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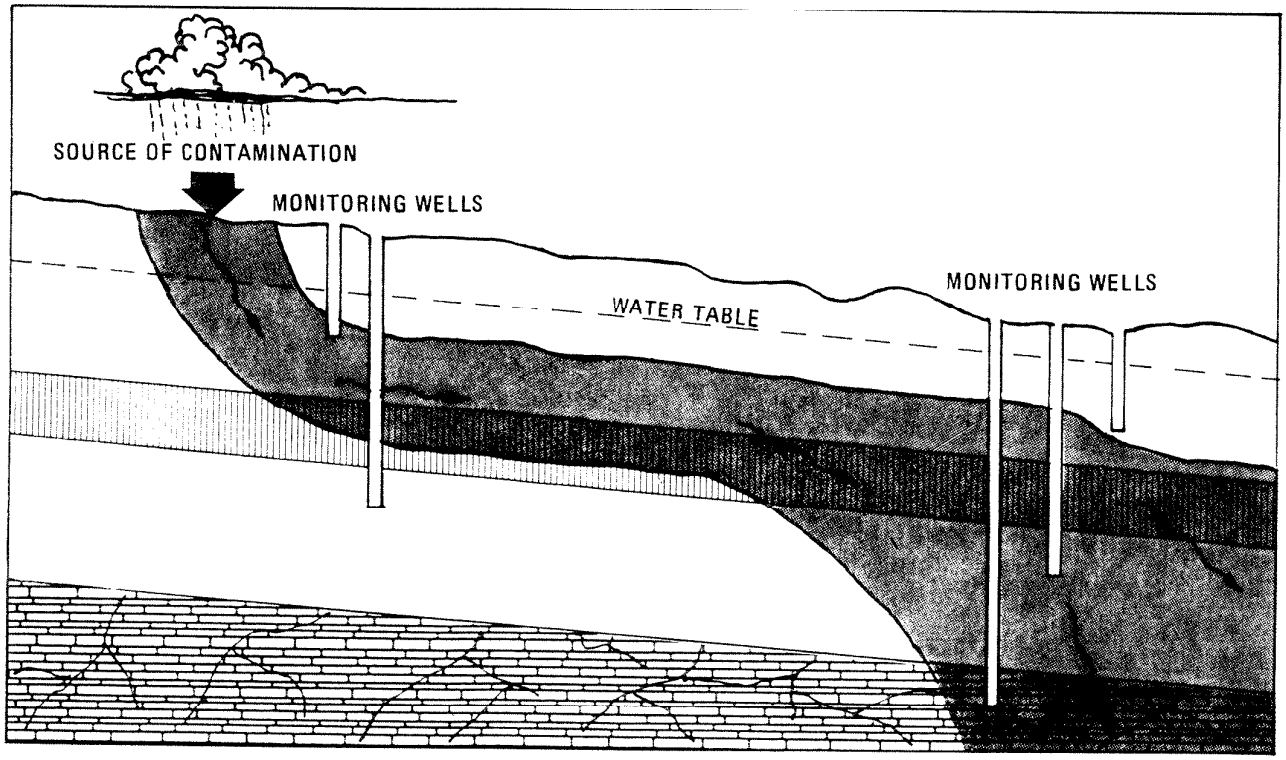
GROUND WATER MONITORING STRATEGY FOR WASHINGTON

II. SUMMARY OF GROUND WATER MONITORING ACTIVITIES

APRIL 1987



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WATER QUALITY INVESTIGATIONS SECTION
WASHINGTON STATE DEPARTMENT OF ECOLOGY

GROUND WATER MONITORING STRATEGY FOR WASHINGTON

II. Summary of Ground Water Monitoring Activities

April 1987

by

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I. Introduction

This report is the second in the five-report series, Ground Water Monitoring Strategy for Washington. The first report identified and described the Department of Ecology's (Ecology's) primary objectives for ground water monitoring. In addition, Report No. 1 examined the roles that different types of monitoring play in meeting these objectives such as ambient, intensive, and compliance monitoring.

This second report summarizes major, recent ground water monitoring and sampling activities in Washington State. It focuses mainly on studies conducted between 1970 and 1987.

A third report will evaluate these monitoring activities in terms of the objectives defined in the initial report. Objectives that are not being adequately addressed by present monitoring activities will be identified. New or expanded ground water monitoring activities to meet these needs will be outlined and prioritized.

The fourth report will describe development of a ground water monitoring program that will meet the priority ground water data needs for the present and enable updating as circumstances change.

Management of these ground water data will be evaluated in the fifth report. Recommendations will be included for improvements in accessibility, coordination, and ease of use.

Monitoring objectives usually drive a study and its design. The appropriate use of monitoring information is likewise related to the objective(s) for which it was collected. With this in mind, existing and recent ground water studies in Washington are organized according to the five objectives described in the first monitoring strategy report (Ecology, 1987):

1. Characterize the ground water resource
2. Promptly identify new problems
3. Assess known problems by determining cause-and-effect relationships
4. Ensure compliance with regulations
5. Evaluate program effectiveness

Major ground water studies are tabulated in Section V and are arranged by primary objective. Abstracted information on each study or monitoring program include: study location, type of sampling site, number of sampling sites, frequency and dates of sampling, parameters measured, quality assurance procedures, and secondary objectives (represented by the primary objective number).

Preceding Section V are introductory summaries of ground water monitoring activities. Section III presents a brief description of federal, state, and local ground water monitoring activities and data management capabilities. Section IV lists specific activities by agency, study location, date, and page of Section V where a more detailed summary is shown.

II. Purpose and Scope

Information describing ground water monitoring and sampling is presented in this report in three formats:

1. A general overview of federal, state, and local efforts.

2. A list of activities by federal, state, and local agencies, including location information and monitoring dates.

3. A detailed table of activities organized by primary objective. Under each objective, sampling efforts are listed by agency conducting or overseeing the study (beginning with federal, then state, and local).

Information presented here was obtained mainly from reports and personal communication with data gatherers in federal, state, local, and private organizations. The major ground water monitoring efforts in Washington are included. Undoubtedly, there are ground water monitoring efforts that I was not aware of, and are therefore not included, especially locally sponsored efforts.

III. Overview of Ground Water Monitoring Activities by Agency

The following summary of ground water monitoring efforts provides a general overview of federal, state, and local programs.

Federal

U.S. Geological Survey (USGS)

The U.S. Geological Survey has mainly been involved in ground water characterization studies in Washington. These are usually rather short-term studies to describe ground water flow and water quality. A few of these studies have been useful in modeling and managing ground water. Sea water intrusion studies have involved repeated sampling of some of the same wells, therefore have longer records for trend analysis. Several recent reconnaissance studies have dealt with hydrogeology at hazardous waste sites.

The USGS is also carrying out two ground water research studies: the Columbia Basin Regional Aquifer Systems Analysis (RASA) study which is part of a nationwide study of major aquifers and a study of the fate and movement of petroleum products spilled near Yakima.

Most ground water studies carried out by the USGS are conducted cooperatively with Ecology, but some also involve local governmental entities. Laboratory analyses are typically conducted at the USGS laboratory in Denver, Colorado.

Data are entered into the local PRIME data file at the Tacoma District Office and periodically transferred to the WATSTORE system at their headquarters in Reston, Virginia. New water quality and updated data in WATSTORE in Reston is entered into the EPA national STORET system every quarter. (Water level, geology, and well information are not part of the water quality data set and are not transferred to STORET.)

U.S. Environmental Protection Agency (EPA)

Most of EPA Region 10's ground water monitoring activities focus on hazardous waste investigations and overseeing contractor work related to CERCLA (Superfund) sites and RCRA regulatory monitoring. Samples collected for CERCLA investigations are analyzed at EPA contract laboratories which are required to follow strict, detailed procedures for quality assurance.

EPA has also been involved in sampling drinking water wells. EPA Region 10 cooperated with the Washington State Department of Social and Health Services (DSHS) in analyzing samples from numerous western Washington wells for the pesticide EDB.

STORET is EPA's primary data base. However, Region 10 has not entered much of the available ground water data into STORET. A small portion of data collected at CERCLA sites are being entered into STORET. Region 10 is also developing a dBase III system that can interchange hydrogeologic and sampling site data with STORET. This data base will include some additional information that STORET does not. Water quality data will not be included in the dBase III system, but will be entered into STORET.

State

Department of Ecology (Ecology)

Most recent ground water monitoring activity has focused on hazardous waste problems, including overseeing contractor work, conducting field inspections, and reconnaissance sampling related to CERCLA, the State Hazardous Waste Clean-up Authority, RCRA, and the State Dangerous Waste Law. The Hazardous Waste Cleanup Program handles monitoring activities related to state and federal Superfund sites. The Hazardous Waste Section of the Solid and Hazardous Waste Program handles monitoring at federal or state RCRA sites. Data from these studies are not yet computerized.

Regional office technical staff oversee preliminary ground water investigations at petroleum spills sites. Regional office inspectors oversee compliance monitoring at some regulated facilities with waste discharge permits to ground. Data is stored in paper files. Well logs are also kept in the regional offices in paper files.

The Water Quality Investigations Section (WQIS) of the Technical Services Program conducts reconnaissance surveys related to ground water contamination to support the Hazardous Waste Cleanup Program, enforcement actions, and to check for permit compliance.

The WQIS also manages ground water quality data from other agencies such as DSHS and USGS in STORET. A large part of the inorganic ground water data collected from Class 1 and 2 public supply wells since 1980 has been transferred to STORET. The remainder will be transferred by September 1987. All new public supply well data will be routinely transferred after that. USGS ground water quality, geology, and well data for Washington is in the process of being transferred.

The Solid Waste Section of the Solid and Hazardous Waste Program works with local health departments to oversee ground water monitoring at solid waste handling facilities. However, staff is extremely limited for the amount of assistance that local health departments need. Data collected at solid waste facilities is in paper files.

The Water Resources Investigations Section of the Water Resources Program conducts studies related to ground water supply and flow characteristics. This group also collects seawater intrusion data. Most water level data collected by Water Resources Investigations is entered into the USGS WATSTORE system.

The Water Resources Program regulates ground water withdrawals in the state. A permit is required for any withdrawal greater than 5,000 gallons per day. Information on permitted water rights is stored on the Water Rights Inventory System, a cumbersome, computerized system. Location, date of permit, water use(s), amount used, number of acres irrigated, if any, and number of wells permitted are all included in the data system.

The Water Quality Program distributes federal funds for ground water monitoring projects to a few local agencies (Section 205j, and in previous years, 208 Clean Water Act funds).

Beginning in 1987, the Water Quality Program will begin to award and oversee grants to designated Ground Water Management Areas (GWMAs) under Chapter 173-100 WAC. The eight areas designated so far are all in the Puget Sound Basin. Part of each grant will be used by the local consortiums to collect data for characterizing ground water quality and quantity. This data will be used to develop a site-specific ground water management program. Data will also be collected following implementation of the management program to evaluate the effectiveness of measures taken. Data from GWMAs will be stored in STORET and WATSTORE.

Department of Social and Health Services (DSHS)

The Environmental Health Division of the DSHS has been responsible for overseeing purveyor monitoring of inorganics in public drinking water supplies, including wells. DSHS is now developing a plan for monitoring organic chemicals to meet the recent amendments to the federal Safe Drinking Water Act. Data submitted since 1980 are stored in the DSHS computer system.

DSHS was involved in initial sampling of wells for the pesticide EDB.

State Universities

Washington State University, Western Washington Research Extension Center in Puyallup is conducting intensive field research into the fate and transport of three pesticides used in berry-growing areas. Data will be stored in a computerized format.

The University of Washington College of Forest Resources conducts a number of studies involving the effects of sludge application, forest practices, and atmospheric deposition on ground water and the unsaturated zone. The forestry studies are carried out mainly at Pack Forest in Eatonville and the Thompson Research Center in the Cedar River watershed. Some of the data from these studies are stored in a computerized format.

Local

The Spokane '208' Program and the Tacoma-Pierce County Health Department (Chambers Creek/Clover Creek area) have the longest, most detailed ground water quality records. Broad-scale data collection and analysis have also been most extensive in these two areas. Spokane's data are stored on a WANG computer, while Tacoma-Pierce County's data are on a dBase II system.

The Clark County PUD has assembled all available PUD well water quality data and stored it on a dBase III system.

County health departments are legally responsible for ensuring that ground water monitoring at solid waste facilities complies with the Minimum Functional Standards for Solid Waste Handling (Chapter 173-304 WAC). Health departments are also responsible for carrying out monitoring inspections at these facilities. Few solid waste facilities in the state meet minimum legal standards for ground water monitoring. Little technical support is available from Ecology to assist local health departments.

Most other local ground water monitoring efforts, if they exist, are in preliminary stages. As noted, monitoring is scheduled to begin in several designated GWMAs during 1987 (Ecology Water Quality Program). Standardized methods for sample collection and analysis have been established for GWMA grants (Ecology, 1986). Data will be entered into the STORET and WATSTORE systems.

IV. List of Ground Water Monitoring Activities by Agency

The following is a list of specific ground water quality monitoring and related efforts described in this summary. They are arranged according to agency, beginning with federal, then state, and finally local agency efforts. Further details are provided for each study in Chapter V.

Federal

USGS:

- Ground water quality in principal aquifers of Washington 1979-1983 (5 regions), p. 15.
- Assessment of fluoride, nitrate, and dissolved solids data for ground water around the state, p. 15.
- Mapping for evaluating broad-scale suitability of areas for hazardous waste management facilities, p. 16.
- Columbia Plateau ground water sodium study (Regional Aquifer Systems Analysis), 1982-1983, p. 16.
- Horse Heaven Hills ground water sodium study, 1982-1984, p. 17.
- Spokane Aquifer 1977-1978 sampling to develop a ground water flow and transport model, p. 20.
- Bainbridge Island ground water quality survey, 1985, p. 21.
- San Juan Islands ambient sea water intrusion study, p. 22.
- Sequim - Dungeness Peninsula survey - effects of land use changes on water quality, p. 22.
- Sea water intrusion in coastal aquifers - comparison of 1966-68 with 1978, p. 28.
- Ground water quality on four of the largest San Juan Islands, 1981, 1986, and on-going, p. 28.
- Pasco Basin (Benton/Franklin County) ground water study - effects of changing land use (on-going), p. 29.
- Yakima gasoline and diesel spill - research study (on-going), p. 29.

- Determination of water levels and occurrence and levels of selected organic compounds in Gas Works Park, Seattle, soils and shallow ground water, 1986, p. 30.

- Evaluation of geohydrology and water quality near three landfills in Washington based on existing data, 1985 and 1986, p. 39.

EPA:

- Environmental Services Division provides technical support for CERCLA, RCRA, TSCA, SMCRA, drinking water, and enforcement work, p. 31.

- Technical Assistance Team (TAT) of the CERCLA Program for emergency spill response, p. 31.

- Contracts out work on a portion of the Superfund (CERCLA) sites in the state, p. 32.

- RCRA group oversees ground water monitoring plans developed by hazardous waste facilities and approved by Ecology, takes part in inspections, p. 41.

- Contracted with Ecology and SCS Engineers to conduct reconnaissance surveys of effects on ground water of wastewater treatment practices on ground water near three eastern Washington apple packing plants (1979), p. 33.

State

Ecology:

- Regional offices and Water Resources Program maintain statewide water level observation network, p. 17.

- Northwest Regional Office and Water Resources Investigations Section conducting seawater intrusion monitoring in northern coastal counties, especially Island County, p. 23.

- Northwest Regional Office conducted South Camano Island seawater intrusion study, 1985-1987, p. 24.

- Damage investigation teams in the regional offices conduct ground water sampling in response to petroleum product spills, p. 32.

- Ecology contracted with EPA and SCS Engineers to conduct reconnaissance surveys of effects on ground water of wastewater treatment practices at eastern Washington apple packing plants (1979), p. 33.

- Hazardous Waste Cleanup Program conducts periodical sampling for EDB and other selected pesticides in Thurston, Skagit, and Whatcom county berry-growing areas, pp. 34, 35.

- Hazardous Waste Cleanup Program and Technical Services Program (Water Quality Investigations Section) conduct preliminary sampling at selected hazardous waste cleanup (Superfund) sites, pp. 32, 36, 37.

- Pasco Industrial Park survey of petroleum contamination in ground and surface water 1985, 1986, Technical Services Program Water Quality Investigations Section, p. 37.

- Hazardous Waste Section of the Solid and Hazardous Waste Program reviews, approves, and oversees ground water monitoring plans; conducts inspections for RCRA and State Dangerous Waste Permits (Central Operations Program, Industrial Section oversees hazardous waste permits for aluminum, petroleum, and pulp and paper facilities.), p. 41.

- Regional regulators evaluate, approve, and oversee compliance monitoring at sites with waste discharge permits to ground, p. 42.

- Solid Waste Section of Solid and Hazardous Waste Program supports local health departments in developing ground water monitoring plans to meet state Minimum Functional Standards for Solid Waste Handling, p. 43.

DSHS:

- Chambers Creek/Clover Creek Basin assembly and analysis of existing ground water data, 1931-1980, p. 25.

- Skagit, Thurston, and Whatcom counties EDB initial sampling 1984, with EPA and local health departments, p. 34.

- West Yakima County ground water survey for nitrate, bacteria and other contamination indicators, 1973, p. 40.

- Oversees, manages, and ensures public supply well compliance monitoring under Public Water Systems statute, p. 42.

State Universities:

- University of Washington College of Forest Resources, Pack Forest study to determine effects of tree-harvesting schemes on soil pore water, p. 24.

- University of Washington College of Forest Resources, Cedar River Watershed study of effects of atmospheric deposition on nutrient status of forest ecosystem (including ground water), p. 25.

- Washington State University Research and Agricultural Extension Center, Puyallup, study of three soil-applied pesticides used in berry-growing areas of western Washington, p. 33.

- University of Washington College of Forest Resources, Pack Forest study to determine water quality effects of various types of sludge application on ground water and soil pore water, p. 35.

Local:

- Vashon and Maury islands ground water study, 1981-1982, funded by King County Department of Planning and Community Development, p. 18.

- Seattle Water Department - Highline Aquifer monitoring program, p. 18.

- Clark County (Salmon Springs Corridor) study, using existing water quality data, p. 19.

- Pilchuck Tree Farm - Seattle METRO study to determine background soil and water quality, p. 19.

- Spokane County '208' Program ambient monitoring 1977-present, p. 20.

- Chambers Creek/Clover Creek Basin, Tacoma-Pierce County Health Department study, 1980-1981, p. 26.

- Chambers Creek/Clover Creek Basin, Tacoma-Pierce County Health Department study, 1984-1985, p. 26.

- City of Vancouver Public Works Department public supply well monitoring 1978-present, p. 27.

- Clark County Public Utility District public supply well monitoring 1978-present, p. 27.

- Skagit, Thurston, and Whatcom county health departments took part collecting EDB samples from wells in berry-growing areas, pp. 34, 35.

- Island County - ground water sampling near two Whidbey Island landfills, 37.

- Long and Pattison lakes area, Thurston County Health Department assessment of land use practices on ground water quality, p. 38.

- Deer Park, Spokane County Health Department study of elevated nitrate levels in ground water, p. 38.

- Tacoma-Pierce County Health Department monitoring near three landfills, p. 40.

- West Yakima County (Wiley City) sampling, 1986 - Yakima County Council of Governments, p. 40.

- Wildrose Prairie, City of Spokane sludge application study, 1982-1986, p. 43.

- Ground water monitoring near sludge application sites in Mason, Thurston, and King counties, p. 44.

V. Table of Ground Water Monitoring Activities by Primary Objective

The following table is organized according to the five objectives listed in the Introduction:

1. Characterize the ground water resources.
2. Promptly identify new problems.
3. Assess known problems by determining cause-and-effect relationships.
4. Ensure compliance with regulations.
5. Evaluate program effectiveness.

Each study is included under what the most appropriate primary objective.

Fifteen categories of information are given for each monitoring effort listed in Section IV. The numbers used to categorize "Secondary Objectives" refer to the five objectives above.

1. CHARACTERIZE THE RESOURCE

STUDY LOCATION	Washington (Divided into 5 regions)	Washington (Statewide)
OBJECTIVES	To survey overall water quality in ground water in principal aquifers. Compare results with historic data from wells in same regions.	To assemble existing data on fluoride, nitrate, and dissolved solids in ground water and establish baseline for historical comparison.
SECONDARY OBJECTIVES	2	2
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Reconnaissance sampling.	Existing data used.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Domestic, municipal, irrigation wells, a few industrial wells.	Public supply, irrigation, and domestic wells.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	About 100 wells per region, chosen primarily for uniform areal distribution but emphasizing areas of high use (about 700 all together). Regional boundaries based on aquifer mapping (Molenaar, et al., 1980).	Several hundred wells were selected. All wells from the USGS data base were used. Data from EPA and DSHS were used to augment areas of sketchy coverage.
FREQUENCY/DATES OF SAMPLING	One time sampling, 1979-1983 (one region sampled each year).	Existing data compiled, mapped, completed 1982.
QA/QC PROCEDURES ESTABLISHED	No field blanks or duplicates. Standardized sampling procedures. Samples field filtered. Laboratory analyses done using auto-analyzer or atomic absorption. Laboratory blanks analyzed. Other standard procedures (USGS, 1977).	Data mainly from USGS studies. Other sources include Dept. of Social and Health Services, EPA, and Batelle Pacific Northwest Laboratory. Map texts describe assumptions made regarding data quality.
COST	$230,000	Approximately $50,000
FUNDING SOURCE	50% USGS/50% Ecology	50% USGS/50% Ecology
AGENCY OR GROUP CONDUCTING MONITORING	USGS	USGS, EPA, Batelle Northwest Laboratory, and public well purveyors.
PARAMETERS SAMPLED	Field: Temperature, specific conductance, pH Lab: Major ions, nitrate plus nitrite, iron, manganese, fecal coliform bacteria (sodium adsorption ratio and total dissolved solids calculated from major ions). Trace metals analyzed in 20% of samples: aluminum, arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver, and zinc.	Fluoride, nitrate, dissolved solids.
DATA MANAGEMENT	WATSTORE, STORET	WATSTORE, STORET
MAPS INCLUDED IN REPORTS	Sampling well locations, aquifer boundaries, specific conductance, nitrate. Most of the regional maps include dissolved solids, major ions, iron, and manganese concentrations relative to drinking water standards and locations of sites with historic water quality data.	One map for each parameter.
REFERENCES	Ebbert (1984), Ebbert and Payne (1985), Turney (1986,a,b,c)	Lum and Turney (1982)

1. CHARACTERIZE THE RESOURCE (Continued)

STUDY LOCATION	Washington (Statewide)	Columbia Plateau (RASA)
OBJECTIVES	To develop a series of maps using existing information to show geologic, hydrologic, and cultural features to characterize land areas relative to waste disposal.	To map spatial and temporal variability of dissolved sodium in the three basalt aquifers and relate this variation to the geohydrologic system, and to identify factors controlling occurrence of sodium in ground waters.
SECONDARY OBJECTIVES		3
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Existing data used.	Reconnaissance sampling.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Public supply, irrigation, and private wells.	Domestic, irrigation, public supply wells.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	Existing data used.	418 wells.
FREQUENCY/DATES OF SAMPLING	Existing data compiled, mapped.	At least once during three periods: Summer - 1982 Spring - 1983 Summer - 1983
QA/QC PROCEDURES ESTABLISHED	Only areas greater than 10 sq. mi. were considered large enough to map where sufficient information existed. Areas considered unsuitable for waste disposal a priori were not mapped (e.g. wilderness areas, national parks, sole-source aquifers, municipal watersheds).	Where possible, samples were collected from well heads. Flow-through chamber used to measure purging parameters. Samples collected after temperature of purge water stabilized. Standard procedures (USGS, 1977).
COST	About $100,000	$1,160,000
FUNDING SOURCE	50% USGS/50% Ecology	USGS
AGENCY OR GROUP CONDUCTING MONITORING	Existing data from various sources used.	USGS, Regional Aquifer Systems Analysis (RASA).
PARAMETERS SAMPLED	See maps included in reports.	Temperature, pH, dissolved oxygen, specific conductance, dissolved inorganic species, major ions.
DATA MANAGEMENT	USGS Ground Water Site Inventory (GWSI), WATSTORE	USGS Ground Water Site Inventory (GWSI), WATSTORE, STORET (water quality data only)
MAPS INCLUDED IN REPORTS	18 maps showing major geologic units; places where natural hazards possible due to earthquakes, faulting, and volcanoes; climate; locations of major surface and ground water bodies; population density; land and water uses. Maps specifically related to ground water include: 1. Major geologic units and relative permeability. 2. Location of principal ground water aquifers. 3. Depth to water table. 4. Water use from ground water.	o Sodium concentration. o Sodium - adsorption ratio. o Water type (major ions). o Specific conductance. o Well locations.
REFERENCES	Dion, et. al. (1984)	Hearn, et. al. (1985) Bortleson and Cox (1986)

1. CHARACTERIZE THE RESOURCE (Continued)

STUDY LOCATION	Horse Heaven Hills (South-Central Washington)	Washington (Statewide)
OBJECTIVES	To map spatial and temporal variability of dissolved sodium in three basalt aquifers, to relate this variation to the geohydrologic system, and to identify factors controlling occurrence of sodium in ground waters.	To monitor changes in static water levels in selected wells over time, especially related to water rights. Central Regional Office is also using data to model ground water areas and test effects of various withdrawal scenarios.
SECONDARY OBJECTIVES	3	2, 3
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Reconnaissance sampling.	Ambient (observation network)
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Domestic, irrigation, and public supply wells.	Public supply and observation wells.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	23 wells.	Eastern Region: About 200 in Columbia River basalts. Central Region: 350 chosen for equal spatial distribution in Grande Ronde, Wanapum, and Saddle mountains basalts. Northwest Region: About 20 in coastal areas. Southwest Region: Program starting spring 1987, about 45 wells in problem areas.
FREQUENCY/DATES OF SAMPLING	At least once between March 1982 and April 1984, and as many as four times at a few wells. Other recently collected data from wells in the area were also used in data analysis.	Eastern: Once per year for past 20 years. Central: Twice per year since 1980; a subset of these measured for the past 15 years. Northwest: Variable. Southwest: Planning quarterly to every two weeks (in Clark County 60 wells were measured quarterly for several years during the 1970s).
QA/QC PROCEDURES ESTABLISHED	Same as for Columbia Plateau (RASA) Study.	Standard procedures (USGS, 1977)
COST	$743,000	Not determined.
FUNDING SOURCE	USGS	Washington Department of Ecology
AGENCY OR GROUP CONDUCTING MONITORING	USGS	Washington Department of Ecology, Water Resources Program
PARAMETERS SAMPLED	Temperature, pH, dissolved oxygen, specific conductance, dissolved inorganic carbon species, major ions.	Water level.
DATA MANAGEMENT	USGS Ground Water Site Inventory (GWSI), WATSTORE, STORET (water quality data only).	Paper files.
MAPS INCLUDED IN REPORTS	o Potentiometric map of Wanapum Basalt, spring 1980. o Dissolved sodium and sodium adsorption ratios in the Wanapum Basalt. o Dissolved calcium and magnesium in the Saddle Mountains Basalt.	No reports.
REFERENCES	Steinkampf, et. al. (1985)	

1. CHARACTERIZE THE RESOURCE (Continued)

STUDY LOCATION	Vashon and Maury Islands	Seattle Highline Aquifer
OBJECTIVES	To characterize the ground water on the islands in terms of location, movement, quality, and future management concerns.	To determine if sufficient high quality ground water is available in the Highline area to supplement city water system (300 ft depth zone). After system is on-line, to ensure high quality of water.
SECONDARY OBJECTIVES	2	2, 4
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Reconnaissance sampling.	Intensive developing into ambient monitoring.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Public supply and domestic wells.	Five large diameter test wells; 5 existing private or abandoned wells. Six monitoring wells installed in 1986 for on-going monitoring in the 50-100 ft depth zone.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	72 wells.	Sites chosen for large-scale production from the Salmon Springs Aquifer (large--diameter) and for detection of contamination.
FREQUENCY/DATES OF SAMPLING	At least once, with some wells sampled more than once to evaluate seasonal changes.	In 1985 five large diameter test wells sampled several times for inorganics during pump test, once for priority pollutants. Five existing shallow wells sampled once (50-150 ft depth zone).
QA/QC PROCEDURES ESTABLISHED	Those used as standard procedure by Lauck's Laboratory.	Seattle Water Department standard procedures for inorganics; Lauck's Laboratory for priority pollutants.
COST	$45,000	$25,000 per year for sampling and analysis.
FUNDING SOURCE	King County	Seattle Water Department
AGENCY OR GROUP CONDUCTING MONITORING	J.R. Carr Associates	Herrera Consulting
PARAMETERS SAMPLED	Specific conductance, nitrate, chloride, and iron.	Primary Drinking Water Parameters: Arsenic, barium, cadmium, chromium, fluoride, lead, mercury, nitrate, selenium, silver. Secondary Drinking Water Parameters: Color, iron, manganese, total dissolved solids, chloride, sulfate, copper, zinc, odor. Others: pH, alkalinity, hardness, priority pollutants.
DATA MANAGEMENT	Paper files	Paper files.
MAPS INCLUDED IN REPORTS	Contour maps for parameters sampled.	
REFERENCES	Carr Associates (1983).	Economic and Engineering Services (1985).

1. CHARACTERIZE THE RESOURCE (Continued)

STUDY LOCATION	Clark County (especially the Salmon Creek Corridor)	Pilchuck Tree Farm (Snohomish County)
OBJECTIVES	To provide data for a ground water development and management strategy to guide PUD managers (e.g. Identify flow patterns and water quality based on existing data).	To characterize background water and soil quality at the Pilchuck Tree Farm for proposed demonstration sludge application project.
SECONDARY OBJECTIVES	2	3
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Ambient observation network, existing water quality data.	Ambient/Intensive
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Water levels from public or domestic supply wells. Public supply wells (PUD) for water quality data.	Domestic wells, monitoring wells, lysimeters, springs, soils.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	Water levels: 20 private wells and PUD wells (about 20). Water quality: all public supply wells with data available (about 80).	Three domestic wells upgradient of proposed site, 3 monitoring wells on-site, 18 lysimeters, 8 soil sampling sites. Lysimeters and soil sampling sites separated into "control" and "test" sites for possible future sludge testing.
FREQUENCY/DATES OF SAMPLING	Water levels: PUD wells weekly starting in 1983, private wells quarterly. Water quality: Once every three years since 1980, periodically before 1980.	Monthly to bimonthly for three years (1982-84).
QA/QC PROCEDURES ESTABLISHED		According to METRO's in-house manuals (to conform to EPA protocols).
COST	$60,000 (not including water quality sampling and analysis).	$500,000 - $1,000,000
FUNDING SOURCE	Clark County	Seattle METRO
AGENCY OR GROUP CONDUCTING MONITORING	Water levels measured by J.R. Carr Associates	Seattle METRO
PARAMETERS SAMPLED	Water levels measured. Water quality data from Dept. of Social and Health Services public supply well sampling. Primary drinking water parameters.	Conventionals: Temperature, pH, specific conductance, chloride, fluoride, solids, turbidity, ammonia, nitrate, organic nitrogen, soluable reactive phosphorus, total phosphorus, potassium. Microbiological: 7 bacteria, 6 parasites, 6 viruses. Metals: Arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, zinc. Organics: Base neutrals and acid extractables on EPA's priority pollutant list (one spring, 2 wells, and 8 composite soil samples).
DATA MANAGEMENT	dBase III Contouring: Golden software.	METRO Prime computer accessible from outside. RAMIS - can be downloaded to IBM-PC (Lotus) with modem (Contact METRO Sludge Management Program).
MAPS INCLUDED IN REPORTS	Well locations. Computer contours for water quality parameters.	Station locations.
REFERENCES	Carr Associates (1985).	Harper-Owes (1985).

2. IDENTIFY NEW PROBLEMS

STUDY LOCATION	Spokane Aquifer (USGS Work)	Spokane Aquifer (Spokane County '208' Program)
OBJECTIVES	To construct and calibrate a ground water flow and solute transport model for the Spokane Aquifer. To describe the water chemistry of the aquifer.	To determine what, if any, changes occur in the upper 50 feet of the Spokane Aquifer along its flow path.
SECONDARY OBJECTIVES	1, 3	1, 3
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Reconnaissance sampling.	Ambient.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Large diameter wells (mainly public supply wells).	Public supply wells (30-50 ft deep), domestic wells, and depth-selective monitoring wells (65-300 ft deep).
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	142 sites including most of the 80 wells used by the Spokane Health Department at about the same time for ground water studies (see following study description).	80 sites: 20 depth-selective monitoring wells (4-6 depths sampled) located to represent 5 cross-sections perpendicular to the flow of the aquifer; 60 public supply and domestic wells selected to provide uniform areal coverage (about one well per square mile).
FREQUENCY/DATES OF SAMPLING	Three times: May and October 1977, and May 1978.	Monthly at most sites: May 1977 - June 1978.
QA/QC PROCEDURES ESTABLISHED	Limited as per USGS standard procedures (USGS, 1977).	Limited lab blanks analyzed. Washington State University Environmental Engineering Laboratory and Idaho Health and Welfare Laboratory analyzed samples. Standardized sampling procedure used. Inflatable packers used in depth-selective wells; corrosion a problem with perforated steel casings. Monthly chloride and nitrate spikes analyzed by field staff and two labs.
COST	$255,500	$140,000 ($60,000 for well drilling).
FUNDING SOURCE	USGS/Federal Clean Water Act (Section 208).	Federal Clean Water Act (Section 208), Spokane City and County.
AGENCY OR GROUP CONDUCTING MONITORING	USGS	Spokane '208' Program.
PARAMETERS SAMPLED	Water level, temperature, specific conductance, nitrate, nitrite, ammonia, orthophosphate, and chloride.	Field: Temperature, pH, specific conductance, hardness, chloride, nitrate (specific ion electrode). Idaho Health and Welfare Lab: Specific conductance, chloride, hardness, total dissolved solids, alkalinity, calcium, magnesium, sodium, potassium, arsenic, barium, cadmium, chromium, iron, copper, iron, lead, total and fecal coliforms, total plate count, one-time pesticides scan from 40 wells. WSU Lab: Nitrate + nitrite, nitrate, ammonia, ortho- and total phosphorus, sulfate, detergent (MBAS), COD, TOC, total Kjeldahl nitrogen.
DATA MANAGEMENT	WATSTORE, GWSI, STORET (water quality data only).	STORET, WANG VS, WANG-PCs (GEOPLANS software).
MAPS INCLUDED IN REPORTS	Many maps including saturated thickness of the aquifer, transmissivity, porosity, specific yield, ground water velocity, specific conductance, chloride and nitrate concentration, water level configuration, and other model predictions.	Sampling locations. Semi-monthly equipotential lines (1977-78) Land use 1976 Population area boundaries Aquifer boundary/aquifer sensitive area/priority sewer service area.
REFERENCES	Bolke and Vaccaro (1981) and Vaccaro and Bolke (1983).	Esvelt and Miller (1983) Spokane County '208' Program (1979) Stan Miller, Spokane County Office of the County Engineer (1985)

2. IDENTIFY NEW PROBLEMS (Continued)

STUDY LOCATION	Spokane Aquifer (Spokane County '208' Program)	Bainbridge Island
OBJECTIVES	1. Provide on-going ground water quality monitoring data for trend analysis. 2. Provide data to assess aquifer suitability as a drinking water source. 3. Analyze for a wide range of contaminants to determine effects of contamination incidents. 4. Provide a data base to evaluate the effects of human activities on the aquifer.	1. To define the general lithology and ground water flow system of the unconsolidated deposits. 2. To define present ground water quality and identify problems. 3. To design a monitoring network for determining changes in quality or quantity.
SECONDARY OBJECTIVES	1, 3	1, 3
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Ambient	Reconnaissance sampling.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Public supply wells.	Mostly private domestic, some small public supply wells.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	7 wells February through April 1979. 30-50 wells 1980-86. Only wells in operation sampled. Three surface water sites (except 1980, 50 sites). Uniform areal coverage major consideration in choosing sites. 1986 - resumed sampling 10 depth-selective wells at 3 depths (see previous Spokane Aquifer study for more details).	210 wells - must have well log.
FREQUENCY/DATES OF SAMPLING	Twice between February and April 1979; quarterly during most of the period 1980-86 (semi-annually at a minimum).	Two times: April and September 1985.
QA/QC PROCEDURES ESTABLISHED	1979 - same as previous Spokane County '208' program. 1980-86 - depended on laboratory for QA/QC; Inorganics: DSHS Lab, Seattle from mid-1980 to mid-1982; Panhandle Health District Lab, Cour d'Alene, Idaho - mid-1982 until present. Organics: EPA/Ecology Lab, Manchester until October 1984; Lauck's Lab, Seattle, October 1984-1985; ABC Lab, Spokane, 1986.	Standard procedures (USGS, 1977) - depend on laboratory for QC, no field blanks or duplicates.
COST	$42,000/yr before 1986. About $100,000/yr 1986.	$138,000.
FUNDING SOURCE	Federal Clean Water Act Section 208 funds, Spokane City and County, EPA.	50% USGS, 50% combined from Ecology, Kitsap County, and City of Winslow.
AGENCY OR GROUP CONDUCTING MONITORING	Spokane Health District collects samples. Spokane County '208' Program manages and interprets data.	USGS
PARAMETERS SAMPLED	Specific conductance, calcium, magnesium, potassium, sodium, sulfate, chloride, nitrate, orthophosphate, fluoride, manganese, 16 volatile organics. In 1986, added metals, benzene, toluene, xylene, phenols, pesticides, and total organic carbon.	Specific conductance and chloride in all wells both times. In April 50 wells also sampled for major cations and anions, trace metals, and fecal coliform bacteria.
DATA MANAGEMENT	STORET, WANG VS, WANG PCs, GEOPLANS (software).	WATSTORE, STORET
MAPS INCLUDED IN REPORTS		Yes
REFERENCES	Stan Miller, Spokane County Office of the County Engineer (1985).	USGS report not yet available.

2. IDENTIFY NEW PROBLEMS (Continued)

STUDY LOCATION	Sequim - Dungeness Peninsula, Clallam County	San Juan Islands
OBJECTIVES	1. To examine the effects of decreased irrigation and increased use of septic systems on aquifers underlying the peninsula. 2. To predict future effects of land use changes on the ground water system via computer model.	To detect changes over time due to sea water intrusion in areas where intrusion previously documented.
SECONDARY OBJECTIVES	2	3
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Reconnaissance sampling.	Ambient.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Private wells.	Mostly private, some public supply wells. Selected based on initial study (USGS, 1983): Wells that showed elevated chloride concentrations and some that were at background levels.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	138 wells, 13 river and creek stations, and 24 irrigation system stations.	60-70 wells.
FREQUENCY/DATES OF SAMPLING	Once during the period June 16-19, 1980.	Every two years, spring and fall.
QA/QC PROCEDURES ESTABLISHED	Standard procedures (USGS, 1977).	Standard procedures (USGS, 1977).
COST		Approximately $4,000/biennium.
FUNDING SOURCE	USGS, Ecology, and Clallam County.	USGS, San Juan County
AGENCY OR GROUP CONDUCTING MONITORING	USGS	USGS
PARAMETERS SAMPLED	Static water levels, surface water discharges, chloride, nitrate-plus-nitrite, and ammonia.	Static water level, chloride.
DATA MANAGEMENT	WATSTORE, GWSI, STORET (water quality data only).	WATSTORE, GWSI, STORET (chloride data only).
MAPS INCLUDED IN REPORTS	25 maps showing aquifer characteristics and model predictions, one map of nitrate-plus-nitrite concentration and septic tank densities.	
REFERENCES	Drost (1983).	Whiteman (1987). See also San Juan County Study, Objective 3.

2. IDENTIFY NEW PROBLEMS (Continued)

STUDY LOCATION	Northern Coastal Counties, mainly Island County
OBJECTIVES	To detect changes in seawater intrusion due to well pumping.
SECONDARY OBJECTIVES	1, 3
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Ambient.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Public supply, private, and test wells.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	Three test wells on Lopez Island; 8 in Island County. Eleven public and private wells in Island County. Eleven Ecology observation wells distributed among Island, San Jaun, Skagit, and Whatcom counties.
FREQUENCY/DATES OF SAMPLING	Twice annually (spring and fall) starting in 1986.
QA/QC PROCEDURES ESTABLISHED	Chloride field analysis (Hach titration kit). Some samples split with EPA/Ecology Lab, Manchester.
COST	
FUNDING SOURCE	Water Resources Program.
AGENCY OR GROUP CONDUCTING MONITORING	Ecology Northwest Regional Office and Water Resources Investigations Section.
PARAMETERS SAMPLED	Chloride and static water level.
DATA MANAGEMENT	Plans for entering water level data into WATSTORE system; choride data in paper files.
MAPS INCLUDED IN REPORTS	
REFERENCES	Perkins (1986a, b).

2. IDENTIFY NEW PROBLEMS (Continued)

STUDY LOCATION	South Camano Island	University of Washington Pack Forest, Eatonville
OBJECTIVES	To determine the extent and severity of sea water intrusion on Camano Island, the effect of seasonal variation, and potential adverse effects of additional withdrawals on existing water rights.	To determine effects of various forest practices and tree-harvesting schemes on soil pore water in high and low productivity red alder and Douglas fir stands.
SECONDARY OBJECTIVES	1	3
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Intensive.	Intensive.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Public supply wells.	Lysimeters, lysimeter plates.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	20 wells, chosen for uniform areal distribution.	4 sites, 4 treatments per site: forest floor, 10 cm, and 40 cm depth. 1. Control. 2. Normal logging (removing bole only). 3. Removing whole tree (branches too), leaving understory. 4. Scraping site bare.
FREQUENCY/DATES OF SAMPLING	Monthly, April 1985-March 1987.	
QA/QC PROCEDURES ESTABLISHED	Limited - submitted a few duplicates to EPA/Ecology Laboratory, Manchester, where samples analyzed.	
COST		$350,000 (estimate)
FUNDING SOURCE	Department of Ecology.	U.S. Department of Energy.
AGENCY OR GROUP CONDUCTING MONITORING	Department of Ecology, Northwest Regional Office.	University of Washington College of Forest Resources (coordinated through Oak Ridge Natural Laboratory).
PARAMETERS SAMPLED	Chloride, specific conductance, water level measured.	pH, nutrients, bicarbonate, major anions and cations, quantity of water leached.
DATA MANAGEMENT	Paper files.	
MAPS INCLUDED IN REPORTS	Well locations.	
REFERENCES	Ecology report in preparation.	Bigger and Cole (1983)

2. IDENTIFY NEW PROBLEMS

STUDY LOCATION	Thompson Research Center and Findley Lake (Cedar River Watershed)	Chambers Creek/Clover Creek Basin, Pierce County
OBJECTIVES	To project effect of atmospheric deposition on nutrient status of various forest ecosystems.	1. To document ground water quality based on existing data. 2. To document trends in water quality and determine if any correlation with development. 3. Compile available data in usable form and make recommendations for further action.
SECONDARY OBJECTIVES	3	1
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Intensive.	No actual monitoring. Existing data assembled from USGS, DSHS, Ecology, Tacoma-Pierce County Health Department, and local engineering and planning reports.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Lysimeters, lysimeter plates, soil samples.	Public supply wells, some private wells.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	Lysimeters (triplicate) immediately below forest floor, 10 cm, and 40 cm depth.	135 wells for chemical data; 43 wells for bacteriological data.
FREQUENCY/DATES OF SAMPLING	Sampling began 1984-85; monthly in some study areas.	Variable frequency; chemical data: 1931-1980, bacteriological data: 1960-1980.
QA/QC PROCEDURES ESTABLISHED		Very limited. All data found was used and given equal consideration.
COST		
FUNDING SOURCE	Electric Power Research Institute and National Science Foundation Ecosystem Studies Program.	Department of Social and Health Services (DSHS)
AGENCY OR GROUP CONDUCTING MONITORING	University of Washington College of Forest Resources (coordinated through Oak Ridge National Laboratory).	Department of Social and Health Services (DSHS).
PARAMETERS SAMPLED	Lysimeter Solutions: pH, total nitrogen, calcium, magnesium, potassium, sodium, aluminum, ammonia, nitrate, chloride, sulfate, phosphate, bicarbonate.	Nitrate, chloride, total dissolved solids, total coliform bacteria.
DATA MANAGEMENT		Paper files.
MAPS INCLUDED IN REPORTS		Well locations. Mean parameter values before and after 1965. Chloride and nitrate contours before and after 1965. Known bacteriological problem sites.
REFERENCES	Cole (1985) Van Miegroet and Cole (1985) Van Miegroet and Cole (1984)	Washington Department of Social and Health Services (1980).

STUDY LOCATION	Chambers Creek/Clover Creek Basin, Pierce County	Chambers Creek/Clover Creek Basin, Pierce County
OBJECTIVES	1. To establish a baseline for ground and surface water quality. 2. To determine the areas of the basin most seriously contaminated and degree of contamination. 3. To determine the extent and significance of existing or potential health problems.	1. To provide data establishing relationships between land use activities and water quality. 2. To augment existing baseline data to identify hydrologic and water quality trends. 3. To identify areas of contamination. 4. To establish a foundation for long-term monitoring.
SECONDARY OBJECTIVE	1	1
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Reconnaissance sampling.	Reconnaissance sampling.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Public supply wells (large and small) and private wells.	Mainly public supply wells, 2 domestic wells. Near the end of the study, monitoring wells were drilled: - 3 single completion wells near McChord AFB. - 1 double completion well near Hidden Valley landfill.
NUMBER OF SAMPLING SITES/METHOD FOR CHOOSING	260 wells, 3 springs, 2 surface water sites. Well logs required for selection. Attempted to get even distribution of wells areally and various depths down to 1300 ft (24 sites chosen for proximity to potential organics sources; organics samples collected).	35 wells chosen for having historical data, priority monitoring areas, control areas, and areas where no previous water quality data (5 additional wells for volatile organics analysis).
FREQUENCY/DATES OF SAMPLING	November 1980 - February 1981. Inorganic drinking water parameters once; nitrate, chloride, phosphate two to three times; bacteriological samples every two weeks; organics once.	Quarterly, 5 times from January 1984 to January 1985.
QA/QC PROCEDURES ESTABLISHED	Limited. Samples taken close to the well head, flushed for three minutes; sampling point flamed before sampling where practical. DSHS Lab, Seattle and Tacoma-Pierce County Lab, Tacoma ran bacteriological samples. DSHS, Seattle Lab also analyzed for inorganics. DSHS, Wenatchee (Pesticide Lab) ran trihalomethane and pesticide samples. EPA contracted priority pollutant scans to commercial labs.	Fairly extensive. 5-10 well volumes purged before sampling. Duplicate volatile organic samples collected at each site and chain of custody procedures followed (see Appendix VII of reference below for more details).
COST		$510,000
FUNDING SOURCE		205j funds, Tacoma-Pierce County Health Department.
AGENCY OR GROUP CONDUCTING MONITORING	Tacoma-Pierce County Health Department.	Tacoma-Pierce County Health Department contracted to Brown and Caldwell (Robinson and Noble personnel collected samples).
PARAMETERS SAMPLED	Drinking water parameters (Chapter 248-54 WAC), chloride, phosphate; priority pollutants, trihalomethanes, selected pesticides; total and fecal coliform bacteria, total plate counts.	Routinely: Temperature, specific conductance, pH, nitrate, chloride, total dissolved solids, fecal coliform bacteria, static water level. One time: arsenic, volatile organics analysis (VOA) (detects resampled once); 2 domestic wells near McChord AFB - 50 priority pollutants.
DATA MANAGEMENT	Paper files.	dBase II software for IBM PCs. Data base includes well locations and construction information for about 500 wells, historical water quality data, soils, land use for over 5,000 locations (future, historical, and present), and sewage treatment system.
MAPS INCLUDED IN REPORTS	o Geologic units. o Average values for each parameter at each site, compared with historical data. o Sampling sites for organics. o 13 potential contamination sites.	Many maps.
REFERENCES	Washington Department of Social and Health Services (1982).	Brown and Caldwell (1985).

2. IDENTIFY NEW PROBLEMS (Continued)

STUDY LOCATION	Vancouver	Clark County
OBJECTIVES	To detect problems and/or trends in City of Vancouver water supply wells.	To help PUD managers plan future ground water management and development (e.g. identify recharge areas, water quality problems, trends).
SECONDARY OBJECTIVES	4	4
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Ambient/Compliance	Ambient/Compliance
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Public supply wells.	Public supply wells (private wells also used for water level monitoring).
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	9 wells/yr (one in each well field).	18 wells/yr out of 80 total.
FREQUENCY/DATES OF SAMPLING	Annually since 1978.	Since 1983, water levels measured weekly in PUD wells, quarterly in private wells. Water quality at 80 wells once every three years since 1978.
QA/QC PROCEDURES ESTABLISHED	Standard QA/QC procedures used by Coffey Laboratory, Portland.	
COST	About $1,000/yr for laboratory analysis only.	$3,600/yr for laboratory analysis only.
FUNDING SOURCE	City of Vancouver	Clark County
AGENCY OR GROUP CONDUCTING MONITORING	City of Vancouver, Public Works Department, Operations Center.	Clark County PUD contracted to J. Carr Associates.
PARAMETERS SAMPLED	DSHS drinking water parameters (Chapter 248-54 WAC).	Water levels measured. DSHS drinking water parameters (Chapter 248-54 WAC). In 1986, 5 wells sampled for TOC, TOX, specific organics.
DATA MANAGEMENT	Inorganics on PC, MULTIPLANS software.	All data on dBase III software.
MAPS INCLUDED IN REPORTS		o Well locations. o Water level contours for various aquifers. o Contour map of specific conductance, well yield, and specific capacities in various aquifers. o Geological cross-sections.
REFERENCES		Carr Associates (1985).

3. ASSESS SITE-SPECIFIC PROBLEMS

STUDY LOCATION	Coastal Aquifers	San Juan County
OBJECTIVES	To characterize the location, extent, and severity of sea water intrusion; identify where future intrusion may occur and water quality changes that have occurred since 1966-68 possibly related to sea water.	To define ground water quality on four islands (especially related to sea water intrusion). To define the nature and hydrologic characteristics of the unconsolidated deposits and flow system within these deposits.
SECONDARY OBJECTIVES	1	1, 2
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Reconnaissance sampling.	Reconnaissance sampling.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Wells within one mile of the coast drilled to depths at or below sea level.	Domestic and public supply wells.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	1,289 wells (680 of these were also sampled for the same parameters during 1966-1968).	279 wells two times--April and September 1981. 56 of 279 wells monthly April through September. 60-70 wells April and September 1986. Site choice based on well use, depth, geographic location (within one mile of coast), geologic framework, reported yield, existing water quality data, and permission to sample.
FREQUENCY/DATES OF SAMPLING	One time (May-August 1978) unless major difference between 1978 and 1966-68 results. Then also sampled October 1978.	See above.
QA/QC PROCEDURES ESTABLISHED	Standard procedures (USGS, 1977).	Chloride electrode (field) results compared with USGS lab results to determine accuracy; replicates collected occasionally. Standard procedures (USGS, 1977).
COST	$55,800	
FUNDING SOURCE	50% USGS, 50% Ecology	USGS, Ecology, San Juan County
AGENCY OR GROUP CONDUCTING MONITORING	USGS (Ecology sampled 34 of 1,289 wells).	USGS
PARAMETERS SAMPLED	Chloride and specific conductance.	Chloride and specific conductance for April, September, and monthly samples. June 1981: all 56 wells: alkalinity, hardness, dissolved solids, specific conductance, pH, major cations and anions, and nitrate. 16 of 56 wells: aluminum, arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, silver, zinc. August 1981: fecal coliform, fecal streptococcus, total coliform bacteria. 1986: temperature, specific conductance, chloride, static water level.
DATA MANAGEMENT	WATSTORE, STORET	WATSTORE, STORET
MAPS INCLUDED IN REPORTS	Plate for each of 14 counties showing well locations. Text accompanies each plate showing results (table) and analysis of data from individual areas.	12 plates: ground water conditions, geology and geohydrologic conditions, glacial drift thickness, flow system, specific capacities of wells, geochemistry, chloride, changes in chloride, bacteria occurrence, location of major withdrawals, estimated ground water use 1980, use compared with water rights.
REFERENCES	Dion and Sumioka (1984).	Whiteman, et al. (1983). See also San Jaun Islands study, Objective 2.

3. ASSESS SITE-SPECIFIC PROBLEMS (Continued)

STUDY LOCATION	Pasco Basin (Benton/Franklin County)	Yakima (gasoline and diesel spill site)
OBJECTIVES	1. To determine flow patterns and quantity of ground water so that artificial recharge and ground water withdrawals can be documented. 2. To determine effects of various land uses and rising water levels on water quality. 3. To test mitigation procedures. 4. To look for pesticides in areas of high usage and down-gradient. 5. To develop a regional model of core area. (Core area is the area of primary interest in each county.)	1. To determine effectiveness of soil gas sampling as a good indication of hydrocarbon plume location; determine effect of large paved areas on hydrocarbon volatilization and biodegradation. 2. To gain a better understanding of the process of hydrocarbon dissolution and the effect of water table fluctuations on that process. 3. To investigate the transport of lead from fuel near the spill site.
SECONDARY OBJECTIVES	1, 2	1
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Ambient/Intensive.	Intensive.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Public supply, irrigation, and private wells covering all major water-bearing units.	Monitoring wells, piezometers, lysimeters, soil vapor sampling devices.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	Water levels: 1,100 wells for water level in 1986, samples for water quality parameters from 250 of these in 1986. Selected number of these to be tested in 1987.	32 boreholes drilled so far (2 multiple wells), 4 older wells chosen for characterizing hydrogeology and contaminant flow characteristics as well as water quality (50 wells altogether).
FREQUENCY/DATES OF SAMPLING	Water levels in 1,100 wells measured two times per year starting 1986 (Feb-Mar, and early Sept), monthly to bimonthly in 145 wells starting Feb-Mar 1986. Ten continuous water level recorders. Nitrate + nitrite and specific conductance were sampled in 250 wells in Sept 1986. First quarter 1987 monthly samples will be collected for nitrate + nitrite and specific conductance at selected sites.	- A subset of wells to be sampled 3 times per year for benzene, toluene, and xylene. - Other constituents at undetermined intervals. - Sampling began 1986.
QA/QC PROCEDURES ESTABLISHED	Standard procedures (USGS, 1977).	Extensive, including use of glass bailers. Other standard procedures (USGS, 1977).
COST	About $1 million over four years.	About $200,000 per year for about 4 years.
FUNDING SOURCE	USGS, Ecology, 9 conservation districts.	USGS
AGENCY OR GROUP CONDUCTING MONITORING	USGS with support from Ecology, U.S. Bureau of Reclamation, and U.S. Army Corps of Engineers.	USGS
PARAMETERS SAMPLED	Nitrate + nitrite and specific conductance in 250 wells 1986, static water level in all wells. Selected wells will be sampled for specific conductance, ammonia, nitrate + nitrite, chloride, fluoride, major ions, pesticides. Surface water sampling also for similar constituents.	Static water level, metals, inorganics, 19 aromatic hydrocarbons (including benzene, xylene, toluene, naphthalene) in ground water and soil gas.
DATA MANAGEMENT	WATSTORE, ARC INFO, STORET	WATSTORE, GWSI, STORET (water quality data only)
MAPS INCLUDED IN REPORTS	ARC INFO mapping (Geographic Information System) for well locations, elevation, slope, aspect, land use, recharge, and water quality.	
REFERENCES	Turney (1987)	Ebbert (1987)

STUDY LOCATION	Gas Works Park, Seattle
OBJECTIVES	To assess the degree of organic and metals contamination of ground water at the park. Compare ground water contamination with soil contamination. Define water table.
SECONDARY OBJECTIVES	1
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Reconnaissance sampling. (Monitoring wells were installed, data collected on a one-time basis.)
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Monitoring wells.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	Fifteen wells in the park, one offsite. Areal coverage and definition of ground water flow.
FREQUENCY/DATES OF SAMPLING	One time sampling, December 1986.
QA/QC PROCEDURES ESTABLISHED	Field blanks, duplicates, metals samples field-filtered. Other standard procedures (USGS, 1977).
COST	$150,000
FUNDING SOURCE	USGS, Seattle Dept. of Parks and Recreation
AGENCY OR GROUP CONDUCTING MONITORING	USGS
PARAMETERS SAMPLED	Standard field parameters, metals, organics. Detailed PCB, pesticide, and volatile data collected at 5 wells. Soil gas also collected.
DATA MANAGEMENT	WATSTORE, STORET, City of Seattle Consultant files.
MAPS INCLUDED IN REPORTS	
REFERENCES	USGS reports in progress.

3. ASSESS SITE-SPECIFIC PROBLEMS (Continued)

STUDY LOCATION	Statewide - EPA Environmental Services Division (including Field Investigations Team (FIT))	Statewide - EPA Technical Assistance Team (TAT)
OBJECTIVES	To provide technical and field assistance to all EPA programs, especially CERCLA (Superfund) and RCRA. Also assist in drinking water, TSCA, and other ground water studies related to enforcement.	As spill-response team, to determine if a human health risk exists due to a hazardous chemical spill and to make recommendations for further action.
SECONDARY OBJECTIVES	2, 4	4
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Reconnaissance.	Reconnaissance sampling.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Varies according to project.	Existing wells.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	Varies according to project.	Site specific.
FREQUENCY/DATES OF SAMPLING	Varies according to project.	Short term.
QA/QC PROCEDURES ESTABLISHED	EPA Contract Lab Program (CLP) laboratories used for Superfund work; EPA/ Ecology Lab, Manchester used for non-Superfund samples. EPA protocols for sampling and analysis used for all sampling.	EPA contract laboratory program protocols.
COST		
FUNDING SOURCE		EPA
AGENCY OR GROUP CONDUCTING MONITORING	EPA Environmental Services Division reviews contractor plans, conducts inspections at RCRA sites, and conducts other field work.	EPA contracts to Roy Weston, Inc. (consultants).
PARAMETERS SAMPLED	Varies according to project.	Site specific.
DATA MANAGEMENT	Paper files mainly. A small portion of data goes into STORET. Plans for more data to be entered into STORET.	Paper files.
MAPS INCLUDED IN REPORTS		
REFERENCES	Schmidt (1987).	

3. ASSESS SITE-SPECIFIC PROBLEMS (Continued)

STUDY LOCATION	Statewide Hazardous Waste Cleanup Program - CERCLA or Superfund	Statewide - Regional Operations and Enforcement Technical Support Section
OBJECTIVES	1) To determine if a past practice is negatively affecting ground or surface water quality. 2) To define the extent of the problem. 3) To determine corrective measures. 4) To assess corrective action measures.	1) To document whether petroleum product has reached ground water following a spill. 2) To characterize the extent of the problem. 3) To determine the effect of corrective action.
SECONDARY OBJECTIVES	4	2
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Intensive (some reconnaissance sampling).	Anywhere from reconnaissance sampling to intensive.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Mostly monitoring wells and piezometers, some private and public supply wells, soils, and soil gas.	Initially usually private wells, monitoring wells drilled as necessary.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	28 sites on the EPA National Priority List; 52 sites now being investigated. Number of wells per site varies.	Start with about 3-5 wells, more added. Water Resources Investigations Section in Ecology advises on monitoring well location. Usually consultant takes over investigation.
FREQUENCY/DATES OF SAMPLING	Variable. Monitoring should continue as long as a threat of a problem exists.	Variable. 90 days after a spill property owner responsible, but Ecology often continues to sample periodically.
QA/QC PROCEDURES ESTABLISHED	Extensive QA project plan prepared for each site. Chain of custody procedures used. EPA Contract Laboratory Protocols used.	EPA/Ecology Laboratory, Manchester analyzes samples.
COST	Millions of dollars.	$500,000/year.
FUNDING SOURCE	EPA, Ecology, and site owner.	Coastal Protection Fund and Hazardous Waste Cleanup Fund.
AGENCY OR GROUP CONDUCTING MONITORING	EPA lead agency in about half of the projects, Ecology lead agency in other half. Both agencies contract out most of investigations to private contractors. Ecology Hazardous Waste Cleanup and Water Quality Investigations Section conduct some preliminary sampling.	Ecology Regional Offices initially. Private contractor takes over after 90 days.
PARAMETERS SAMPLED	Static water levels, priority pollutants, depends on the site.	Benzene, toluene, xylene, lead, EDB, priority pollutant scan with emphasis on lighter petroleum products.
DATA MANAGEMENT	Paper files. Plans for development of a Geographical Information System.	Paper files.
MAPS INCLUDED IN REPORTS		
REFERENCES	Ecology (1985).	Kittle (1987).

3. ASSESS SITE-SPECIFIC PROBLEMS (Continued)

STUDY LOCATION	Puyallup, Western Washington Research and Extension Center (WSU)	Oroville, Tonasket, and Wenatchee (Washington Apple Packers)
OBJECTIVES	To study the potential and mechanism for ground water contamination from soil-applied pesticides (carbofuran, simazine, and metalaxyl) on strawberries and raspberries.	1) To characterize apple packing wastewater. 2) To investigate potential ground water contamination.
SECONDARY OBJECTIVES		2, 4
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Intensive (2 locations, 1 acre on each site, 2 crops on each acre divided into smaller plots).	Reconnaissance sampling.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Soil cores, lysimeters, PVC monitoring wells.	Public supply and industrial wells, well points, packing plant tanks, and drenchers.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	Two composite soil samples at 4 sites (5 depths/sample); lysimeter samples at 3 depths; 12 pairs of monitoring wells (one shallow, one deeper).	Oroville - 7 sources Tonasket - 6 sources Wenatchee - 7 sources (One control well at each site.)
FREQUENCY/DATES OF SAMPLING	Immediately before treatment (1986), 2 and 4 weeks post-treatment, and monthly thereafter. (Plan to collect data for 4 years.)	Once in October 1979.
QA/QC PROCEDURES ESTABLISHED	Extensive, e.g. soil sample blanks and spikes analyzed. Puyallup Research Station analyzing soil samples, Oregon State U. Agricultural Chemistry Lab analyzing water samples.	
COST	$76,000/year for 4 years.	
FUNDING SOURCE	Washington State University, U.S. Department of Agriculture, Washington State Water Research Center, USGS, and industry.	EPA and Ecology.
AGENCY OR GROUP CONDUCTING MONITORING	WSU Agricultural Research and Extension Center.	SCS Engineers under contract to EPA and Ecology.
PARAMETERS SAMPLED	Residues of carbofuran, simazine, and metalaxyl (selected samples for mobile metabolites), nitrate, chloride, temperature, pH, organic carbon, cation exchange capacity, moisture holding capacity, static water level.	pH, chemical oxygen demand, biochemical oxygen demand, dissolved oxygen, total suspended solids, turbidity, phenols, chlorine residuals, benomyl, thiabendazole (TBZ), sodium orthophenyl phenate (SOPP), diphenylamine (DPA).
DATA MANAGEMENT	Computerized	Paper files.
MAPS INCLUDED IN REPORTS	Pesticide Root Zone Model (PRZM) or PRESTANS model results compared with field results.	Well locations and concentrations of benomyl, TBZ, SOPP, and DPA.
REFERENCES	Getzin (1986).	SCS Engineers (1980).

3. ASSESS SITE-SPECIFIC PROBLEMS (Continued)

STUDY LOCATION	Skagit, Thurston, and Whatcom Counties	Thurston County Berry-Growing Areas
OBJECTIVES	To sample wells near berry fields where EDB used in the past and to protect public health.	1) To follow up on 1984 EDB sampling near berry fields, to assess whether EDB contamination plume has moved. 2) To determine if 5 other herbicides and pesticides used in the area are present in local well water. 3) To determine which households should receive alternative water supplies.
SECONDARY OBJECTIVES	2	
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Reconnaissance sampling.	Reconnaissance sampling.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Public supply and private wells.	Mostly private wells, some public supply wells.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	Ninety-six wells: downgradient and less than a half mile from application site; 15 percent of samples upgradient; wells in shallow, unconfined aquifers with permeable soils.	27 wells - some where EDB previously detected in 1984 (see preceding study description). Some wells chosen for being in assumed flow direction, some for being outside the flow direction; one background well.
FREQUENCY/DATES OF SAMPLING	Once June-October 1984. If EDB detected, then 2 more samples collected to confirm.	February, August, and October 1986.
QA/QC PROCEDURES ESTABLISHED	EPA's Standard Laboratory Instruction Sheet was followed for sample collection and transport. If possible, samples collected at well head or as close as possible and upstream of pressure tanks. EPA/Ecology Laboratory, Manchester analyzed samples.	Relatively extensive: Duplicates collected for at least one well per sampling event. Lauck's Laboratory, Seattle analyzed some samples. EPA/Ecology Laboratory in Manchester others.
COST	$31,000 for lab expenses plus 1.5 FTEs.	$5,600 per sampling event.
FUNDING SOURCE	DSHS, EPA, local health departments.	State Hazardous Waste Cleanup Fund.
AGENCY OR GROUP CONDUCTING MONITORING	DSHS, EPA, local health departments.	Ecology Hazardous Waste Cleanup Program.
PARAMETERS SAMPLED	Ethylene dibromide (EDB), nitrate, and bacteriological samples.	Ethylene dibromide (EDB), 1,2 dichloropropane in each well; simazine, methylbromide, dionoceb, and diphenamide in 6 wells.
DATA MANAGEMENT	Paper files.	Paper Files.
MAPS INCLUDED IN REPORTS	Aerial photos of sampled wells available.	
REFERENCES	Washington Department of Social and Health Services (1985)	Dunster (1986)

3. ASSESS SITE-SPECIFIC PROBLEMS (Continued)

STUDY LOCATION	Skagit County Berry-Growing Areas	University of Washington College of Forest Resources, Pack Forest, Eatonville; Port Angeles
OBJECTIVES	1) To follow up 1984 EDB sampling near berry fields. 2) To roughly define the extent of contamination.	To determine effects of municipal and pulp and paper sludge application on concentrations of selected constituents in soil pore water and ground water. Research and control plots compared.
SECONDARY OBJECTIVES		
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Reconnaissance sampling.	Intensive.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Private and public supply wells.	Monitoring wells and lysimeters.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	33 wells, one spring - some wells where EDB detected in 1984, others to define the extent of contamination.	Two wells since 1973, plus 4 new wells since 1983, many lysimeters.
FREQUENCY/DATES OF SAMPLING	Five rounds of samples between June 1984 and April 1985; once in February 1986.	Early data weekly. Two 2-yr periods between 1973 and present with no data. Past two years (1985 and 1986) monthly sampling.
QA/QC PROCEDURES ESTABLISHED	Relatively extensive. EPA/Ecology Laboratory, Manchester analyzed samples.	University of Washington College of Forest Resources lab for inorganics. Split some samples with Seattle METRO lab. Organics and bacteria analyzed by Seattle METRO lab.
COST		
FUNDING SOURCE	State Hazardous Waste Cleanup fund.	Ecology, Seattle METRO, Crown Zellerbach
AGENCY OR GROUP CONDUCTING MONITORING	EPA, Ecology, and Skagit County Health Department.	University of Washington, College of Forest Resources
PARAMETERS SAMPLED	Ethylene dibromide (EDB).	. Nitrate and specific conductance. . Heavy metals (cadmium, lead, zinc, copper, nickel), quarterly in lysimeters and 2 of 4 new wells.
DATA MANAGEMENT	Paper Files.	1984-87 data stored on METRO's computer data base.
MAPS INCLUDED IN REPORTS		
REFERENCES	Beery (1986)	Henry (1987, 1986).

3. ASSESS SITE-SPECIFIC PROBLEMS (Continued)

STUDY LOCATION	Eagle Harbor, Bainbridge Island	Budd Inlet, Olympia
OBJECTIVES	To quantify conventional and priority pollutant concentrations (especially polynuclear aromatic hydrocarbons indicative of creosote) in seepage, ground water, and sediments near a wood-treating facility.	Preliminary study to determine if creosote, pentachlorophenol, or metals were discharging into Budd Inlet from a wood-treating facility.
SECONDARY OBJECTIVES		
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Reconnaissance sampling.	Reconnaissance sampling.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	One private test well, seeps.	A stormwater discharge, a bank seep, and an off-site storm drain in communication with contaminated ground water, and two monitoring wells.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	Four seeps, 1 well.	See above.
FREQUENCY/DATES OF SAMPLING	Well - twice: May, June 1985. One seep - 3 times: May, June, October 1985. Three seeps - once: June 1985.	Once: February 1985.
QA/QC PROCEDURES ESTABLISHED	Extensive - field procedures, conventional parameters and metals analyzed at EPA/Ecology Lab, Manchester; prioirty pollutants at METRO Lab, Seattle.	Extensive - field procedures, samples analyzed at EPA/Ecology Lab, Manchester.
COST		
FUNDING SOURCE	Ecology Hazardous Waste Cleaup Program.	Ecology Water Quality Program.
AGENCY OR GROUP CONDUCTING MONITORING	Ecology - Water Quality Investigations Section, Technical Services Program.	Ecology - Water Quality Investigations Section, Technical Services Program.
PARAMETERS SAMPLED	pH, specific conductance, turbidity, color, oil and grease, recoverable phenolics, ammonia, nitrate, nitrite, orthophosphorus, total phosphorus, total suspended solids, total organic carbon, metals, volatile organics, pesticides/ PCBs. (One seep: base/neutrals and acid extractables. Laboratory problems with well and other seep samples.)	Temperature, pH, specific conductance, total suspended solids, metals, volatile and semivolatile organics.
DATA MANAGEMENT	Paper files.	Paper files.
MAPS INCLUDED IN REPORTS	Study area showing sampling locations.	Study area showing sampling locations.
REFERENCES	Yake, et al (1986).	Johnson (1985).

3. ASSESS SITE-SPECIFIC PROBLEMS (Continued)

STUDY LOCATION	Pasco Industrial Park	Whidbey Island Landfills, Island County
OBJECTIVES	To document petroleum contamination and screen for other contaminants of concern (especially pesticides and PCBs).	To detect contamination from two unlined landfills: Freeland and Coupeville.
SECONDARY OBJECTIVES		4
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Reconnaissance sampling.	Reconnaissance sampling.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Monitoring wells.	Monitoring wells, old drinking water wells.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	Two wells previously on the site.	Freeland Landfill: 3 wells (single completion). Coupeville landfill: one single completion, one double completion well, and one drinking water well.
FREQUENCY/DATES OF SAMPLING	Twice: September 1985 and September 1986.	Quarterly: October 1985-September 1986 for indicator parameters (4 replicates at each well). October 1985 for drinking water parameters and volatile organics.
QA/QC PROCEDURES ESTABLISHED	Field blanks and duplicates analyzed. Samples analyzed at EPA/Ecology Laboratory, Manchester.	Extensive, chain of custody procedures. Analytical Technologies, Inc., California analyzed all samples (according to EPA methods). Duplicates, spikes, standard solutions.
COST		$100,000
FUNDING SOURCE	Ecology.	Federal 205j funds through Ecology and Island County funding.
AGENCY OR GROUP CONDUCTING MONITORING	Ecology - Water Quality Investigations Section, Technical Services Program.	Island County Health Department.
PARAMETERS SAMPLED	Specific conductance, total suspended solids, oil and grease, volatiles, semi-volatiles, PCBs, pesticides, 8 metals, cyanide, and hydrocarbon matching test.	Indicator parameters: pH, specific conductance, chloride, sulfate, TOC, TOX. Drinking Water Parameters: Metals (arsenic, barium, cadmium, copper, chromium, iron, lead, manganese, mercury, selenium, silver, zinc), nitrate, fluoride, color, odor, total dissolved solids, fecal coliform bacteria, organics (endrin, lindane, methoxychlor, toxaphene, 2,4-D, 2,4,5-TP and volatile organics).
DATA MANAGEMENT	Paper files.	Paper files going to personal computer.
MAPS INCLUDED IN REPORTS	Study area and sampling locations.	
REFERENCES	Johnson and Norton (1986)	Sweet Edwards and Associates (1986).

3. ASSESS SITE-SPECIFIC PROBLEMS (Continued)

STUDY LOCATION	Long and Patterson Lake Area, Thurston County	Deer Park, Spokane County
OBJECTIVES	To provide data for a regional model to predict effects of various types of land use practices on ground water quality.	1) To identify sources and determine extent of nitrate contamination in Deer Park ground water (6 square mile area). 2) To recommend corrective action.
SECONDARY OBJECTIVES	1	
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Intensive	Reconnaissance sampling.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	41 private wells, 20 shallow monitoring wells around shorelines, and 20 well point samplers.	Mostly private wells, 5 public supply wells.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	1981-85: 20 well points and 20 domestic wells. 1984-86: 20 additional domestic wells. 1985-86: 20 shallow monitoring wells added. (Limited data back to 1977.)	90-100 wells (most of the existing wells in the study area).
FREQUENCY/DATES OF SAMPLING	Every two months.	Five times in about ten months, 1986.
QA/QC PROCEDURES ESTABLISHED	Limited before 1984; beefed up in 1984.	Spokane Health District Lab analyzed samples. A few samples split with Benton/ Franklin Health District Lab. Samples collected as close to the well head as possible.
COST		$52,000
FUNDING SOURCE	Ecology, Thurston County, and local homeowners.	Federal 250j funds through Ecology and Spokane County.
AGENCY OR GROUP CONDUCTING MONITORING	ENTRANCO Engineers on contract to Thurston County.	Spokane Health Department and Eastern Washington University.
PARAMETERS SAMPLED	Specific conductance, chloride, nitrate plus nitrite, total and orthophosphate.	Nitrate, chloride, fecal coliform bacteria.
DATA MANAGEMENT	IBM - AT Computer	Paper files.
MAPS INCLUDED IN REPORTS		
REFERENCES	ENTRANCO Engineers (in preparation).	Spokane Health District final report (in preparation); Anderson (1986).

3. ASSESS SITE-SPECIFIC PROBLEMS (Continued)

STUDY LOCATION	Three landfills in Washington: Tacoma, Argonne Road, Green Acres
OBJECTIVES	Using existing data: 1) To describe the hydrogeologic setting in the immediate area. 2) To determine whether ground or surface water contamination attributable to the landfill. 3) To make recommendations for additional data if necessary to accomplish 1) and 2) above.
SECONDARY OBJECTIVES	2, 4, 5
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Only existing data from EPA, Ecology, USGS, DSHS, and Tacoma-Pierce County Health Department used.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Public supply and private wells.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	25-30 wells per study area. Chose wells close to landfill sites.
FREQUENCY/DATES OF SAMPLING	Variable.
QA/QC PROCEDURES ESTABLISHED	Many different programs; most data collected before QA/QC a concern.
COST	$40-45,000/landfill.
FUNDING SOURCE	50% USGS/50% Ecology (Hazardous Waste. Cleanup Program)
AGENCY OR GROUP CONDUCTING MONITORING	USGS (Ecology cooperated).
PARAMETERS SAMPLED	(From existing data): pH, specific conductance, total dissolved solids, cations, anions, nitrate, trace metals, and volatile organics.
DATA MANAGEMENT	No new data collected.
MAPS INCLUDED IN REPORTS	- Waste disposal areas. - Geohydrologic cross-sections of study areas. - Well locations.
REFERENCES	Lum and Turney (1985), Lum, et al. (1986), Dion (in press).

3. ASSESS SITE-SPECIFIC PROBLEMS (Continued)

STUDY LOCATION	Pierce County Landfills	West Yakima County
OBJECTIVES	Preliminary investigation to determine if contamination from three landfills (Purdy, Tacoma, and Thun Field) is affecting nearby drinking water wells.	To make a preliminary characterization of shallow ground water quality in areas wher nitrate and bacterial contamination are a problem.
SECONDARY OBJECTIVES	2, 4	2
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECON-NAISSANCE SAMPLING	Reconnaissance sampling/Ambient.	Reconnaissance sampling.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Private wells (one dual completion monitoring well near Thun Field).	Private wells.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	4-12 wells sampled (all wells in 1-2 mile radius in the direction of flow - subset of these sampled).	1973: 100 wells. 1986: 30 wells - A local announcement was made for anyone in the community who wantec to sample their well water.
FREQUENCY/DATES OF SAMPLING	Quarterly: Tacoma began 1984; Thun Field and Purdy 1985.	Wiley City, Ahtanum, Skyview Acres, Meadowbrook Acres, Wide Hollow, and rural area: Once, June 1973. Wiley City: Once, August 1986.
QA/QC PROCEDURES ESTABLISHED	Field crew collecting samples trained by EPA. Split samples when potential legal implications (with EPA/Ecology Lab) 1984 - mid-1986 Water Management Lab, Tacoma, analyzed inorganics, Weyerhaeuser Lab organics. Since mid-1986 AmTest Lab, Seattle, has analyzed both inorganics and organics.	1986: Very limited.
COST	$30-40,000/year.	1986: $10,000.
FUNDING SOURCE	Pierce County.	1973: DSHS 1986: Rural Community Action Committee.
AGENCY OR GROUP CONDUCTING MONITORING	Tacoma-Pierce County Health Department.	1973: Yakima County Health District and DSHS. 1986: Yakima Council of Governments and Yakima County Health Department.
PARAMETERS SAMPLED	Specific conductance, arsenic, cadmium, chromium, iron, lead, manganese, copper, nickel, zinc, nitrate, ammonia, turbidity. Occasionally TOX, TOC (Tacoma Landfill - VOA, base neutrals, pesticides).	1973: Coliform bacteria, nitrate, nitrite, phosphate, LAS detergent, hardness, chloride. 1986: Nitrate and phosphate.
DATA MANAGEMENT	Paper files, plan to put on a computer data base.	Paper files.
MAPS INCLUDED IN REPORTS		
REFERENCES	Sandison (1986).	Washington Department of Social and Health Services (1973).

4. ENSURE COMPLIANCE WITH REGULATIONS

STUDY LOCATION	Statewide- Hazardous Waste Management Facilities	Statewide - Aluminum Producers and Oil Refineries
OBJECTIVES	To meet the requirements of the Federal Resource Conservation and Recovery Act (RCRA) and the State Dangerous Waste Regulations (Chapter 173-303 WAC). Objective of regulations: To detect and identify hazardous waste constituents in ground water at levels which cause a statistically significant change - near hazardous waste management facilities. To assess the nature and extent of contamination if discovered.	To meet the requirements of the Federal Resource Conservation and Recovery Act (RCRA) and the State Dangerous Waste Regulations (Chapter 173-303 WAC). To detect and identify hazardous waste constituents in ground water at levels that cause a statistically significant change - near aluminum production facilities and oil refineries. (Pulp and paper facilities handled by the Industrial Section not required to monitor ground water).
SECONDARY OBJECTIVES	2, 3	2, 3
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Compliance/Intensive.	Compliance/Intensive.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Monitoring wells and piezometers, mainly.	Monitoring wells.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	Minimum of 4 wells per site (one hydraulically upgradient and three downgradient) in the uppermost aquifer and all interconnected aquifers. Most facilities have about 20 wells. 36 facilities now monitoring.	Minimum of 4 wells (one hydraulically upgradient and three downgradient) in the uppermost aquifer, and all interconnected aquifers. 8 facilities in the state now monitoring.
FREQUENCY/DATES OF SAMPLING	Interim status: quarterly first year. If no indication of contamination, twice per year thereafter. If increases in constituents downgradient, then quarterly for the life of the facility and 30 years after closure and annually for the Appendix VIII constituents (40 CFR 261).	Same as Hazardous Waste Management Facilities.
QA/QC PROCEDURES ESTABLISHED	Laboratory methods according to EPA Publication SW-846, "Test Methods for Evaluating Solid Waste - Physical/Chemical Methods." QA/QC according to U.S. EPA (1986)	Same as Hazardous Waste Management Facilities
COST	Millions of dollars.	
FUNDING SOURCE	Facility owners/operators.	Facility owners.
AGENCY OR GROUP CONDUCTING MONITORING	Contractors hired by facilities. Ecology Hazardous Waste Section works with facilities to negotiate and approve ground water monitoring details. Hazardous Waste and Regional Office Staff conduct sampling inspections. EPA oversees.	Contractors hired by facility owners. Ecology Industrial Section works with facilities (along with Hazardous Waste Section) to negotiate and approve ground water monitoring plans. Ecology carries out sampling inspections. EPA oversees.
PARAMETERS SAMPLED	Interim status (first 1½-2 years): 1st year: primary drinking water parameters under the Federal Safe Drinking Water Act. Every year: Chloride, iron, manganese, phenols, sodium, sulfate, specific conductance, pH, total organic carbon, total organic halogen, static water level. Assessment (if leakage detected): Site-specific parameters quarterly and Appendix VIII constituents annually. Corrective Action: Site-specific.	Same as Hazardous Waste Management Facilities.
DATA MANAGEMENT	Paper files, Ecology and EPA planning to enter in computer data bases.	Paper files.
MAPS INCLUDED IN REPORTS		
REFERENCES	U.S. Federal Register (July 1, 1984) Sanders (1985)	U.S. Federal Register (July 1, 1984)

4. ENSURE COMPLIANCE WITH REGULATIONS

STUDY LOCATION	Statewide - Department of Social and Health Services (DSHS)	Statewide - Facilities with Permits for Known or Suspected Discharges to GW Ground Water
OBJECTIVES	To detect contamination in public drinking water supplies and protect public health. To ensure compliance with Public Water Systems (Chapter 248-54 WAC).	To detect ground water contamination due to a industrial, commercial, municipal facility (e.g. land application of wastewater, seepage lagoons, etc.).
SECONDARY OBJECTIVES	2	2
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Compliance.	Compliance with waste discharge permits (issued under Chapter 90.48 WAC).
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Class 1 and 2 public supply wells (Class 3 and 4 wells required to sample for nitrate once every 3 years). Class 1: Systems with 100 or more permanent services or transitory population of 1,000 or more on any one day. Class 2: Systems with 10-99 permanent services or transitory population of 300-999 on any one day.	Private wells, monitoring wells, a few with lysimeters.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	All class 1 and 2 systems (2,400 systems in the state which represent 3,560 wells).	1-5 per facility (of 183 discharge permits where potential to contaminate ground water exists, only 50 require any ground water monitoring - information available from Southwest, Central, and Eastern Regional Offices only. Many other facilities and activities have a high potential to contaminate ground water but do not have waste discharge permits).
FREQUENCY/DATES OF SAMPLING	Every three years for inorganics; bacteriological sampling frequency depends on the population served (at least two samples per month per system).	Variable - monthly to annually.
QA/QC PROCEDURES ESTABLISHED	Limited. Samples are collected by purveyors, preserved in the lab (supposedly within 48 hours). DSHS Lab in Seattle analyzes most of the inorganics. Local health department labs and DSHS Lab, Seattle analyze bacteriological samples.	Extremely limited in most cases.
COST	About $160,000-200,000 per year.	Variable.
FUNDING SOURCE	Well purveyors.	Facility owners.
AGENCY OR GROUP CONDUCTING MONITORING	Purveyors collect samples, DSHS oversees and manages program.	Facility owners' contractors - Ecology regulates. Permits written in Ecology regional offices.
PARAMETERS SAMPLED	Primary drinking water parameters: Arsenic, barium, cadmium, chromium, fluoride, lead, mercury, nitrate, selenium, silver, fecal coliform bacteria. Secondary drinking water parameters: Color, iron, manganese, total dissolved solids. When DSHS determines that it is necessary: chloride, sulfate, copper, zinc, odor.	Typically a subset of the following: Nitrate, ammonia, chloride, fecal and total coliform bacteria.
DATA MANAGEMENT	Paper files for data collected before 1980. DSHS computer system for data collected in 1980 and after. DSHS/Ecology data transfer capability being developed.	Paper files in regional offices.
MAPS INCLUDED IN REPORTS		
REFERENCES		

4. ENSURE COMPLIANCE WITH REGULATIONS (Continued)

STUDY LOCATION	Statewide - Solid Waste Facilities * (Landfills in particular)	Wildrose Prairie, Spokane County
OBJECTIVES	To detect ground water contamination due to a solid waste facility.	To detect leachate in wells within 500 feet of experimental sludge application sites (outside the Spokane Aquifer boundaries).
SECONDARY OBJECTIVES	3	2
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Compliance with Minimum Functional Standards for Solid Waste Handling (Chapter 173-304 WAC). Most solid waste facilities in the state not in compliance with ground water monitoring requirements).	Compliance/Ambient.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Monitoring wells, some private wells.	Private wells.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	Minimum of 1 well hydraulically upgradient and three downgradient at appropriate locations and depths to collect samples from the uppermost aquifer and all connected aquifers below the active portion of the facility.	8 wells routinely, 18 wells one time only 1982-1984; 25 wells 1985, 1986.
FREQUENCY/DATES OF SAMPLING	At least quarterly during the active life (including closure period) and post-closure care period.	8 wells about three times yearly (February, June, September) 1982-1984; (most less than that). 25 wells annually 1984 - 1986.
QA/QC PROCEDURES ESTABLISHED	Laboratory methods according to EPA Publication SW-846, "Test Methods for Evaluating Solid Waste - Physical/Chemical Methods" except total coliform which shall use the latest edition of "Standard Methods for the Examination of Waste and Wastewater."	Limited; City of Spokane Laboratory analyzed samples.
COST	Variable.	$10,000/yr
FUNDING SOURCE	Facility owners.	Ecology, City of Spokane
AGENCY OR GROUP CONDUCTING MONITORING	County health departments responsible for enforcement; Ecology works with health departments.	City of Spokane
PARAMETERS SAMPLED	Static water levels, ground water flow rates and direction, temperature, specific conductance, pH, chloride, nitrate, nitrite, sulfate, dissolved iron and zinc, chemical oxygen demand, total organic carbon, total coliform, and any others that health departments, in consultation with Ecology, specify.	Specific conductance, hardness, nitrate, phosphate, chloride, cadmium, copper, lead, nickel, zinc, fecal and total coliform bacteria, fecal streptococcus.
DATA MANAGEMENT	Paper files.	Paper files.
MAPS INCLUDED IN REPORTS		
REFERENCES	Spokane County Health Department (1986).	

*See Figure 1 for list of landfills doing ground water monitoring.

4. ENSURE COMPLIANCE WITH REGULATIONS (Continued)

STUDY LOCATION	Shelton (Mason County), Skookumchuck Valley (Thurston County), and Cumberland Valley (King County)
OBJECTIVES	To determine effects of sludge application on ground water at three sites in western Washington.
SECONDARY OBJECTIVES	2
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Compliance/Ambient
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Lysimeters, monitoring wells, and private wells.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	Shelton: One deep well upgradient. One lysimeter with a piezometer beside upgradient well. Two lysimeters downgradient with piezometers beside. Skookumchuck Valley: One well upgradient. One well downgradient. Three lysimeters in application plot. Two lysimeters in control area. Cumberland Valley: One well on-site. One well adjacent downgradient. Three to four lysimeters downgradient and one to two lysimeters upgradient (total of five lysimeters).
FREQUENCY/DATES OF SAMPLING	Monthly for 15 months, quarterly thereafter.
QA/QC PROCEDURES ESTABLISHED	ACZ Bookcliff's Laboratory, Colorado analyzes all constituents except bacteria which is done at Water Management Laboratory, Tacoma. Samples collected by hydrologist.
COST	Shelton: $4,800/yr, decreasing to $1,600 after 15 months. Skookumchuck Valley: $900/yr. Cumberland Valley: $700/yr.
FUNDING SOURCE	Property owners.
AGENCY OR GROUP CONDUCTING MONITORING	Solganic Services Corp., Chehalis
PARAMETERS SAMPLED	Nitrate, fecal coliform bacteria, chloride, zinc.
DATA MANAGEMENT	
MAPS INCLUDED IN REPORTS	
REFERENCES	Hickey (1986).

4. ENSURE COMPLIANCE WITH REGULATIONS (Continued)

STUDY LOCATION	Centralia WIDCO Site
OBJECTIVES	To detect effects of Washington Irrigation and Development Company (WIDCO) coal mining and site restoration operation on ground and surface water quality.
SECONDARY OBJECTIVES	3
TYPE OF MONITORING (AMBIENT, INTENSIVE, COMPLIANCE) OR RECONNAISSANCE SAMPLING	Compliance.
STATION (PUBLIC SUPPLY, PRIVATE, MONITORING WELL, ETC.)	Monitoring wells.
NUMBER OF SAMPLING SITES/ METHOD FOR CHOOSING	32 wells, 11 surface water sites.
FREQUENCY/DATES OF SAMPLING	Quarterly for about 20 constituents; annually (every September) for about 55 constituents since November 1982.
QA/QC PROCEDURES ESTABLISHED	Try to keep sampling and handling procedure as standardized as possible. ACZ Bookcliff's Laboratory, Colorado analyzes samples except fecal coliform bacteria which are analyzed at Water Management Associates, Tacoma. Bookcliff's checks cation/anion balances and maintains QC control charts (Lauck's Lab, Seattle analyzed samples for the first year (1982-83).
COST	
FUNDING SOURCE	Facility owner.
AGENCY OR GROUP CONDUCTING MONITORING	WIDCO - Ecology and EPA regulate under NPDES and SMCRA.
PARAMETERS SAMPLED	Quarterly: Temperature, specific conductance, pH, alkalinity (field and lab), static water level, total dissolved solids, ammonia, chloride, sulfate, arsenic, boron, cadmium, dissolved iron, dissolved lead, dissolved manganese, dissolved mercury, dissolved selenium, dissolved sodium, dissolved zinc. Annually (September): The same parameters as quarterly sampling plus total suspended solids, hardness, nitrate, nitrite, fluoride, total phosphate, dissolved aluminum, dissolved calcium, dissolved chromium, dissolved magnesium, dissolved potassium, and anion/cation balance.
DATA MANAGEMENT	Private computer data base, paper files in Ecology.
MAPS INCLUDED IN REPORTS	
REFERENCES	Proffit (1987).

Figure 1. **Landfill Sites with Ground Water Monitoring (most do not meet Minimum Functional Standards but more or less close, many in the process of upgrading)**

Southwest Region

Cowlitz County - Longview
Rainbow Valley - Raymond
Aberdeen - Aberdeen
Thurston County - Olympia
Centralia - Centralia
Thun Field - Tacoma (also Superfund site)
Tacoma - Tacoma
Purdy - Purdy

Eastern Region

Northside - Spokane County (also Superfund site)
Colbert - Spokane County (also Superfund site)
Southside - Spokane County
Mica - Spokane County
Walla Walla County - Walla Walla
Whitman County - Pullman (residential wells, one drinking water well on site)
Pasco Landfill - Pasco

Central Region

Dryden (closed) - Dryden
Ellisforde - Ellisforde) 2 wells each downgradient
Cashmere - Cashmere)
Yakima County - 3 landfills sending out Requests for Proposals (2/86) to begin installing monitoring network

Northwest

Island County - Coupeville
Skagit County
Whatcom County
Snohomish County
Lake Stevens - (post-closure monitoring)
Cathcart - Snohomish County
Olympic View - Kitsap County
Hansville - Kitsap County
Olalla - Kitsap County (post-closure monitoring)
Cedar Falls - King County
Cedar Hills - King County

Monitoring networks to be completed in 1986:

Vashon Island
Hobart
Enumclaw
Newcastle
Duvall/Carnation

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