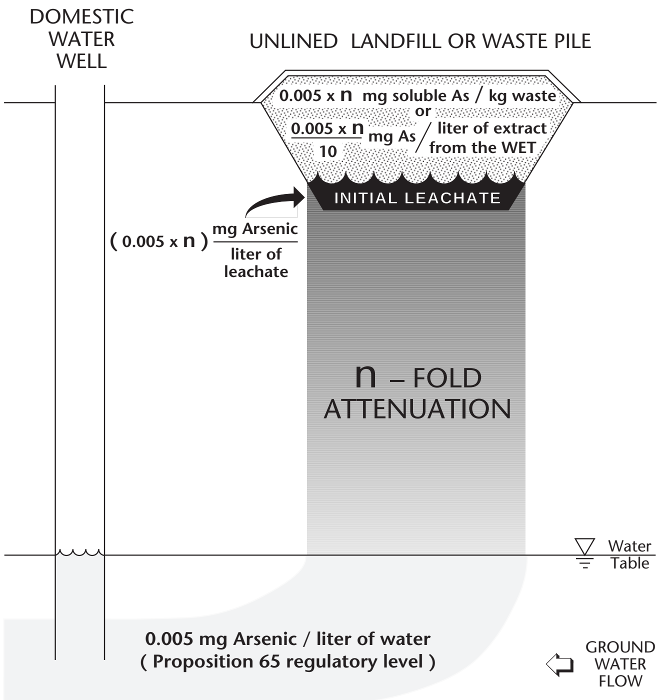

Figure 7

this site. Wastes having concentrations below the Designated Level are assumed not to pose a significant water quality threat at the site and may be discharged to a waste management unit with less than Class II containment.

Due to the constant hydraulic head and mass loading of waste constituents presented by long-term impounding of liquid wastes at a site, most wastes which have a quality poorer than that of underlying ground water will eventually degrade water quality. This occurs as attenuative mechanisms in the vadose zone become saturated. For this reason, such wastes are most often classified as “designated waste” and are required to be discharged to Class II impoudments.

Soluble Designated Levels for Solid Wastes

As moisture from within a waste or infiltrating rainfall percolates toward the base of a landfill, soluble waste constituents are accumulated and leachate is formed. Constituents in leachate at the base of a landfill pose a similar water quality threat to constituents in an impounded liquid waste. The processes of environmental fate which act to attenuate constituent concentrations are the same in either case. Therefore, Designated Levels may be calculated for leachate constituents in the same manner as for liquid waste constituents, as shown in Figure 7. In this example, the Proposition 65 regulatory level for arsenic (0.005 mg/l) has been chosen as the water quality goal to protect ground water at this site for domestic supply, and the environmental attenuation factor has been estimated to be equal to “n”. The Designated Level for arsenic in leachate at this site would be equal to (0.005 ×n) milligrams arsenic per liter of leachate.

The goal in calculating Designated Levels for a solid waste is to determine concentrations of soluble constituents in the waste above which leachate may carry them to ground or surface waters in amounts that could cause water quality goals to be exceeded. Therefore, the next step in the methodology is to convert the Designated Level for leachate into one which may be applied to leachable concentrations of constituents in a solid waste prior to disposal. Rationale presented by DTSC in the 1984 *Statement of Reasons for the Hazardous Waste Identification Regulations* indicates that the concentrations of constituents in leachate could either be numerically higher or lower than the soluble constituent concentrations in the solid waste prior to leaching. In the calculation of Designated Levels, these concentrations are assumed to be numerically equal, as in DTSC’s *Statement of Reasons*. Therefore, the Soluble Designated Level for a constituent in a solid waste is numerically the same as the Designated Level for the same constituent in leachate which forms at the base of the landfill—the water quality goal times the environmental attenuation factor. In the example of Figure 7, the Soluble Designated Level for arsenic in the solid waste is (0.005 ×n) milligrams of soluble arsenic per kilogram of waste.

Soluble concentrations of constituents in solid wastes are determined by performing the Waste Extraction Test (WET) from Title 22 of CCR, Division 4.5, Chapter 11, Appendix II, or a variation of this test. [The Toxicity Characteristic Leaching Procedure (TCLP) from Title 22 of CCR, Division 4.5, Chapter 18, Appendix I, is used for volatile waste constituents.] The WET involves a ten-fold dilution of solid waste into an extract solution, agitation for 48 hours, followed by filtration and analysis of the liquid phase. Results are expressed in milligrams of extractable constituent per liter of extract solution. Therefore, the WET extract is expected to be ten-times more dilute than actual landfill leachate. The Soluble Designated Level for a constituent of a solid waste, expressed in milligrams per liter (mg / l) of WET extract, is equal to the water quality goal times the environmental attenuation factor divided by the ten-fold dilution of the test. [Due to differences in the test methods, a 20-fold dilution factor is used in calculations based on TCLP results.] For the Figure 7 example, the Soluble Designated Level for arsenic is equal to $(0.005 \times n \div 10)$ mg / l of WET extract.

Concentrations of constituents in landfill leachate should not be confused with concentrations of constituents in extract from the Waste Extraction Test or the Toxicity Characteristic Leaching Procedure. They are not the same. Concentrations of constituents in leachate are the result of the accumulation of constituents from the waste as moisture migrates through a landfill or waste pile. The ratio of liquid-to-solids is not expected to be large within a landfill. Concentrations of constituents in the extract from the WET or the TCLP are the result of specific laboratory procedures where waste constituents are extracted from a solid waste by an extract solution under a large liquid-to-solids ratio necessary to ease sample handling. The extract from the WET or the TCLP is, therefore, not a simulation of leachate, but a means to measure the *amounts* of waste constituents that may be leached from the waste in a landfill. As stated above, actual landfill leachate is expected to have considerably higher pollutant concentrations than WET or TCLP extracts due mainly to this difference in liquid-to-solids ratio.

Contaminated Site Assessment

DTSC has prepared guidance materials which contain procedures for performing risk assessments and determining cleanup / mitigation levels for sites contaminated with toxic substances. The object of these procedures is to prevent toxicologic impacts on humans and other potential "biological receptors of concern". While sufficient to cover DTSC's concerns regarding site assessment and cleanup, the procedures in these documents are not designed to fully protect water resources that may be adversely impacted by site contaminants, as required by the Porter-Cologne Water Quality Control Act. Therefore, another methodology must be used by the State and Regional Water Boards to fulfill this need.

Comparison of Figures 7 and 8 reveals that the threat posed to water quality by contaminated soils is similar to that posed by wastes in an unlined landfill. Therefore, *The Designated Level Methodology* can be used to calculate Designated Levels for site contaminants which, if exceeded, indicate a threat to the beneficial uses of nearby ground or surface waters. California's water quality standards (from the applicable Water Quality Control Plans) are used to select water quality goals which protect the beneficial uses of waters which could be adversely impacted by site contaminants. Attenuation factors are estimated based upon site hydrogeologic data and information on the contaminants themselves. Soluble Designated Levels are then calculated by multiplying the water quality goals by the attenuation factors and dividing by the ten-fold dilution of the WET or the 20-fold dilution of the TCLP (for volatile contaminants). The results are expressed as milligrams of soluble constituent per liter of extract.

Soil samples from the site are subjected to the WET and / or TCLP procedure and results are compared with these site- and constituent-specific Soluble Designated Levels. Cleanup or mitigation would be required for soils having extractable concentrations which exceed

SOLUBLE DESIGNATED LEVEL FOR SOIL AT A CONTAMINATED SITE

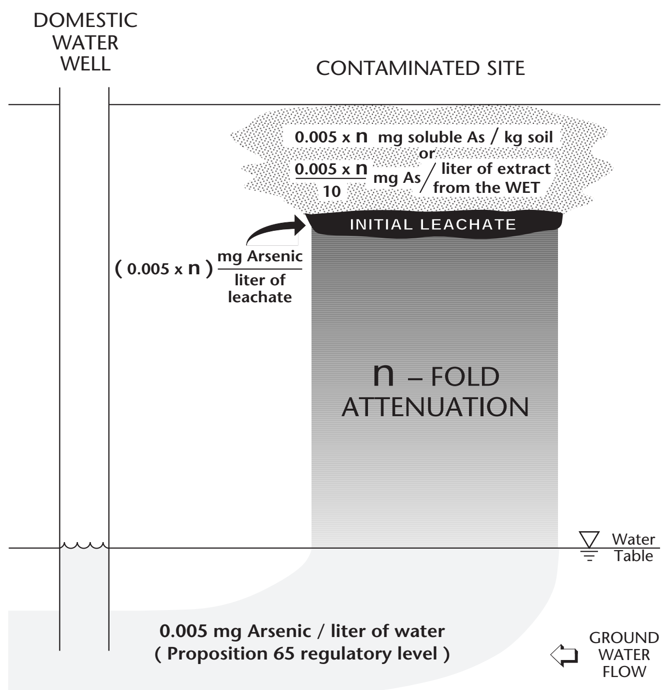

Figure 8

Soluble Designated Levels. For this type of site assessment, the WET procedure is often modified to account for conditions that exist at the site. The standard WET uses an buffered acidic extraction solution designed to account for the acidic conditions often encountered in sanitary landfills. If soils at the site being investigated will only exist under neutral or basic conditions, deionized water or another more suitable extraction solution may be substituted for the standard WET buffer solution.

Soil Cleanup Levels

If contaminated soils are found to threaten beneficial uses of ground or surface water resources, cleanup levels must be chosen. To satisfy the antidegradation policy, and recently readopted State Water Board Resolution No. 92-49, *Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304*, background concentrations of contaminants must be chosen as cleanup levels, unless background levels are technologically or economically infeasible to achieve.

If background levels are determined to be infeasible, cleanup levels greater than background may be selected. As detailed in §2550.4 of Title 23 of CCR, such cleanup levels must:

- ❏ be the lowest concentrations for the individual pollutants which are technologically and economically achievable;
- ❏ not pose a hazard to health or to the environment; and
- ❏ not exceed the maximum concentrations allowable under applicable statutes and regulations for individual pollutants, including applicable water quality standards.

While conventional risk assessment can be used to satisfy the second of these requirements, this technique will not satisfy the third requirement. Designated Levels for contaminated soil constituents, calculated by using the *Designated Level Methodology*, may be used to determine compliance with this last requirement, i.e., that remaining contaminants do not threaten to exceed California's water quality standards.

Conclusion and Status

The staff report, *A Compilation of Water Quality Goals* has been developed to provide a uniform method and a convenient source of numerical limits for determining compliance with California's water quality standards. It has been used for several years by the staff of a number of the California Regional Water Quality Control Boards as a reference for numerical water quality limits.

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 Water Board staff resources are made available for the effort.

When combined with the waste classification, site assessment, and cleanup level setting processes of DTSC and the State Water Board's Chapter 15 regulations, *The Designated Level Methodology* can provide a complimentary set of procedures to ensure the protection of both public health and California's water resources. Comments received during public review of an early draft of *The Designated Level Methodology* staff report were used to produce the October 1986 edition. In June 1989, an updated edition of the report was produced to bring the document in line with then-existing statutes, regulations, and waste testing methods. Further updating of this nature is needed, and will be made as Regional Board staff resources are made available for the effort.

Staff of the Central Valley Regional Water Quality Control Board has shared these reports with the State Water Board and the other Regional Water Boards, and has been working with staff of the State Water Board to develop statewide policy in this area.

Copies of the staff reports my be obtained by mail or in person from the reception desk at the Sacramento Office of the Regional Water Board. *Water Quality Goals* costs $26; while the *Designated Level Methodology* cost $20. Payment must accompany all requests. *Water Quality Goals* may also be obtained free of charge from the State Water Resources Control Board's electronic bulletin board (916/657-9722) or Internet world-wide-web site (http://www.swrcb.ca.gov). The electronic copy includes all of the information contained in the hard copy version as, well as a database of numerical water quality limits that is searchable by chemical name.

March 1996

Glossary

Beneficial Uses — Uses of water that must be protected against water quality degradation. They are established by the Water Boards in the *Water Quality Control Plans*. See “water quality standards.”

Water Quality Criteria — Numerical or narrative limits for constituents or characteristics of water designed to protect specific designated uses of the water. California’s water quality criteria are called “water quality objectives.” See “water quality standards.”

Water Quality Goal — The most stringent, applicable, numerical water quality limit for a constituent or parameter of concern in a specific body of ground or surface water at a specific site that is chosen to protect either (1) existing water quality or (2) beneficial uses ofwater. In the first case, the water quality goal is set equal to the background level in the body of water. In the second case, the water quality goal is also a ***beneficial use protective numerical limit*** and is set at the less stringent of either (a) the numerical limit which implements all applicable water quality objectives or (b) the true background level.

Water Quality Objectives — Numerical or narrative limits on constituents or characteristics of water designed to protect designated beneficial uses of the water. California’s water quality objectives are established by the State and Regional Water Boards in the *Water Quality Control Plans*. See “water quality standards.”

Water Quality Standards — A combination of the designated beneficial uses of water and water quality objectives (criteria) to protect those uses. In California, water quality standards are promulgated by the State and Regional Water Boards in the *Water Quality Control Plans*. Water quality standards are enforceable limits for the bodies of surface or ground waters for which they are established.