CHAPTER 5 ASSESSMENT

In order to protect water quality, we must define and measure it, identify the types and sources of pollution, and implement plans to protect, maintain, and restore water quality. The state of Texas uses a dynamic, flexible cycle of activities to manage water quality. Steps in the cycle include:

- **Standards and Planning**: setting standards for surface water quality and revising or formulating monitoring plans;
- **Monitoring**: collecting data to monitor the condition of surface waters;
- **Assessment and Targeting**: assessing data to determine water quality status and to identify any impairments;
- **Developing Strategies**: for protecting, improving, or restoring water quality with pollutant source controls and practices; and
- **Implementing Pollution Controls**: for both point and non-point sources and evaluating progress, which may lead back to revising those plans or formulating new ones.

Implementing this cycle of activities involves coordination between many different entities and programs around the state of Texas. The development of implementation plans and the implementation of those plans will be discussed in Chapter 7.

Surface Water Assessment

The major surface waters of Texas have been divided into classified water segments. A single river may consist of several classified segments. The term segment refers to a defined, basic unit for assigning site-specific standards, and is intended to have relatively common biological, chemical, hydrological, and physical characteristics. Segments will also normally exhibit common reactions to external stresses such as discharges or pollutants. The establishment

Texas has a large number of water bodies. There are 11,247 streams and rivers large enough to be named, with a total combined length of 191,228 miles. However, only 40,194 miles of streams and rivers (21%) are considered perennial, meaning that they have sustained flow throughout the year. Texas also has 9,993 inland reservoirs and lakes 10 acres or larger in size that together cover approximately 1,994,600 acres. Of those, 211 are major reservoirs which are greater than 5,000 acre-feet each. Texas bays and estuaries cover approximately 2,393 square miles along a coastal shoreline that stretches 624 miles in length. The Gulf of Mexico, within Texas' jurisdiction covers approximately 3,879 square miles. In the conterminous United States, Texas ranks first in total square miles covered by fresh water and saltwater with 4,959.

of segments facilitates planning activities, issuance of permits, and allocation of grant funds necessary to implement various sections of the federal Clean Water Act. Texas currently recognizes 225 stream segments, 100 reservoir segments, and 48 estuary segments. The Gulf of Mexico is treated as one segment. Texas surface water quality standards and the assessment of water quality are based on these classified segments.

Protecting Surface Water Quality

The TCEQ Water Quality Standards Team is responsible for establishing and revising standards to protect surface water quality. The Texas Surface Water Quality Standards (TSWQS), §30, Chapter 307 of the Texas Administrative Code, recognize the regional and geologic diversity of the state. Appropriate water uses are designated for each of the classified segments. Numerical and narrative criteria established in the TSWQS provide a basis for assessing water quality, evaluating use support, and managing point and nonpoint source loadings in Texas surface waters. The TSWQS are designed to:

- establish numerical and narrative criteria for water quality throughout the state;
- provide a basis on which TCEQ regulatory programs can establish reasonable methods to implement and attain the state's standards.

Water quality standards are protective; that is, if one or more water quality standard is not being met in a classified segment, there is some possibility that water quality may be inadequate to meet the designated uses. For example, a water body fails to meet the dissolved oxygen standard established to support aquatic life use, yet no fish kills are observed. However, a decline in the variety or number of aquatic species and an increased probability of fish kills may exist.

Uses

Four general categories of use are defined in the Texas Surface Water Quality Standards: aquatic life use, contact recreation, domestic water supply, and fish consumption.

Aquatic Life Use

The standards associated with this use are designed to protect plant and animal species that live in and around the water. They establish optimal conditions for the support of aquatic life and define indicators used to measure whether these conditions are met. Some pollutants or conditions that may jeopardize this use include low levels of dissolved oxygen, toxic substances such as metals or pesticides, or excess turbidity.

Contact Recreation

The standard associated with this use measures the level of certain bacteria in water to estimate the relative risk of swimming or other water sports involving direct contact with the water. It is possible to swim in water that does not meet this standard without becoming ill; however, the probability of becoming ill is higher than it would be if bacteria levels were lower.

Domestic Water Supply

Domestic water supply consists of two subcategories: Public Water Supply and Aquifer Protection.

Public Water Supply. Standards associated with this use indicate whether water from a lake or river is suitable for use as a source for a public water supply system. Source water is treated before it is delivered to the tap and must meet a separate set of standards established for treated drinking water. Indicators used to measure the safety or usability of surface water bodies as a source for drinking water include the presence or absence of substances such as metals or pesticides. Concentrations of salts, such as sulfate or chloride, are also measured, since treatment to remove high levels of salts from drinking water is expensive.

Aquifer Protection. Segments designated for aquifer protection are capable of recharging the Edwards Aquifer. The principal purpose of this use designation is to protect the quality of water infiltrating and recharging the aquifer. The designation for aquifer protection applies only to those designated portions of the segments that are on the recharge zone, transition zone, or contributing zone of the Edwards Aquifer.

Fish Consumption

The standards associated with this use are designed to protect the public from consuming fish or shellfish that may be contaminated by pollutants. The standards identify levels at which there is a significant risk that certain toxic substances dissolved in water may accumulate in the tissue of aquatic species. However, because pollutant concentrations in water do not always predict when toxic substances will accumulate in fish, the state also conducts tests on fish and shellfish tissue to determine if there is a risk to the public from consuming fish caught in state waters. The standards also specify bacterial levels in marine waters to assure that oysters or other shellfish that may accumulate bacteria from the water are safe for commercial harvest, sale, and consumption by the public.

Water Quality Indicators

Specific indicators of water quality such as bacteria, dissolved solids, and organics are also described in the standards. Several different parameters may be measured to determine whether a water body meets its designated uses. Some of the most common are listed here, with an explanation of why they are important to the health of a water body.

Fecal Coliform, E. Coli, and Enterococci Bacteria

These bacteria are measured to determine the relative risk of swimming or other water sports. These bacteria are found in the waste of warm-blooded animals. Their presence may indicate that pathogens also in these wastes may be reaching a body of water from sources, such as, inadequately treated sewage, improperly managed animal waste from livestock, pets in urban areas, or failing septic systems.

Dissolved Oxygen

The concentration of dissolved oxygen is a single, easy-to-measure characteristic of water that positively correlates with the abundance and diversity of aquatic life in a water body. A water body that can support diverse, abundant aquatic life is a good indication of high water quality. However, highly variable dissolved oxygen concentrations may indicate a related problem associated with an excess of nutrients in water. High concentrations of nutrients in water may stimulate excessive growth of vegetation which may result in very high dissolved oxygen concentrations during the day and very low dissolved oxygen concentrations at night. These conditions may have a negative impact on aquatic life use.

Dissolved Solids

High levels of dissolved solids, such as chloride and sulfate, can cause water to be unusable, or simply too costly to treat for the drinking water supply use. Changes in dissolved solids concentrations also adversely affect the water quality for aquatic life use.

Metals

Concentrations of metals can pose a threat to drinking water supplies and human health. Eating fish contaminated with metals can cause these toxic substances to accumulate in tissue, posing a risk to human health. Metals also pose a threat to livestock and aquatic life. Potentially dangerous levels of metals and other toxic substances are identified through chemical analysis of water, sediment, and fish tissue.

Organics

Toxic substances from pesticides and industrial chemicals, called organics, pose the same concerns as metals. Polychlorinated biphenyls (PCBs), for example, are industrial chemicals that are toxic and probably carcinogenic. Although banned in the United States in 1977, PCBs remain in the environment, and they accumulate in fish and human tissues when consumed. Potentially dangerous levels of toxic substances are identified through chemical analysis of water, sediment, and fish tissue.

Fish Consumption Advisories and Closures

The Texas Department of State Health Services (DSHS) conducts chemical testing of fish tissue to determine whether there is a risk to

human health from consuming fish or shellfish caught in Texas streams, lakes, and bays. Fish seldom contain levels of contaminants high enough to cause an imminent threat to human health, even to someone who eats fish regularly. Risk increases for those persons who regularly consume larger fish and predatory fish from the same area of contaminated water over a long period of time. When a fish consumption advisory is issued, a person may legally take fish or shellfish from the water body under the advisory, but should limit how much fish he or she eats, and how often. When a fish consumption closure is issued, it is illegal to take fish from the water body.

Data Collection

Better understanding the relationship between land and water starts with monitoring the condition of water quality. The mission of the TCEQ Surface Water Quality Monitoring (SWQM) program is to characterize the water quality of the ambient surface waters of the state.

Monitoring activities can be grouped into five categories: routine monitoring, systematic monitoring, targeted monitoring, permit support monitoring and effectiveness monitoring:

Routine monitoring is designed to assess the status and trends of overall water quality throughout the state, and for each river basin. Data are collected using a monitoring network of key sites on the major water bodies in each basin on a regular basis. Monitoring sites may also include smaller water bodies to support characterization of ecoregions and/or basin-specific conditions.

Systematic monitoring focuses on evaluating subwatersheds and unclassified water bodies. Its purpose is to investigate and detect areas of concern, and identify issues that require further study. It also includes monitoring at sites to check the status of water bodies (identify improvements or concerns). This monitoring strategy rotates resources around the river basin to gather information on water bodies that would not normally be included in the routine monitoring program.

Targeted monitoring is conducted on water bodies where there is reason to believe there is a threat or a concern for water quality, to establish the extent and degree of an impairment, or to determine the best strategy for restoring water quality. Sometimes called special studies, targeted monitoring activities usually involve intensive periods of data collection at sites where routine or systematic monitoring identified impacts, concerns, or impaired uses.

Permit support monitoring is used to address specific areas where additional information is need to determine appropriate limits for

wastewater discharges. This may include studies to gather site-specific information for use in developing permits.

Effectiveness monitoring is conducted to evaluate whether management practices, regulatory measures, and watershed improvement and restoration plans are producing the desired results.

Monitoring Coordination

The CRP plays a key role in the TCEQ's yearly integration of these various monitoring needs into a coordinated monitoring schedule for the entire state. The schedule shows all surface water monitoring being conducted by the TCEQ or under its contracts or cooperative agreements for each planning year.

Planning and development of the coordinated monitoring schedule takes place from January through May preceding the state fiscal year for which the plan is developed. To support coordinated monitoring, the TCEQ has developed guidance for selecting sites and for sampling methods for routine, systematic, and targeted monitoring. The coordinated monitoring schedule is hosted by the Lower Colorado River Authority, a CRP Planning Agency, on its Web site at *http://cms.lcra.org/*.

Texas Commission on Environmental Quality Surface Water Quality Monitoring Program

The TCEQ's Surface Water Quality Monitoring (SWQM) Program is coordinated by the Surface Water Quality Monitoring Team and by staff in the TCEQ's 16 regional offices. Routine monitoring and special studies are conducted by SWQM personnel.

Finished drinking water data is collected by the TCEQ's Drinking Water Quality Program. Additional supporting information is provided by the Source Water Assessment and Protection Program (discussed in Chapt 5).

Clean Rivers Program

The CRP is a collaboration of 15 regional water agencies with the TCEQ. It is a unique, water quality monitoring, assessment, and public outreach program that is funded by state fees assessed on the number and size of wastewater treatment plants and surface water right permittees that reside within each river basin. The CRP provides the opportunity to approach water quality issues at the local level through coordinated efforts among diverse agencies, various programs, and the public.

Cost-effective watershed management decisions must be based on scientifically valid and complete assessments of water quality conditions and contributing causes of impact. Water bodies should be selected upon the importance of the resource, risk from pollution, and with input from

the Steering Committees (discussed in Chapter 4). Monitoring activities include fixed monitoring, systematic monitoring, targeted monitoring, and special studies.

United States Geological Survey

The United States Geological Survey (USGS) also conducts a large amount of monitoring statewide and much of the data are utilized by the TCEQ. The USGS surface water collection network in Texas is primarily established to monitor stream flow continuously at many permanent sites. Field measurements, routine water chemistry, and metals in water are also collected at many of the fixed sites. Sites are chosen to represent a mix of natural and human factors that influence water quality. Chemical variables are then related by the USGS to hydrologic conditions to interpret water-resource conditions and meet water quality management needs. Estimation of point and nonpoint source loadings, stormwater management, and chemical-contaminant controls are some of those needs.

Other Sources

Additional data from other state and federal agencies, cities, and other monitoring groups can be assessed in the evaluation of water quality if the data meet clearly defined acceptance and time line criteria established by the TCEQ. Previous contributors of data of this type include the Texas Department of State Health Services (DSHS), Texas Parks and Wildlife Department (TPWD), Texas Institute for Applied Environmental Research (TIAER), and Texas Watch.

Assessing the Data

The current condition of Texas surface water resources and the effectiveness of protection and restoration activities are evaluated by assessing the available data. The physical, chemical, and biological characteristics of aquatic systems are assessed in relation to human health concerns, ecological conditions, and designated uses. Water quality data may be used to:

- characterize existing conditions,
- evaluate spatial and temporal trends,
- determine water quality standards compliance,
- identify emerging problems, and
- evaluate the effectiveness of water quality control programs.

Water Quality Inventory

The TCEQ evaluates the condition of the state's water bodies on a periodic basis as required by CWA§305(b). The results of this evaluation are contained within the *Texas Water Quality Inventory and 303(d) List* which is prepared by the TCEQ's SWQM team and submitted to the EPA for

approval. One of five categories is assigned to each parameter and area of a water body, known as an assessment unit, to provide more information to the public, EPA, and agency staff about water quality status, management plans, and management activities. When an assessment unit has multiple parameters, the highest category is assigned to the assessment unit. When a water body has multiple assessment units, an overall category is assigned to the entire water body. The table below summarizes the categorization of water bodies in Texas. Categories four and five represent the list of impaired water bodies as required by CWA§303(d).

Table 5.1 Categories of the Texas Water Quality Inventory and 303(d) List

Category 1	Attaining the water quality standard and no use is threatened.
Category 2	Attaining some of the designated uses; no use is threatened; and insufficient or no data and information are available to determine if the remaining uses are attained or threatened.
Category 3	Insufficient or no data and information to determine if any designated use is attained.
Category 4	Standard is not supported or is threatened forone or more designated uses but does not require the development of a TMDL.
Category 4a	TMDL has been completed and approved by EPA.
Category 4b	Other pollution control requirements are reasonably expected to result in the attainment of the water quality standard in the near future.
Category 4c	Nonsupport of the water quality standard is not caused by a pollutant.
Category 5	Category 5 is the 303(d) list. The water body does not meet applicable water quality standards or is threatened for one or more designated uses by one or more pollutants.
Category 5a	A TMDL is underway, scheduled, or will be scheduled.
Category 5b	A review of the water quality standards will be conducted before a TMDL is scheduled.
Category 5c	Additional data and information will be collected before a TMDL or review of the water quality standard is scheduled.

Nonpoint Source Assessment

The CWA §319(a) assessment focuses only on those waters which have been identified as being degraded, at least in part, by nonpoint source pollution. Texas' CWA §319(a) assessment of impaired waters is based on the Texas Water Quality Inventory and 303(d) List. In order to address the most current priorities for Texas and have a NPS program based on the most current information, the latest state approved Texas Water Quality Inventory and 303(d) List will serve as the state's 319(a) assessment.

NPS-degraded surface waters appearing in the report will be targeted by the state for additional NPS monitoring and restoration activities.

With regards to CWA §319(h) grant funding, priority for assessment dollars is given to those water bodies that fall under categories 5a, 5b, and 5c of the Texas Water Quality Inventory and 303(d) List. Assessment dollars may also be used to fund development of TMDL Implementation Plans or Pollution Reduction Strategies for water bodies in categories 4a, 4b, and 4c. These plans are discussed in Chapter 6.

Basin Status Reports

Each CRP partner agency collects information on potential sources of pollution throughout its planning area or river basin. This information is used to correlate water quality to the environmental factors that influence it, such as soils, climate, hydrology, wastewater treatment plans, urban runoff, and agricultural runoff. An annual basin status report, the Basin Highlights Report, is produced by each regional water agency, and provides an overview of water quality issues and the status of ongoing projects/tasks. A detailed and in-depth data analysis is provided for each basin in the Basin Summary Report once every five years. This report provides trend analysis, spatial analysis (correlating environmental factors to water quality), an explanation for why certain water quality issues exist, and recommendations for addressing persistent water quality problems. The CRP strives to report water quality data in a user-friendly format to inform the public. The information contained in these reports is utilized by the TCEQ in the development of the Texas Water Quality Inventory and 303(d) List, subsequent statewide rankings, and prioritization of management strategies.

Total Maximum Daily Loads (TMDLs)

A TMDL, or Total Maximum Daily Load, is a tool for achieving water quality standards and is based on the relationship between pollution sources and in-stream water quality conditions. TMDLs are developed to provide an analytical basis for planning and implementing pollution controls, land management practices, and restoration projects needed to protect water quality. The TMDL establishes the allowable loadings or other quantifiable parameters for a water body and thereby provides the basis to establish water quality-based controls. These controls provide the pollution reduction necessary for a water body to meet water quality standards.

CWA§303(d) and its implementing regulations (40 CFR §130.7) require states to identify waters that do not or will not meet applicable water quality standards after the application of technology-based or other required controls, and to establish TMDLs for pollutants that are causing non-attainment of water quality standards. For listed waters, States must

develop TMDLs allowing for seasonal variations and an appropriate margin of safety. A TMDL is a quantitative assessment of water quality problems, contributing sources, and load reductions or control actions needed to restore and protect individual water bodies.

TMDLs address all significant stressors which cause water body use impairment, including: point sources (e.g., sewage treatment plant discharges), nonpoint sources (e.g., runoff from fields, streets, range, or forest land), and naturally occurring sources (e.g., runoff from undisturbed lands). A TMDL is the sum of the individual wasteload allocations for point sources, load allocations for nonpoint sources and natural background pollutants, and an appropriate margin of safety. TMDLs may address individual pollutants or groups of pollutants, as long as they clearly identify the links between the water body use impairment, the causes of the impairment, and the load reductions needed to remedy the impairment.

Public participation is an integral part of the TMDL process. Therefore, the TMDL process provides many opportunities for the public to participate. Listed below are a few of the ways the public can participate in the TMDL process:

- In most cases a watershed committee is established to provide local input on TMDL projects. The public is encouraged to work on these committees or attend these committee meetings.
- TMDL meetings are open to the public. Public notices are provided for these meetings. These meetings provide an opportunity to make comments and get answers to questions.
- The public is given a chance to review and provide comments on the development of the current CWA§303(d) list for the state.
- Before the state adopts a TMDL, a formal public comment period is provided in which the draft TMDL is made available, a public comment hearing is conducted, and responses to all comments are published.
- Resources are available to assist the public's participation in the TMDL process. The TCEQ website provides information about the TMDL program, the status of individual TMDL projects, and links to other TMDL-related websites. The TCEQ has also published printed materials such as Developing Total Maximum Daily Load Projects in Texas: A Guide for Lead Organizations, which provides valuable information on the TMDL process in Texas.

The development of TMDLs begins with the review of existing data and/or the collection of additional data related to water quality, point source discharge, precipitation, soils, geology, topography, and land use (construction, agriculture, mining, etc.) within the watershed. Next, models or other analytical methods are used to calculate pollutant loads

and the water quality response of the receiving water. The appropriate analytical method/model is selected based on the pollutants of concern, the amount of data available, and the type of water body. If a computer model is selected, data collected from the watershed may be used to calibrate and verify the model so that the computed values match those of known field data. The model can then be used to develop different scenarios, by first determining the amount of specific pollutants each source contributes, then calculating the amount each pollutant needs to be reduced, and finally specifying how the reduced pollutant load would be allocated among the different sources. In some cases, TMDLs can be based on readily available information and studies using simple analytical efforts to provide a basis for stressor assessment and implementation planning. In other cases, more complex, data intensive computer simulations are required.

Upon completion of data collection and analyses, a TMDL report is developed adopted by the state after a thorough public review and comment period. The state-adopted TMDL is submitted to EPA for review and approval. The TMDL Report consists of six component parts, each of which is presented and discussed below.

Problem Statement: The TMDL report includes an indication whether the segment is on the latest CWA§303(d) list and its priority, applicable water quality standards are identified, the pollutant or stressor of concern is identified, and the beneficial use impairment of concern is described. Historical water quality data from the impaired water body and its contributing watershed is presented and assessed. The TMDL report describes the characteristics of the water body such as drainage area, length, flow rates, depth, etc. The watershed is described including characterization of soil types, land uses, population, wildlife resources, and topography. The TMDL report includes a general description of the location of the impaired water body including information about the river basin, ecoregion, and political jurisdictions in which it is located.

Endpoint Identification: Numeric water quality target(s) for the TMDL are identified in the TMDL report, and the basis for target(s) as interpretation of water quality standards is documented. These targets identify the specific instream (and potentially watershed) goals or endpoints for the TMDL which equate to attainment of the water quality standard. In some cases, multiple indicators and associated numeric target values may be needed to interpret an individual water quality standard. In addition, some TMDLs may incorporate multiple numeric targets to account for seasonal differences in acceptable pollutant levels in a particular water body. In many cases where applicable standards are expressed in numeric terms, it is appropriate to set the numeric target equal to the numeric water quality standard.

In situations where applicable water quality standards are expressed in narrative terms, it is necessary to develop a quantitative interpretation of

narrative standards. Since a TMDL is an inherently quantitative analysis, it is necessary to determine appropriate quantitative indicators of the water quality problem of concern in order to calculate a TMDL. It is sometimes possible to supplement instream indicators and targets with watershed targets-- measures of conditions within the watershed which are directly associated with water bodies meeting their water quality standards for the pollutant(s) of concern.

Source Analysis: Point, nonpoint, and background sources of pollutants of concern are described in the TMDL report, including the magnitude and location of sources. The TMDL document demonstrates all sources have been considered. The TMDL document provides estimates of the amounts of pollutants entering the receiving water of concern or, in some cases, the amount of pollutant that is bioavailable based on historic loadings stored in the aquatic environment. These pollutant sources or causes of the problem are documented based on site-specific studies, literature reviews or other sources of information. Sources can be categorized in many ways, including but not limited to discharge source, land use category, ownership, pollutant production process (e.g. sedimentation processes), and/or tributary watershed areas. The source analysis discusses the data and methods used to estimate source contributions.

Linkage Between Pollutant Sources and Water Quality in the Receiving Water: The TMDL document describes the relationship between numeric target(s) and the identified pollutant sources, leading to an estimate of the total assimilative capacity (loading capacity) of the waterbody for the pollutant of concern. The loading capacity is the critical quantitative link between the applicable water quality standards (as interpreted through numeric targets) and the TMDL. Thus, a maximum allowable pollutant load is estimated to address the site-specific nature of the impairment. The loading capacity reflects the maximum amount of a pollutant that may be delivered to the water body and still achieve water quality standards. A number of different loading capacity approaches can be used as part of TMDLs.

The loading capacity section discusses the methods and data used to estimate loading capacity. A range of methods can be used from predictive water quality models to inferred linkages based on comparison of local reference conditions with existing conditions in the watershed of concern. In some cases, loading capacity may vary within the watershed of concern (e.g., toxics loading capacity may be higher in areas with high water mixing rates than in backwater areas with poor water exchange), and in different time periods (e.g. nutrient loading capacity may be lowest during high temperature summer low flow periods). The basis for spatial and temporal variations in loading capacity estimates is discussed.

Margin of Safety: A margin of safety is included in the TMDL report to account for uncertainty in the understanding of the relationship between

pollutant discharges and water quality impacts. The TMDL document describes an explicit and/or implicit margin of safety for each pollutant. An explicit margin of safety can be provided by reserving (not allocating) portion of the loading capacity identified for the water body for the pollutant of concern. An implicit margin of safety can be provided by making and documenting conservative assumptions used in the TMDL analysis. The TMDL report provides an explanation of the basis for margin of safety which shows why it is adequate to account for uncertainty in the TMDL. Where an implicit margin of safety is provided, the report includes a discussion of sources of uncertainty in the analysis and how individual analytical assumptions or other provisions adequately account for these sources of uncertainty.

Load Allocations: The TMDL report identifies the total allowed pollutant amount and its components: appropriate wasteload allocations for point sources; load allocations for nonpoint sources; load allocation for an appropriate margin of safety; and, natural background. Allocation of allowable loads or load reductions among different sources of concern are determined. These allocations are usually expressed as wasteload allocations to point sources and load allocations to nonpoint sources. Allocations can be expessed in terms of mass loads or other appropriate measures. The TMDL equals the sum of allocations and cannot exceed the loading capacity. Load allocations for nonpoint sources are generally expressed as specific allocations for "gross allotments" to nonpoint source discharger categories. Separate nonpoint source allocations are established for background loadings. Allocations may be based on a variety of technical, economic, and political factors. The methodology used to set allocations is discussed.

Monitoring the Results

There are many different programs in place throughout the state that are responsible for conducting implementation activities. Upon implementing a best management practice (BMP) or other implementation activity it is necessary to determine the effectiveness of the activity. Data collected after implementation must be compared to data collected prior to implementation to determine effectiveness. These data may be historical, like that collected for a special study, or collected as part of the project tasks prior to implementation. In some cases, routine monitoring can be used to evaluate effectiveness. In other cases, it will be necessary to collect data in a specific project area to evaluate the effectiveness of the implementation activities. Certain types of BMPs or implementation activities will not show immediate results. Effectiveness and water quality improvements will be determined over time, and not immediately upon implementation. More about implementation activities will be discussed later in this document.

Groundwater Assessment

Groundwater supplies about 58% of all water used by Texans for domestic, municipal, industrial, and agricultural purposes. Approximately 36% of the water used for municipal supplies, and 75% of the water used for agricultural purposes is obtained from groundwater sources. This groundwater is produced from aquifers, which are underground layers of rock with water stored in pore spaces, cracks or voids. Major aquifers are defined as producing large quantities of water in a comparatively large area of the state, whereas minor aquifers produce significant quantities of water within smaller geographic areas or small quantities in large geographic areas. Minor aquifers are very important as they may constitute the only significant source of water supply in some regions of the state.

Nine major aquifers and twenty-one minor aquifers have been delineated within the state. These major and minor aquifers underlie approximately 76% of the state's surface area. Other undifferentiated, local aquifers may represent the only source of groundwater where major or minor aquifers are absent. These local aquifers, which provide groundwater that is used for all purposes, vary in extent from very small to several hundred square miles.

Measuring Groundwater Quality

The Texas Water Development Board (TWDB) is authorized by the Texas Water Code to conduct studies and map the state's water resources. The TWDB has identified the state's aquifers, and delineated the boundaries of major and minor aquifers based on yields and significance of aquifer production. These maps depict the extent of each aquifer, including where it is exposed at the surface, which is commonly where recharge occurs, as well as, the portion of the aquifer underground. For most aquifers, a Total Dissolved Solids (TDS) concentration of 3,000 milligrams per liter is used to mark the boundary of usable quality water when mapping aquifers. The boundary of the Edwards Aquifer, for mapping purposes, is defined by a TDS concentration of 1,000 milligrams per liter.

TDS are constituents in groundwater dissolved from the surrounding rock and are the basis for the Texas Groundwater Protection Committee's (TGPC) groundwater classification system.

Under this groundwater classification system, four classes are defined based on quality as determined by TDS concentration. Through classification, groundwater can be categorized, and protection or restoration decisions can be made according to the water quality present or potential use of the groundwater.

Table 5.2 TGPC Groundwater Classification System

CLASS	QUALITY*	EXAMPLES OF USE
Fresh	Zero to 1,000	Drinking and all other uses
Slightly Saline	More than 1,000 to 3,000	Drinking (if freshwater is unavailable), livestock watering, irrigation, industrial, mineral extraction, oil and gas production
Moderately Saline	More than 3,000 to 10,000	Potential/future drinking and limited livestock watering and irrigation (if fresh or slightly saline water is unavailable); industrial, mineral extraction, oil and gas production
Very Saline to Brine	More than 10,000	Mineral extraction, oil and gas production

*Concentration range of total dissolved solids in milligrams per liter.

The state has developed surface water quality standards applicable to certain water bodies that are protective of groundwater affected by surface water. For the recharge zone of the Edwards Aquifer, the state has developed water quality protection measures that specify groundwater recharge as a "designated use" in the state's surface water quality standards. The state has not developed standards for pollutant discharge to groundwater, although, the legislatively mandated (TWC §26.401) goal of non-degradation of use guides the priorities of groundwater programs. However, comparison of measured values for constituents of concern in major and minor aquifers with TDS concentration of 3000 mg/L, or less, against adopted Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCL's) provides an effective method of evaluating groundwater quality in aquifers for the intended use of drinking water.

Aquifer Vulnerability

Since groundwater contamination can remain latent for a lengthy period of time, and since groundwater is difficult to clean up once it has become impacted, the majority of Texas groundwater programs focus on prevention of contamination, rather than remediation. This is true of point-source regulatory and permitting programs, as well as NPS related programs like the Pesticides in Groundwater Program conducted under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) by TCEQ.

DRASTIC
D - **D**epth to water
R - annual **R**echarge
A - **A**quifer media
S - **S**oil media
T - **T**opography
I - vadose zone **I**mpact
C - hydraulic **C**onductivity

Previous NPS assessments have contained an aquifer vulnerability ranking system based on the average DRASTIC index for the aquifers of Texas. This ranking system is used

(Appendix D), because it is a reasonable method of determining the relative vulnerability of aquifers to surface activities, and by extension, possible NPS contamination.

Data Collection

The TWDB has the responsibility for collecting and maintaining an inventory of ambient groundwater conditions throughout the state. The TGPC relies upon ambient monitoring data from the TWDB for state groundwater quality information. The TWDB performs ambient groundwater monitoring on water wells in a particular number of Texas aquifers each year, so that all major and minor aquifers of the state are monitored approximately every five years. The TWDB maintains a database of ambient groundwater monitoring data for the state from over 51,000 water wells and is supplemented by data from the United States Geological Survey (USGS), the Bureau of Economic Geology (BEG), and the TCEQ. Also, many of the groundwater conservation districts throughout the state have well-developed monitoring programs that are primarily intended to monitor the volume of water in an aquifer, but also collect groundwater quality information. Data are maintained by the groundwater conservation district, and generally reported to the TWDB for inclusion in their ambient groundwater database.

Assessing the Data

For the groundwater portion of the *Texas Water Quality Inventory and 303(d) List*, ambient groundwater quality data are drawn from the TWDB database. The number of wells reporting values for constituents of concern above the MCL, or between the Minimum Detection Level (MDL) and the MCL are determined, and these values are posted in a table for each aquifer, along with the total number of wells sampled in that aquifer.

The data are augmented by the data taken from the annual *Joint Groundwater Monitoring and Contamination Report* that lists groundwater contamination cases of the regulatory programs of the TCEQ, Railroad Commission of Texas (RRC) and groundwater conservation districts. TCEQ reports data for groundwater contamination related to industrial and hazardous waste sites, municipal solid waste sites, leaking underground and above ground storage tanks, public drinking water supplies, wastewater disposal facilities, and other occurrences of contamination that may not be directly linked to a specific source or program. The RRC collects and reports data regarding groundwater contamination that may be related to oil and gas well drilling and production activities, transmission (pipeline) spills, and surface mining operations. Groundwater conservation districts typically monitor only those groundwater contamination cases that are of specific interest to the individual district, or those that do not fall under the regulatory umbrella of other agencies.

In 1996, the Texas Groundwater Protection Committee (TGPC) began the groundwater quality assessment process, through a partnership of the TCEQ and the TWD, two of its member agencies. Assessment of all thirty aquifers was completed in 2002. Each aquifer in the *2002 Water Quality Inventory and 303(d) List* is represented with a map showing the locations of water wells sampled and nitrate analyses exceeding EPA drinking water standards. Tables are included that show the parameters assessed against EPA drinking water standards, as well as, summaries of the sources and types of groundwater contamination at regulated facilities. This information is compiled from data contained in the *Joint Groundwater Monitoring and Contamination Report*.

Nitrate is readily soluble and mobile in water, and is considered one of the major human health concerns in drinking water. Coincidentally, nitrate concentration is an indicator of NPS pollution in groundwater, because it can move readily through the soil and vadose zone, entering aquifers by means of percolation. The vadose zone is the stratigraphic region between the soil surface and the water table, or the unsaturated zone. Nitrate in surface water indicates the potential for groundwater contamination.

Since no water quality standards have been designated for groundwater, an assessment standard of degradation or impairment with respect to use must be defined here. For the purposes of the NPS assessment, any measurements of groundwater quality taken from the aquifers listed in the *Texas Water Quality Inventory and 303d List* that exceed the Maximum Contaminant Levels (MCL) for nitrate in drinking water, are considered to be an indicator of either nonpoint source degradation or impairment, with respect to existing or potential use.

Constituents of concern that are above the Minimum Detection Level (MDL), but below the MCL, should be watched carefully over several report cycles. An increase in the number of detections of a constituent can signal a growing problem, even though the MCL has not been exceeded. Groundwater that indicates degradation with respect to existing or potential use will be targeted by the state for additional NPS monitoring and restoration activities.

The ranking for priority waterbodies that appear in Table B.2 are averaged and do not reflect the intrinsic vulnerability of outcrop areas and/or known areas where recharge is occurring. For this reason, spatial examination of contaminant distribution is vital to any true assessment of aquifer quality or vulnerability prediction.

Table B.2 ranks the Seymour, Edwards - Balcones Fault Zone in the San Antonio area, and Edwards - Balcones Fault Zone in the Austin area, as aquifers having "high" vulnerability rankings. The northern extent of the Ogallala, and Cenezoic Pecos Alluvium received "low" or low "medium" rankings, and the Hueco-Mesilla Bolsons rank "low" in the DRASTIC

based aquifer vulnerability ranking scheme. The Joint Groundwater Monitoring and Contamination Reports document a number of significant impacts to the usable groundwater zone of the Bolsons, and related investigations indicate a high potential for NPS impacts.

Upon further examination of the data from the *Texas Water Quality Inventory and 303d List*, it becomes readily apparent that constituent values exceeding the MCL occur predominantly in the "outcrop" portions of any aquifer with "outcrop" (unconfined) and "downdip" (confined) areas, or in the completely unconfined aquifers like the Ogallala, Seymour, and Cenezoic Pecos Alluvium. These "outcrop" areas of aquifers are more vulnerable to NPS impacts.

A spatial context reveals that a disproportionate number of high nitrate values occur in the Rio Grande Valley area of the aquifer. Therefore, this portion of the Gulf Coast aquifer must be labeled as impacted by NPS pollution.

Sampling sites exceeding an MCL for a given constituent will also be targeted. These would include the Lipan, Seymour, Marathon, Bone Spring-Victorio Peak, Edwards-Trinity (High Plains), Blaine, Ogallala, and Cenezoic Pecos Alluvium aquifers.

Future water quality inventories will contain more specific groundwater quality assessments for aquifers. This will allow the focus to be more narrow in determination of potential NPS impacts. The values for nitrate and other constituents in all reports may be revisited in the case of a change in the MCL values, as occurred with the 2003 EPA arsenic evaluation.

Monitoring the Results

The Texas Groundwater Protection Committee (TGPC), through the *Texas Groundwater Protection Strategy*, has commissioned the development of a new statewide groundwater monitoring program that will better evaluate the effectiveness of regulatory programs in preventing impacts from both point sources and nonpoint sources. Future activities of the TPGC, and of its member agencies, may be guided by the results of the new monitoring program.