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Waterway Segment 11-24-GW
TECHNICAL MEMORANDUM

WA-24-0010

Environmental Investigations

Toxics Investigations/Groundwater Monitoring Section

Summary Report - Long Beach Peninsula Ground Water Study

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Report Produced for the Water Quality Program

Clients:
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ABSTRACT

Thirty-six wells on the Long Beach (formally, North Beach) Peninsula were sampled between June 1987 and February 1988. Ground water samples drawn from these wells (most of which were completed near the surface of the shallow unconfined aquifer) were analyzed for a limited range of parameters including nutrients, chloride, bacteria, and selected metals. Data interpretation focuses on nitrate and chloride results.

Physical conditions on the Peninsula (highly drained, sandy soils and a shallow water table) make the ground water highly vulnerable to contamination. Data obtained during this study indicate that ground water quality has been adversely effected by human activities. The degree of degradation is generally moderate. Accurate determination of the rate of degradation and the relative importance of specific pollution sources will require additional monitoring.

INTRODUCTION

In early 1987 the Southwest Regional Office (SWRO) of the Department of Ecology (Ecology) requested that Environmental Investigations (EI) conduct a preliminary study of water quality conditions in the shallow aquifer of the northern portion of the Long Beach Peninsula. The study was requested under the auspices of the Water Quality Program (WQP).

The people of the northern Long Beach Peninsula depend solely on ground water for both domestic uses (drinking, cooking, bathing) and agricultural uses (irrigation, stock watering). This resource is vulnerable, in part, because much of the ground water is found in shallow aquifers (0 to 15 feet to the water table; Tracy, 1978). In addition, conventional septic systems are almost exclusively used in most of the study area. Relatively high densities of development in certain areas (for instance, the town of Ocean Park) concentrate potential sources of ground water contamination like septic systems, stormwater runoff, yard fertilizers, and so on. Vulnerability is also associated with the peninsula's primary agricultural activity: cranberry culture. Bogs, often near the center of the peninsula, are generally contiguous with the water table.

Given the potential vulnerability of shallow ground water in the area, SWRO management and staff were concerned about the extent to which the potential for contamination might have been realized. EI was asked to conduct a reconnaissance study to provide an overview of ground water quality conditions on the peninsula.

The project was designed in mid-1987 by Barbara Carey of the Toxics Investigations/Ground Water Monitoring Section (TI/GMS) of EI. Barbara conducted the field portions of the work between June of 1987 and February of 1988. In July of 1988, Barbara took a new position within Ecology. Reprioritization of staff resources resulted in the elimination of her original position at EI. This "Summary Report" has been written to permit release of the valuable data collected during the study. Some basic interpretation of these data is provided. However, to prevent further delay in releasing this information, full evaluation and interpretation have been set aside until resources are available to complete the work.

BACKGROUND AND SITE DESCRIPTION

The Long Beach Peninsula (formally known as the "North Beach Peninsula") extends northward as a narrow spit from the mouth of the Columbia River in southwestern Washington (Figure 1). The peninsula is about 20 miles long, separating the Pacific Ocean on the west from Willapa Bay on the east. The average width of the peninsula is 1.5 miles (2.4 km). Its total area is 41.7 square miles (108 km^2)(Tracy, 1978).

Population

The permanent population of the peninsula north of the town of Long Beach was 2,253 in 1980. This was a 43 percent increase over the 1970 population of 1,577 people (U.S. Census Bureau).

Because of the importance of tourism in the study area, much of the population is transient. A 1985 estimate of the average transient population of the northern portion of the peninsula was 2,465 (American Engineering, 1985). This estimate was based on the assumption that one-third of transient accommodations were occupied. When added to the permanent population, this results in a total population of 4,718. The average density in the study area is therefore estimated to be about 170 people per square mile.

During peak summer tourist season, total population was estimated at 7,183 (based on two-thirds occupancy of transient accommodations), yielding a total average density of 266 people per square mile.

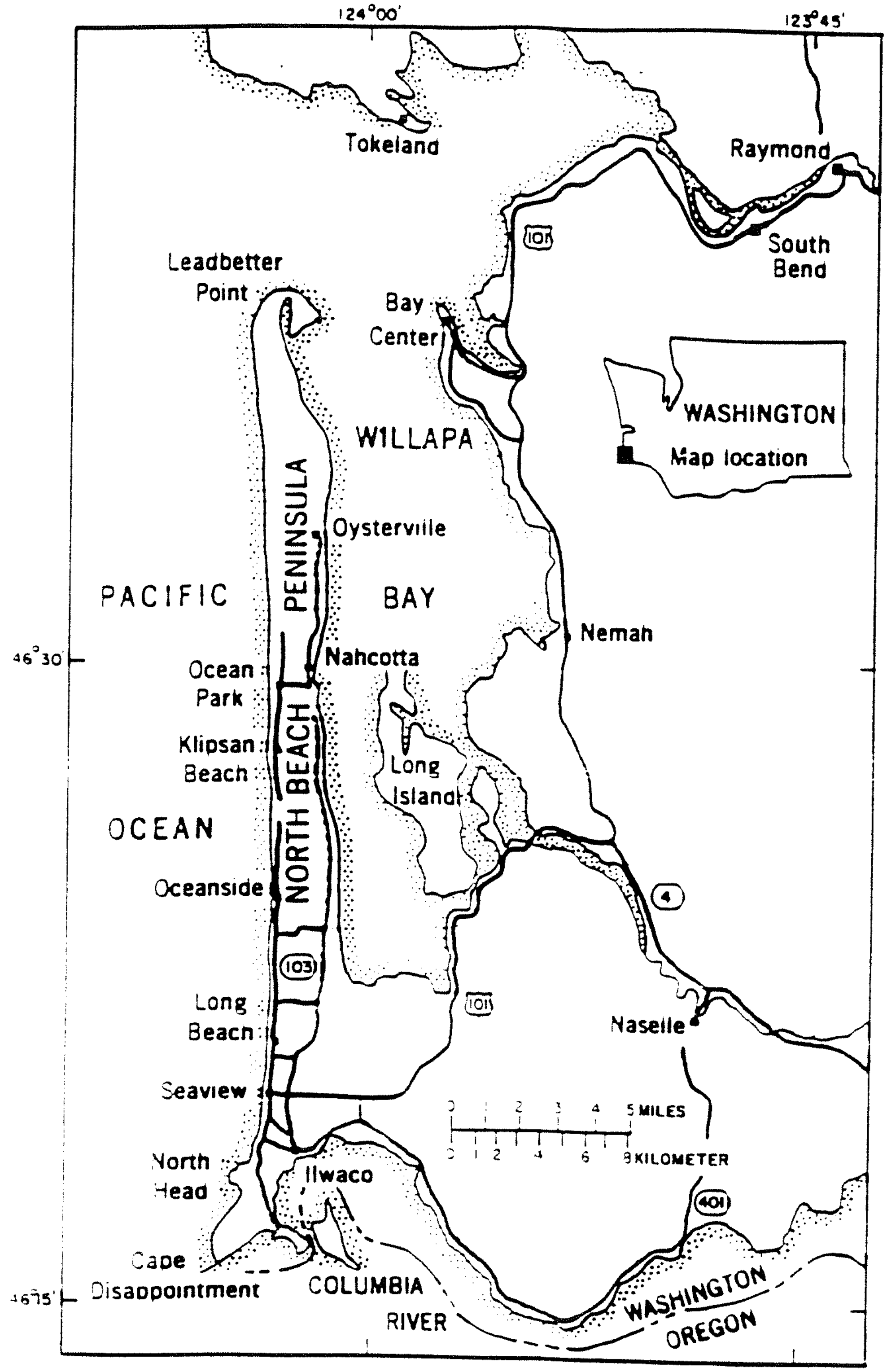

FIGURE 1. LOCATION OF NORTH BEACH (LONG BEACH) PENINSULA

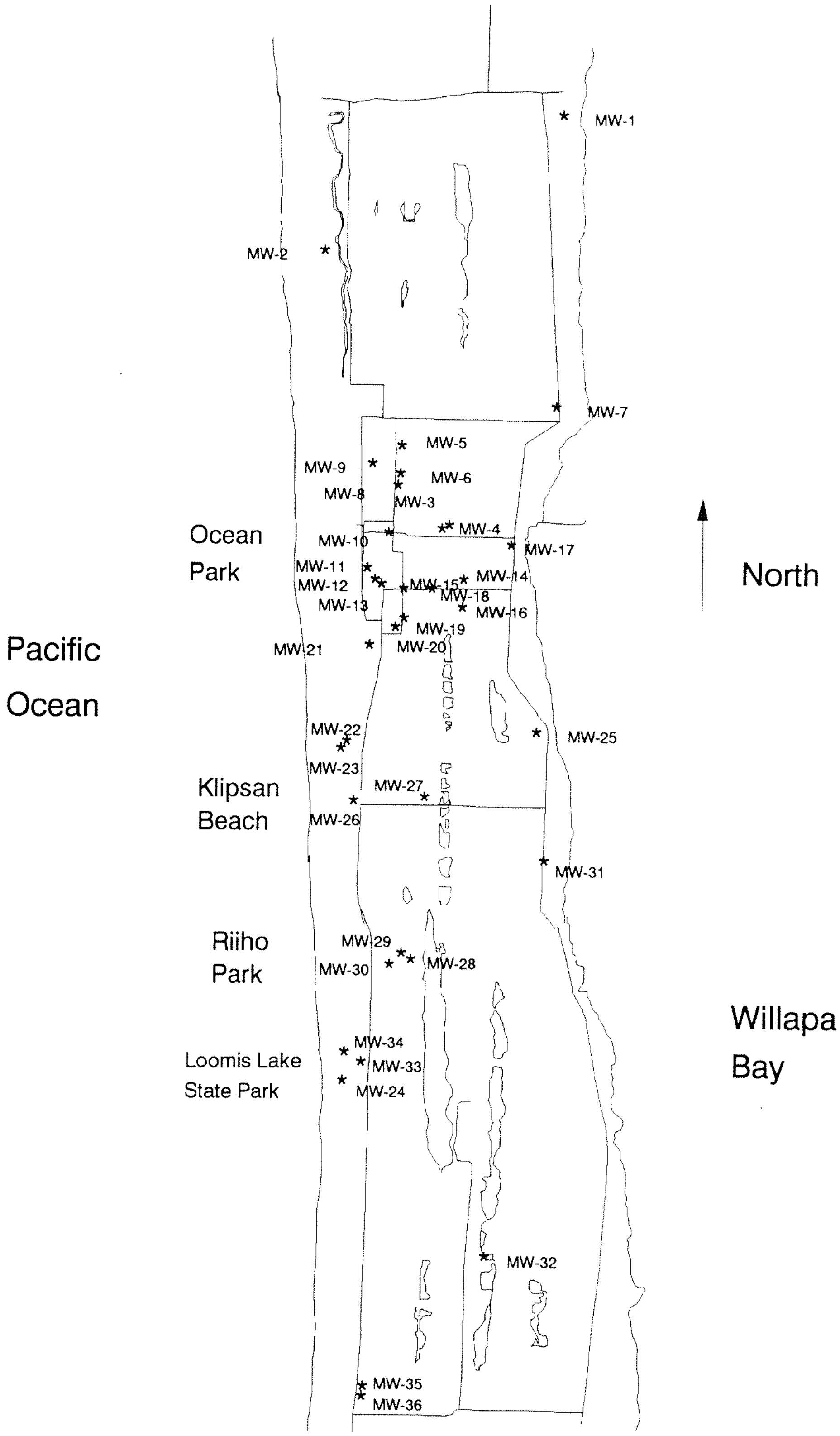

Figure 2. Long Beach Peninsula Study Area

Population
distribution throughout the study area is not even. Densities are higher along the ocean coast and in established communities like Ocean Park.

Geology and Soils

The deep geological structure of the peninsula is not well defined. Based on a single well (Ocean Park Water Co., MW04) that penetrated to bedrock, Tracy (1978) speculated that the peninsula was underlain by basalt. Two major aquifers lie above this bedrock. The shallow, water table aquifer consists of dune sand and marine sand that overlie a clay layer. Depth to clay is about 200 feet at the Ocean Park well. The deeper water-bearing zone, confined below the aquitard, is a deposit of sand, gravel and clay that extends to bedrock (approximately 700 feet below sea level).

This study focuses on the shallower portions (upper dune sand zone) of the water table aquifer. Based on laboratory measurements of permeability in Oregon coastal dune sand of similar origin, Tracy (1978) estimated that the permeability of this zone is about 50 ft/d (.02 cm/s). This is a high permeability, and can contribute to relatively high ground water velocities if the driving force (head differential) is adequate.

Most residential development in the area has occurred on stabilized dunes with well drained soils. Most common is development on Netarts fine sand on to 3 to 12 percent slopes (Soil Conservation Service, 1979). This soil is rated as a poor filter and "severe" for septic tank drain fields. Community sewage systems are recommended if housing density is "moderate to high" in order to "prevent contamination of the water supply from on-site systems" (Soil Conservation Service, 1979).

The combination of highly drained soils, a shallow (0-15 feet) water table, and a very permeable aquifer all contribute to the physical vulnerability of the peninsula's ground water. These are conditions which can allow contamination to move quickly into ground water with relatively little attenuation.

Climate (Precipitation)

The long-term annual average rainfall on the peninsula is 77 inches. Rainfall is heaviest from October to April (Tracy, 1978). From 1970 - 1987 the annual average was 81.9 in. (standard deviation of + 12.6 in.) as measured at the Long Beach Experimental Station (U.S. Climatological Data).

Table 1. Precipitation (1970 to 1987) and estimated potential evapotranspiration and recharge for selected years associated with ground water studies.

Year	Precipitation (in.)*	Estimated Potential Evapotranspiration (in.)**	Estimated Potential Recharge (in.)***
1970	83.95		
1971	98.4E		
1972	88.26		
1973	84.15	23.57	64.85
1974	87.49	24.66	68.16
1975	91.81	24.42	73.91
1976	68.10		
1977	76.34		
1978	69.99	25.11	49.92
1979	79.28	24.82	59.76
1980	73.59	25.17	54.93
1981	83.80		
1982	98.84		
1983	101.86		
1984	90.78		
1985	55.31	24.18	36.59
1986	78.55	25.48	55.27
1987	64.21	25.62	48.78

* U.S. Weather Service Climatological Data for Washington
** Estimated using Thornwaite Method for mean monthly data for Long Beach Experimental Station (Gray, 1970)
*** Precipitation minus estimated evapotranspiration
E Estimated amount (one month's data missing)

Table 1 summarizes annual precipitation, estimated evapotranspiration, and (by difference) recharge. Precipitation, and therefore recharge, is a major influence on water table elevation.

METHODS

Sampling Site Selection

A total of 36 existing wells were chosen for sampling during this study. Their locations are shown in Figure 2. Table 2 summarizes location information on these sampling sites. Of these, 33 were shallow PVC well points used as sources of private drinking water.

Wells were chosen based on access, location and use. Wells used year-around were preferred, but were not always available at desired locations. Wells were selected from areas that represented both rural (low) densities and urban (relatively high) densities.

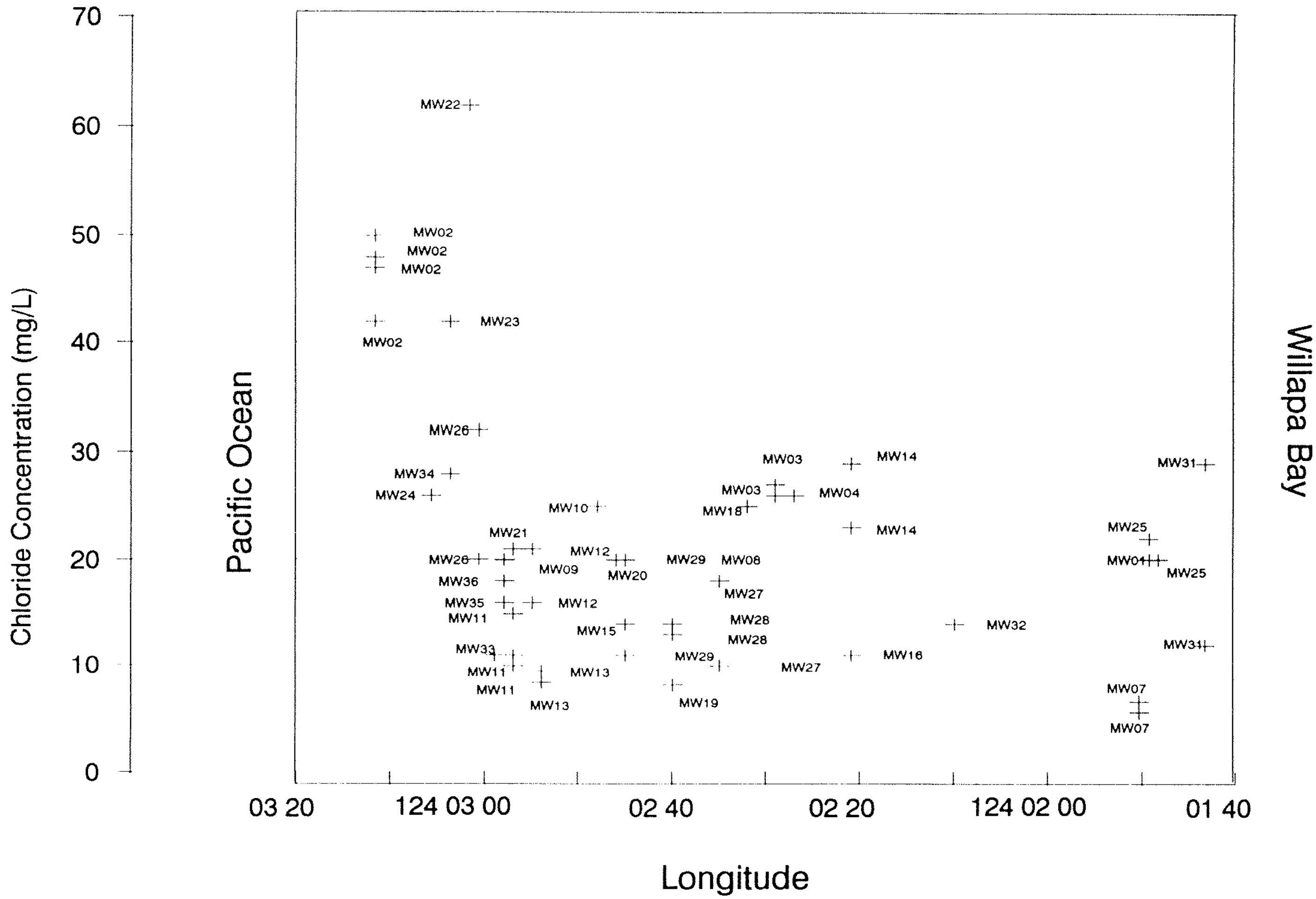

Figure 4: Chloride Concentration vs. Proximity to Pacific Ocean

Table 2. Wells Sampled during Long Beach Peninsula Study

Site Number	Site Name Section/ Township	Latitude	Longitude
MW01	12/11-10D1	46 32 43	124 01 49
MW02	12/11-17A1	46 31 55	124 03 12
*MW03	12/11-28G3	46 29 53	124 02 29
*MW04	12/11-28G2	46 29 55	124 02 27
MW05	12/11-21L1	46 30 31	124 02 45
MW06	12/11-21P1	46 30 18	124 02 45
MW07	12/11-22E2	46 30 47	124 01 51
MW08	12/11-28C1	46 30 15	124 02 46
MW09	12/11-21N1	46 30 21	124 02 58
MW10	12/11-28L1	46 29 53	124 02 48
MW11	12/11-28N1	46 29 37	124 02 57
MW12	12/11-28N2	46 29 33	124 02 55
MW13	12/11-28P3	46 29 31	124 02 54
MW14	12/11-28Q3	46 29 31	124 02 21
MW15	12/11-28P2	46 29 29	124 02 40
MW16	12/11-33B1	46 29 21	124 02 21
MW17	12/11-27M1	46 29 48	124 02 03
MW18	12/11-28Q2	46 29 29	124 02 32
MW19	12/11-33C1	46 29 18	124 02 40
MW20	12/11-33F1	46 29 14	124 02 45
MW21	12/11-33E1	46 29 05	124 02 57
MW22	11/11-4D1	46 28 25	124 03 02
MW23	11/11-4D2	46 28 23	124 03 04
MW24	11/11-16N4	46 26 04	124 03 06
MW25	11/11-3C1	46 28 29	124 01 50
MW26	11/11-4M3	46 28 01	124 03 01
MW27	11/11-4L3	46 28 03	124 02 35
MW28	11/11-9P1	46 26 54	124 02 40
MW29	11/11-9P2	46 26 58	124 02 45
MW30	11/11-9P3	46 26 53	124 02 49
MW31	11/11-10C1	46 27 35	124 01 44
MW32	11/11-28H1	46 24 53	124 02 10
MW33	11/11-16N2	46 26 10	124 02 59
MW34	11/11-16N3	46 26 14	124 03 04
MW35	11/11-33E1	46 23 54	124 02 58
MW36	11/11-33E2	46 23 51	124 02 58

* Class 1 Public Water Supply Wells

On average, the private wells sampled during this effort were 20 to 30 feet deep, with the lower five feet screened. Based on a single measurement in 1988 and several measurements in 1975 (Tracy, 1978) at piezometers along two east-west transects, many of these wells are screened at levels 3 to 28 feet below the water table.

The private wells sampled during this study did not have surface seals. Prior to 1988, it was not common local practice to install surface seals on well points (Sinclair, 1988).

In addition to private wells, two Class I public water supply well systems near Ocean Park were also sampled. One of these systems (MW03) uses a mixture of water from several well points completed in the deeper part of the surficial aquifer; the other (MW04) withdraws water from the lower, confined aquifer.

Sampling Events (Timing)

Initial reconnaissance sampling (three wells) was conducted on June 22, 1987. The major sampling events were conducted in three distinct seasons:

- o Midsummer — July 27-30, 1987
- o Late summer — September 28-29, 1987
- o Winter — February 22-24, 1988

Sampling Procedures

Wells were purged prior to field analysis and sample collection. In February 1988, two wells were sampled using a hose with metal fittings; the other wells were sampled by using a plastic garden hose with plastic fittings attached to an outside spigot as close to the well pump and storage tank as possible.

Well and delivery systems were purged for 3 to 15 minutes at a rate of 2 to 6 gallons per minute. An average of about 20 gallons of water per well was purged prior to collecting samples. This volume (about 2.5 times the total volume of the casing) was purged to clear the well and delivery system of standing water and replace it with water fresh from the aquifer. The flow rate was measured using a calibrated bucket.

The temperature of the purge water was monitored periodically. If the temperature had not stabilized by the time 20 gallons had been removed, purging continued until it did stabilize.

After purging, field analyses were conducted and samples collected for subsequent laboratory analyses. Field analyses included temperature, specific conductivity, pH, chloride, and nitrate. Samples were collected for subsequent laboratory analyses: nitrate+nitrite-N, ammonia-N, total phosphate-P, chloride, total and fecal coliform bacteria, and selected metals.

Special care was taken in collecting the microbiological samples. They were collected directly from the spigot after it had been flamed with a cigarette lighter or match for 1 to 2 minutes. Samples were shipped on ice to the Ecology/USEPA laboratory at Manchester, Washington.

Analytical Procedures

Table 3 summarizes the procedures used to analyze water samples collected during this study.

Table 3. Analytical Methods and Detection Limits

Parameter	Method of Analysis*	Reference	Detection Limit
Field Parameters:			
pH	Beckman pH Meter	NA	.05 S.U.
Specific Conductance	Beckman RC-15C Conductivity Bridge	NA	10umhos/cm
Temperature	Precision Thermometer	NA	0.1 C
Chloride	EPA #325.4	USEPA(1983)	20 mg/L
Nitrate-N	EPA #353.3	USEPA(1983)	0.1 mg/L
Laboratory Analyses:			
Nutrients			
Ammonia-N	EPA #350.1	USEPA(1983)	.01 mg/L
Nitrate+Nitrite-N	EPA #353.2	"	.01 mg/L
Total Phosphate-P	EPA #365.1	"	.01 mg/L
Major Anions:			
Chloride	EPA #325.4	USEPA(1983)	.1 mg/L
Microbiology			
Fecal Coliforms	Standard Methods #909C	APHA(1985)	1 col/100ml
Total Coliforms	Standard Methods #909A	"	1 col/100ml
Metals (Total):			
Arsenic	EPA #200.7	USEPA(1983)	50 ug/L
Iron	EPA #200.7	"	10 ug/L
Lead	EPA #200.7;#239.2	"	1-50 ug/L
Manganese	EPA #200.7	"	5 ug/L
Zinc	EPA #200.7	"	2 ug/L

* = Huntamer (1986)
NA = Not Applicable

Project Data Base

Selected site and sampling information, as well as the results of water quality analyses were stored using ENVIS software, a dBase 3 application. If requested, data can be provided on diskettes.

RESULTS AND DISCUSSION

The results of field analyses are summarized in Table 4. Laboratory results for conventional water quality analyses (nutrients, conductivity, etc.) are presented in Table 5. Table 6 contains the results of metals analyses.

Table 4. Field Data; Long Beach Peninsula Ground Water

Site	Date	Time	pH	Temp (Cent.)	Spec. Cond (umhos/cm)	Nitrate* (mg/L as N)	Chloride (mg/L)
MW01	02/23/88	15:50	6.21	11.2	70		20 K
MW02	06/22/87	14:00	7.15		350	0.15*	48
	07/28/87	14:35	6.30	14.5	322	0.1 *	45
	09/29/87	12:10	7.22	14.5	340		50
	02/23/88	13:00	7.28	11.1	305		
MW03	06/22/87	12:00	8.30	11.7	255		26
	09/29/87	00:00					28
	09/29/87	11:50	8.0	11.6	250	0.1 *	
	02/23/88	10:08	8.02	10.9	235		
MW04	02/23/88	10:45	7.98	10.7	190		
MW05	07/27/87	09:00	6.13	13.5	98		
MW06	02/24/88	13:05	6.0	11.8	73		
MW07	07/29/87	09:00	5.95	14.3	87	0.35*	
	02/23/88	15:18	6.24	10.7	87		
MW08	02/22/88	11:25	6.16	11.6	110		20 K
MW09	02/23/88	16:43	5.88	11.6	100	0.5 *	20 K
MW10	07/30/87	10:30	6.30	12.3	180	0.2 *	
	02/22/88	10:45		11.4	125		
MW11	07/28/87	08:40	6.82	12.7	95		
	09/28/87	09:52	6.40	12.3	100	0.9 *	20 K
	02/23/88	11:25	7.0	11.4	75		
MW12	07/27/87	10:00	6.36	13.5	119		
	09/28/87	11:30	6.20	13.8	138		
	02/23/88	09:00	6.74	12.6	150		
MW13	07/27/87	12:10	6.50	14.0	120		
	09/28/87	11:00	6.20	13.6	130		
MW14	07/27/87	12:40	6.23	12.3	146		
	02/24/88	11:40	5.98	8.1	130		23
MW15	06/22/87	14:35	6.50		195		
	07/27/87	10:30	6.50	12.6	182		

K = not detected at specified quantitation limit
* = approximation only

Table 4 (con't). Field Data; Long Beach Peninsula Ground Water

Site	Date	Time	pH	Temp (Cent.)	Spec. Cond (umhos/cm)	Nitrate (mg/L as N)	Chloride (mg/L)
MW16	07/27/87	00:00	6.26		79		
	07/27/87	09:30		12.1			
MW17	07/29/87	10:28	5.75	13.3	100	0.6 *	
	02/24/88	11:14	6.21	12.5	107		
MW18	07/29/87	12:05	6.29	13.0	210	3.0 *	
MW19	07/27/87	11:15	6.20	13.5	60		
	09/28/87	10:25	6.01	13.3	65		
	02/22/88	10:00	6.37	11.4	51		
MW20	07/28/87	09:15	6.38	12.1	70		
	09/28/87	13:10	6.17	12.3	80	0.6 *	20 K
MW21	07/29/87	13:10	6.09	12.2	275	5.0 L*	
MW22	09/29/87	10:15	6.58	12.5	320		50
MW23	02/23/88	13:45	6.66		275		43
MW24	09/29/87	09:00	8.15	14.5	230	0.1 *	26
MW25	09/29/87	12:15	5.95		145	0.3 *	
	09/29/87	12:35		11.5			
	02/24/88	13:25	6.29	11.4	145		20 K
MW26	09/29/87	13:00	6.53	12.5	190	1.25*	35
	02/24/88	14:18	6.36	9.7	107		20 K
MW27	07/27/87	10:40				0.4 *	
	07/28/87	10:40	6.35	13.4	90		
	02/22/88	12:15	6.30	12.3	91		
MW28	07/28/87	08:40	6.03				
	07/28/87	12:05		13.5	110	1.0 *	
	09/28/87	09:08	6.03	12.3	130	3.25*	20 K
	02/22/88	09:00	6.08	12.0	112		20 K
MW29	07/29/87	15:30	5.97		140	2.75*	
	09/28/87	08:25	6.08	11.8	130		
	02/22/88	09:30	5.58	10.5	145		20 K

K = not detected at specified quantitation limit
L = actual value greater that specified maximum quantitation limit
* = approximation only

Table 4 (con't). Field Data; Long Beach Peninsula Ground Water

Site	Date	Time	pH	Temp (Cent.)	Spec. Cond (umhos/cm)	Nitrate (mg/L as N)	Chloride (mg/L)
MW31	09/29/87	11:35	6.35	11.9	140		
	02/24/88	10:38	6.13	11.3	90		
MW32	07/30/87	14:00	6.27		190	3.75*	
	02/24/88	09:45	6.44	8.8	135		20 K
MW33	07/30/87	11:30	6.16	12.3	97	0.9 *	
	02/24/88	08:47	6.07	12.1	220		
MW34	02/24/88	09:15	6.41	11.3	160		28
MW35	07/30/87	12:37	5.99		150	3.25*	
MW36	09/28/87	15:20	6.11	12.9	165	4.5 *	
	09/29/87	08:30	6.17	11.7	150		
	02/22/88	08:20	6.04	11.4	160		18 E

K = not detected at specified quantitation limit
E = estimated value
* = approximation only

Table 5. Laboratory Data: Conventional Analyses, Long Beach Peninsula Ground Water

Site	Date	Time	Ammonia-N (mg/L)	NO3+NO2-N (mg/L)	Tot Phos-P (mg/L)	Chloride (mg/L)	Fecal Coliform (#/100ml)	Total Coliform (#/100ml)
MW01	02/23/88	15:50	0.04	0.26	0.02			
MW02	06/22/87	14:00	0.01 K	0.16	0.07			
	07/28/87	14:35				42		
	09/29/87		0.01 K	0.16	0.05			
	02/23/88	13:00	0.01 K	0.41	0.06	47		
MW03	06/22/87	12:00	0.01	0.01 K	0.07			
	09/29/87	11:50	0.02	0.01 K	0.06	27	1 K	1 K
	02/23/88	10:08	0.03	0.02	0.07	27		
MW04	02/23/88	10:45	0.03	0.01	0.06	26		
MW05	07/27/87	09:00	0.01	1.8	0.03			
MW06	09/28/87	12:18	0.01 K	0.60	0.01		1 K	1 K
	02/24/88	13:05	0.01 K	0.58	0.02			
MW07	07/29/87	09:00	0.17	0.78	0.02	5.7		
	02/23/88	15:10	0.16	0.63	0.01	6.7		
MW08	02/22/88	11:25	0.01 K	2.1	0.02		1 K	1 K
MW09	02/23/88	16:43	0.01 K	0.39	0.02			
MW10	07/30/87	10:30	0.01 K	0.17	0.02			
	02/22/88	10:45	0.01 K	0.18	0.02	25	1 K	1 K
MW11	07/28/87	08:40	0.01 K	1.5	0.02	15	1 K	1 K
	09/28/87	09:52	0.01 K	0.55	0.02	11	1 K	1 K
	02/23/88	11:25	0.01 K	0.42	0.02	10		
MW12	07/27/87	10:00	0.01	1.2	0.05	16		1 K
	09/28/87	11:30	0.01 K	1.2	0.02		1 K	1 K
	02/23/88	09:00	0.01 K	1.8	0.02	21		
MW13	07/27/87	12:10	0.01	1.9	0.04	9.5		1 K
	09/28/87	11:00	0.01 K	1.7	0.03	8.4	1 K	1 K
MW14	07/27/87	12:40	0.01 K	1.0	0.01	29		1 K
	02/24/88	11:34	0.01 K	1.7	0.01			
MW15	06/22/87	14:35	0.01 K	6.7	0.01			
	07/27/87	10:30	0.02	6.1	0.02	14		27
MW16	07/27/87	09:37	0.01 K	1.6	0.02	11		1 K
MW17	02/24/88	11:14	0.01 K	0.51	0.02			
MW18	07/29/87	12:05	0.01 K	4.1	0.02	25		
MW19	07/27/87	11:15	0.01	1.0	0.03	8.2		4
	09/28/87	10:25	0.01 K	0.64	0.01	7.2	1 K	1 K
	02/22/88	09:50	0.01 K	0.74	0.01		1 K	1 K
MW20	07/28/87	09:15	0.02	0.44	0.03		1 K	1 K
	09/28/87	13:10	0.01 K	0.40	0.01		1 K	1 K

K = not detected at specified quantitation limit

Table 5 (con't). Laboratory Data: Conventional Analyses, Long Beach Peninsula Ground Water

Site	Date	Time	Ammonia-N (mg/L)	NO3+NO2-N (mg/L)	Tot Phos-P (mg/L)	Chloride (mg/L)	Fecal Coliform (#/100ml)	Total Coliform (#/100ml)
MW21	07/29/87	13:10	0.01 K	14	0.03	21		
MW22	09/29/87	10:15	0.01 K	1.6	0.03	62	1 K	1 K
MW23	02/23/88	13:45	0.01 K	2.7	0.04	42		
MW24	09/29/87	09:00	0.01 K	0.18	0.04			
MW25	09/29/87	12:35	0.01 K	0.36	0.01	22	1 K	1 K
	02/24/88	13:25	0.01 K	1.2	0.02			
MW26	09/29/87	13:00	0.01 K	0.79	0.02	32	1 K	1 K
	02/24/88	14:18	0.01 K	0.53	0.03			
MW27	07/28/87	10:40	0.01	1.9	0.04	10	1 K	1 K
	02/22/88	12:08	0.01 K	2.0	0.02	18	1 K	1 K
MW28	07/28/87	12:05	0.01 K	2.6	0.03		1 K	1 K
	09/28/87	09:08	0.01 K	2.3	0.02	13	1 K	1 K
	02/22/88	08:43	0.01 K	3.3	0.02	13	1 K	1 K
MW29	07/29/87	15:30	0.01 K	2.7	0.02			
	09/28/87	08:25	0.01 K	2.4	0.01	11	1 K	1 K
	02/22/88	09:30	0.01 K	6.2	0.02	14	1 K	1 K
MW30	07/29/87	15:00	0.01 K	1.1	0.02			
MW31	09/29/87	11:35	0.01 K	0.08	0.01	29		
	02/24/88	10:38	0.01 K	0.09	0.02	12		
MW32	07/30/87	14:00	0.01 K	2.1	0.02	14		
	02/24/88	09:50	0.01 K	0.75	0.02			
MW33	07/30/87	11:15	0.01 K	0.48	0.02	11		
	02/24/88	08:47	0.01	3.8	0.02			
MW34	02/24/88	09:15	0.01 K	1.4	0.06			
MW35	07/30/87	12:37	0.01 K	1.6	0.02	16		
MW36	09/29/87	08:30	0.01 K	2.0	0.01		1 K	1 K
	02/22/88	08:05	0.01 K	5.1	0.01	18	1 K	1 K

K = not detected at specified quantitation limit

Table 6: Laboratory Data: Metals Results, Long Beach Peninsula Ground Water

Site	Date	Time	As-Total (ug/L)	Fe-Total (ug/L)	Pb-Total (ug/L)	Mn-Total (ug/L)	Zn-Total (ug/L)
MW03	02/23/88	10:08	50 K	239	50 K	76	8
MW04	02/23/88	10:45	50 K	799	50 K	132	
MW07	07/29/87	09:00		1,010			
MW10	02/22/88	10:45	50 K		50 K		63
MW11	07/28/87	08:40		20	1 K		
	02/23/88	11:25	50 K		50 K		2 K
MW12	07/27/87	10:00		130	1 K		
	02/23/88	09:00	50 K	247	50 K	7	211
MW13	07/27/87	12:10		24	1 K		
MW15	07/27/87	10:30		40	1 K		
MW16	07/27/87	09:30		34			
MW19	02/22/88	10:00	50 K	85	50 K	7	

K = not detected at specified quantitation limit

Chloride and Conductance:

Chloride concentrations were measured both in the field and in the laboratory. Figure 3 compares field determinations to laboratory measurements. Because the nominal detection limit for field measurements were 20 mg/L, field results below this concentration were treated as equal to 1/2 the detection limit (i.e. 10 mg/L).

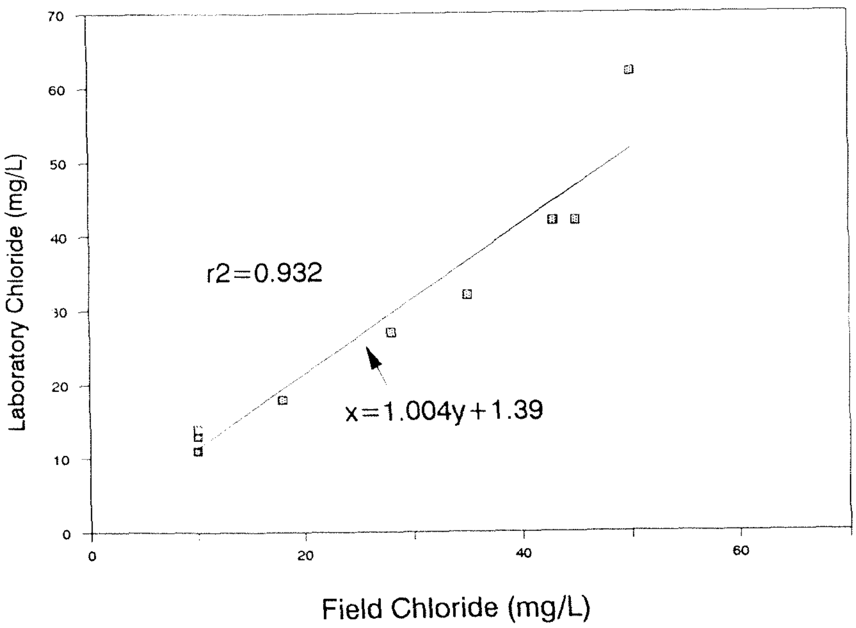

Figure 3 : **Field Chloride Determinations vs.**

Laboratory Chloride Determinations

The comparison between field and laboratory measurements was excellent. Not only was the coefficient of correlation high ($r=.965$, $r^2=.932$), but there was nearly a one-to-one correspondence, with the slope equal to 1.004.

Chloride is an important, often the primary, anionic constituent of ground water. Elevated concentrations can indicate the effects of seawater intrusion, wastewater contamination, salt spray or other human-induced or natural causes. Specific conductivity is generally proportional to the concentration of all dissolved constituents (both anions and cations) in a water sample.

Dion and Sumioka (1984) summarize chloride and specific conductance results for ground water in Pacific County (largely Long Beach Peninsula data) from 1960's studies and their own work in 1978. These results are compared to the results of the current study in Table 7. It is important to note that wells sampled in the present study are generally not the same wells sampled in the earlier studies. It is interesting that values are similar. This may, however, be deceptive as sampling sites chosen for the present study were, on average, further inland than sites sampled in the earlier studies.

Table 7. Comparison of Chloride and Conductivity Data from Analyses of Ground Water in the 1960's, 1978, and the Present Study (1987-1988). (see text)

Years	1960's[1]	1978[1]	1988-9
Number of Wells	65	65	36
Median Chloride Concentration (mg/L)	19	19	18
Median Specific Conductivity (umho/cm)	187	190	138

1) Dion and Sumioka, 1984

Figure 4 shows the distribution of chloride concentrations as a function of east-west location on the peninsula. Both laboratory and field measurement are included in this figure. If both were available from a single sampling event, only the laboratory result was used. If the only estimate available for a sample was based on a field analysis in which no chloride was detected at the detection limit of 20 mg/L, then a default value of 10 mg/L was used.

The four wells with the highest chloride concentrations (MW02, MW22, MW23, MW26) are located near the Pacific Ocean. The most likely explanations for these elevated chloride concentrations are salt spray effects and seawater intrusion. Walters (1971) makes the somewhat conservative assumption that "Only chloride concentrations in excess of 50 mg/L have been considered as indicating seawater intrusion on the peninsula because several wells that do not extend to sea level produce water with concentrations of 25 to 50 mg/L."

Interestingly, the only well in the present study to exceed this 50 mg/L threshold (MW22) was also apparently sampled by Walters. The chloride concentration (70 mg/L) and conductivity (335 umhos/cm) measured in 1968 compare closely with the values (62 mg/L and 320 umhos/cm, respectively) measured in 1987.

MW02 was also sampled by Walters (1971). This well, which he reported was completed 10 feet below sea level, had a chloride concentration of 27 mg/L in 1968. Concentrations measured during the present study ranged from 42 to 50 mg/L. Seawater intrusion seems to be a reasonable explanation for this apparent increase.

It is likely that the four wells noted above have elevated chloride concentrations, at least in part, due to the effects of ocean spray. This may, in part, explain the fact that the highest chloride concentrations are found on the Pacific side of the peninsula rather than the bay side (prevailing winds are from the southwest).

Chloride concentrations from the Ocean Park public supply wells, which are located near the center of the peninsula, were somewhat elevated and nearly identical: whether collected from deep in the surficial aquifer (MW03: 26-27 mg/L) or in the deeper confined aquifer (MW04: 26 mg/L).

Based on the results of this and earlier studies, we somewhat arbitrarily set the average "background" chloride concentration for shallow ground water at 10 mg/L.

For the purposes of this study, background chloride concentration is defined as an estimate of the average concentration of chloride at locations where concentrations in the ground water are minimally effected either by human activities or by the localized effects of sea spray or other natural phenomena.

Nitrate

Nitrate-N concentrations were measured both in the field and in the laboratory. Figure 5 compares field measurements to laboratory results.

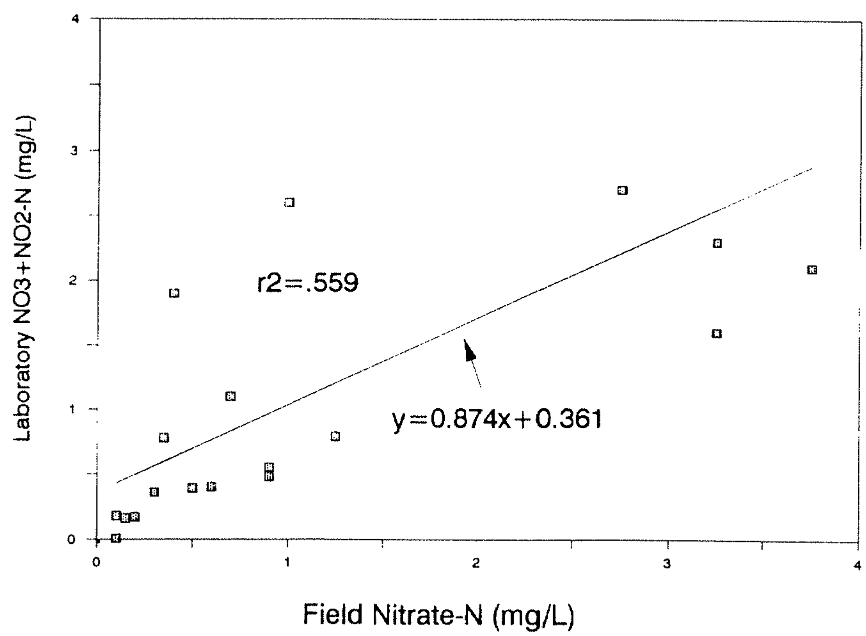

Figure 5: **Field Nitrate-N Determination vs.**
Laboratory Nitrate-N Determination

Field determination of nitrate was not as successful as field determination of chloride. The correlation coefficient was lower (r^2=.559) and there was greater bias: field measurements underpredicted laboratory measurements by 13 percent.

The usefulness of field nitrate measurements appears to be limited to screening purposes. Accurate quantification with this technique probably requires laboratory analysis. However, the value of screening samples in the field should not be underestimated. It provides an effective way to determine which samples should be submitted for more precise (but more expensive) laboratory analyses.

Nitrate-N results are summarized by site and collection season in Table 8. The site mean, median and mode of nitrate-N concentrations are 1.80, 1.37, and 1.60 mg/L, respectively. Background nitrate-nitrogen concentrations are assumed to average about 0.1 mg/L and range up to perhaps 0.5 mg/L.

Table 8. Laboratory results for nitrate summarized by site and collection period (units: mg NO_3-N/L).

Site	Collection Period				
	June '87	July '87	Sept. '87	Feb. '88	Mean
MW01				0.26	0.26
MW02	0.16		0.16	0.41	0.24
MW03	0.01K		0.01K	0.02	0.01
MW04				0.01	0.01
MW05		1.80			1.80
MW06			0.60	0.58	0.59
MW07			0.78	0.63	0.47
MW08				2.10	2.10
MW09				0.39	0.39
MW10		0.17		0.18	0.18
MW11		1.50	0.55	0.42	0.82
MW12		1.20	1.20	1.80	1.40
MW13		1.90	1.70		1.80
MW14		1.00		1.70	1.35
MW15	6.70	6.10			6.40
MW16		1.60			1.60
MW17				0.51	0.51
MW18		4.10			4.10
MW19		1.00	0.64	0.74	0.79
MW20		0.44	0.40		0.42
MW21		14.0			14.00
MW22			1.60		1.60
MW23				2.70	2.70
MW24			0.18		0.18
MW25			0.36	1.20	0.78
MW26			0.79	0.53	0.66
MW27		1.90		2.00	1.9
MW28		2.60	2.30	3.30	2.73
MW29		6.20	2.40	2.70	3.77
MW30		1.10			1.10
MW31			0.08	0.09	0.09
MW32			2.10	0.75	1.43

Table 8 (con't). Laboratory results for nitrate summarized by site and collection period (units: mg NO_3-N/L).

Site	June '87	July '87	Sept. '87	Feb. '88	Mean
		Collection Period			
MW33		0.48		3.80	2.14
MW34				1.40	1.40
MW35		1.60			1.60
MW36			2.00	5.10	3.55
				Overall Site Mean	1.80
				Overall Site Median	1.38
				Overall Site Mode	1.60

K = less than

Concentrations of nitrate-nitrogen detected during this study ranged from less than the detection limit (.01 mg/L) to 14 mg/L. The federal standard for nitrate in potable water is 10 mg as N/L. Ground water from one well exceeded this standard.

An initial comparison of nitrate results by season revealed no clear or consistent trends.

Figure 6 shows the spatial distribution of nitrate-N concentrations at each sampling site. Some of the highest concentrations occur in the higher population density (i.e. Ocean Park, Riiho Park); however, there is a great deal of spatial variability in the nitrate distribution.

Nitrate and Chloride

To provide some perspective on the nitrate and chloride results, we prepared Figure 7. The average chloride and nitrate-N concentration for each well is plotted except for four wells for which chloride concentrations were not obtained. To classify water quality in each well, three ranges of concentration were chosen for nitrate and chloride. They are given below:

	Nitrite+Nitrate-N (mg/L)	Chloride (mg/L)
Background	0-0.5	0-20
Moderately Elevated	0.5-2	20-40
Elevated	>2.0	>40

Figure 7 is divided into nine segments based on these ranges. In addition, the drinking water standard of 10 mg NO_3-N/L is shown.

Table 9 gives some of the same information in tabular/matrix form. The four wells not included in Figure 7 or Table 9 (missing chloride data) were MW05, MW06, MW17, and MW30. Each of these four wells had mean nitrate-N concentrations between 0.5 and 2.0 mg/L (Row B).

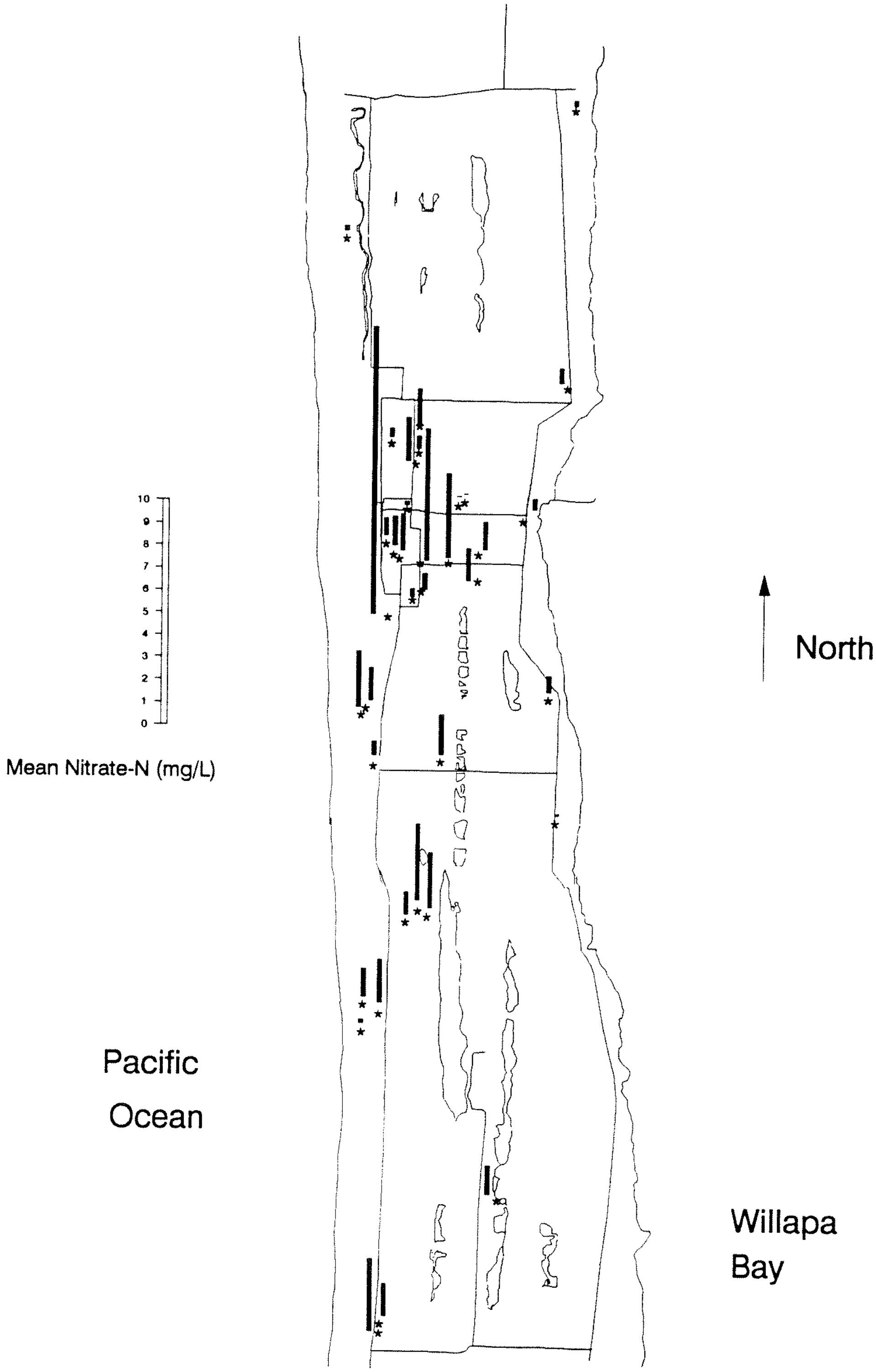

Figure 6: Average Nitrate-N Concentrations
in Long Beach Ground Water

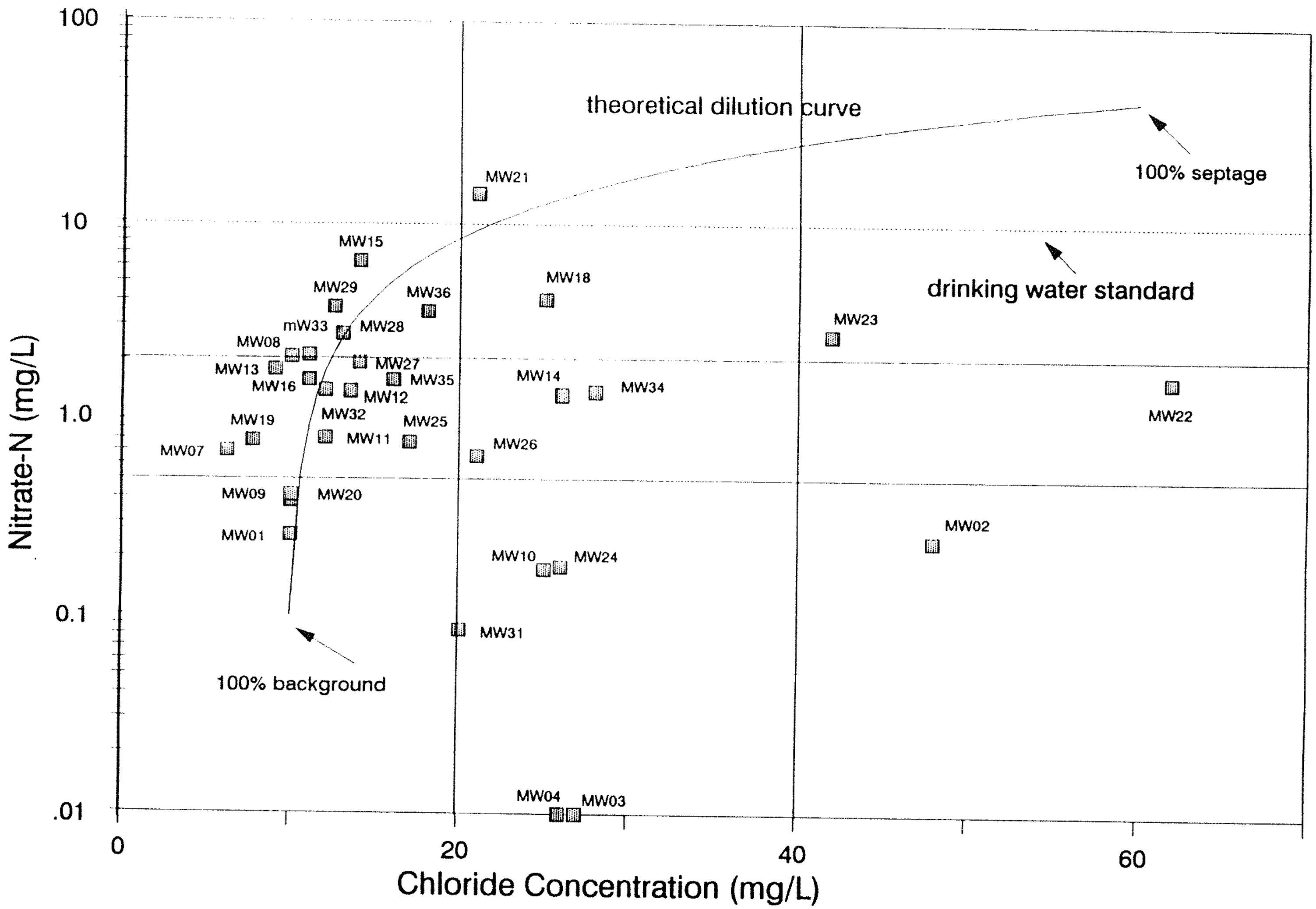

Figure 7: Chloride and Nitrate Results

Table 9. Monitored Wells Segregated by Chloride and Nitrate Concentrations.

Nitrate-N (mg/L)	I	II	III	
>2.0	MW08 MW33 MW15 MW36 MW27 MW28 MW29	MW18 MW21	MW23	C
0.5-2.0	MW07 MW25 MW12 MW27 MW13 MW32 MW16 MW35 MW19	MW14 MW26 MW33	MW22	B
0-0.5	MW01 MW09 MW20 MW31	MW03 MW04 MW10 MW24	MW02	A
Chloride Concentration (mg/L)	0-20	20-40	>40	

Segment IA contains wells with background water quality. Wells in other segments appear to have somewhat elevated concentrations of nitrate and/or chloride.

Finally, Figure 7 includes a line labeled "theoretical dilutions of septage with background quality water". This line was generated assuming the following concentrations:

	Nitrite+Nitrate-N (mg/L)	Chloride (mg/L)
Background	0.1	10
Septage	42	60

The chloride concentration in septage is a mean of two values reported by Gilliom and Patmount (1982); the nitrate-N value was obtained from the sample-weighted mean from two studies reported by Canter and Knox (1985). The curved line in Figure 7 represents a range of mixtures of background water and septage (from 100% background to 100% septage).

The model represented by this figure is a simple one; it is clearly simpler than reality. If all background water and septage quality on the peninsula could be represented by the assumptions above, if all perturbations in groundwater quality were caused by septage, and if chloride and nitrate were in all cases conservative parameters (neither consumed nor created in the saturated or unsaturated zones), then all points would fall on the theoretical line. They do not. However, it is interesting and perhaps significant that so many points fall so near the line.

Wells lying near the "dilution curve" may be candidates for sampling for parameters like boron and methylene blue active substances (MBAS) that, because they are associated with soaps and detergents, are used to identify contamination with septage. Wells lying high on the curve may be particularly good candidates for this kind of follow-up, because they are potentially effected to a greater degree.

The only wells where (total) coliform bacteria were detected (MW15, MW19) lie near the dilution curve. This may be significant; however, the lack of surface well seals makes interpretation of bacterial data difficult. The potential for direct contamination from the ground surface is too high to discount.

A second potentially significant nitrate source should also be considered. Nitrogen fertilizers are applied to the cranberry bogs between April and August of each year. Based on information from the WSU Research Center at Long Beach, application of 40 pounds of nitrogen per acre per year is recommended. There are about 450 acres of cranberry bogs north of Long Beach (Wanz, 1990). Based on the recommended application rate, this would equate to an annual load of about 18,000 pounds of nitrogen per year.

By comparison, the total nitrogen load from domestic sewage/septage in the study area could be about 55,000 pounds of nitrogen per year. This estimate is based on a population of 4,700, an average daily discharge of 100 gallons per capita per day, and a total nitrogen concentration of 40 mg/L in septage (Jewell and Swan, 1975).

Wells lying to the right of the dilution curve have chloride concentrations above those that could be attributed solely to effects of septic system discharges. Earlier we discussed the potential effects of seawater intrusion and sea spray in elevating chloride concentrations in some of these wells. These causes are less satisfactory in explaining the somewhat elevated chloride concentrations in the municipal Ocean Park wells (MW03, MW04) located near the center of the peninsula. One of these wells is completed deeper in the surficial aquifer; the other in the lower, confined aquifer. Given the very low nitrate concentrations in these wells, the source of chloride here is clearly unrelated to septage.

Metals

Samples were collected for selected metals at a subset of wells. Results are summarized in Table 6. There are proposed federal primary (health-related) maximum contaminant levels (MCL's) for two of these metals: arsenic (30 ug/L) and lead (5 ug/L at source). No excursions of these criteria were noted, although in many cases the detection limits were higher than the MCL's. There are secondary maximum contaminant levels (SMCL's) for the remaining three metals: iron (300 ug/L), manganese (50 ug/L), and zinc (5000 ug/L). Secondary MCL's have been developed to minimize aesthetic impacts like staining of fixtures, unpleasant tastes and odors, and so forth.

Two wells exceeded the iron standard (MW04 at 799 ug/L, MW07 at 1010 ug/L); two wells exceeded the manganese standard (MW03 at 76 ug/L, MW04 at 132 ug/L); no wells exceeded the zinc standard, although the 211 ug/L detected at MW12 is higher than expected.

The excursions of the iron and manganese SMCL's are probably due to natural sources of these metals. Elevated concentrations occurred primarily in deep wells.

The elevated zinc concentration is more unusual; although by itself, it does not imply a human health or environmental threat. Lead and zinc can be introduced to ground water through septic systems as well as from urban runoff sources such as stormwater dry wells (Horner and Mar, 1982). There are reportedly four stormwater injection wells in central Ocean Park (Goldstein, 1987). MW12 is located within a few hundred feet of one of these injection wells; it is also located quite near the "dilution curve" in Figure 7. It is likely that the zinc source is anthropogenic, although the specific source cannot be ascribed based on this study.

Conclusions

- o Well drained soils, shallow depths to ground water (0 to 15 feet) and high aquifer permeability all contribute to make the water table aquifer on the Long Beach Peninsula vulnerable to contamination. Increased loading of contaminants will lead to increased contamination of ground water.

- o Average chloride concentrations measured in 32 wells ranged from 7 to 62 mg/L. Twenty wells had concentrations less than 20 mg/L (defined here as background); 9 wells fell in the 20-40 mg/L range (moderately elevated); and 3 were above 40 mg/L (elevated). All were well below the Secondary Maximum Contaminant Level (SMCL) of 250 mg/L.

- o Average nitrate-N concentrations measured in 36 wells ranged from 0.01 to 14 mg/L. Nine wells had nitrate-N concentrations of less than 0.5 mg/L (defined here as background); 17 wells were in the 0.5 to 2.0 mg/L range (moderately elevated), and 9 were greater than 2.0 mg/L (elevated). One well exceeded the primary MCL of 10 mg/L developed to prevent adverse affects on human health.

- o Preliminary interpretation of chloride and nitrate data implies a number of potential sources. Seawater intrusion and sea spray effects may be responsible for the highest chloride concentrations. Effluent from septic tank systems may be responsible for elevation of both nitrate and chloride at some wells, although further work would be required to verify this. Additional potential sources of nitrate include lawn, garden, and crop (specifically cranberry) fertilization.

- o The data presented here are inadequate detect meaningful time series trends (either seasonal or long-term). Chloride data for one well (MW02) implies an increase over the last 20 years.

- o Limited analyses of selected metals in ground water yielded generally unremarkable results. There were two measurements, each of iron and manganese concentrations above the SMCL's, probably due to natural causes. There was a substantially elevated zinc concentration (211 ug/L) measured at one well; which, although it is well below the SMCL of 5000 ug/L, may merit follow-up.

- o Field measurement of chloride was very successful: yielding accurate, low cost, quick results. Field analysis for nitrate was less accurate, although it probably can serve as a very useful screening tool.

Recommendations

- o Data collected during this and previous studies (including, but not limited to, data in STORET and WATSTORE, hydrogeological information, and more detailed information on specific wells) should be thoroughly evaluated and interpreted. This could be done by any of various state, local, or federal entities depending on their capabilities.

- o Based on the results of the analysis suggested above, sources of nitrate and other contaminants could be evaluated and more accurately defined. A variety of techniques are available to assist this process. Chemical analyses for boron and MBAS can be used to indicate the presence of septage. Other potentially useful tools are site specific studies and modeling.

- o Efforts to define, prevent and resolve ground water quality problems on the North Beach (Long Beach) Peninsula should continue. After evaluating existing data and determining unfilled data needs, design and implementation of a monitoring program should be considered. For example, a routine monitoring program at selected locations might correct the present lack of time-series data. Filling this need would allow managers to evaluate the rate and severity of ground water degradation on the peninsula.

- Local efforts to implement appropriate actions to prevent and/or moderate ground water pollution should be supported. These actions may include, but are not limited to, controls on urban development through zoning or other mechanisms.

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