G473 Environmental Geology

Field Trip:
Environmental Overview of Monmouth-Independence Area

Independence Well Field

Env. Geology G473 - Independence Public Works Field Trip **Name__________**

Critical Questions / Tasks for the Day

1. Describe the geologic materials that underlie the Monmouth-Independence Area

2. Total Well Depth for City Wells?

3. Depth to Bedrock under Mon-Ind area?

4. Area of Sludge Ponds?

5. No. of City Wells?

6. Pumping Rate of City Wells?

7. Depth to Water in City Wells?

8. Description of Aquifer (confined, unconfined, artesian, etc.)?

9. Total Water Useage Per Day for Mon-Ind area?

10. Total Sewage Output Per Day?

11. Hydraulic Conductivity of Aquifer Near Well Field?

12. Draw a Groundwater Contour Map of the Independence Aquifer System / with Groundwater Flow Lines (see attached map)

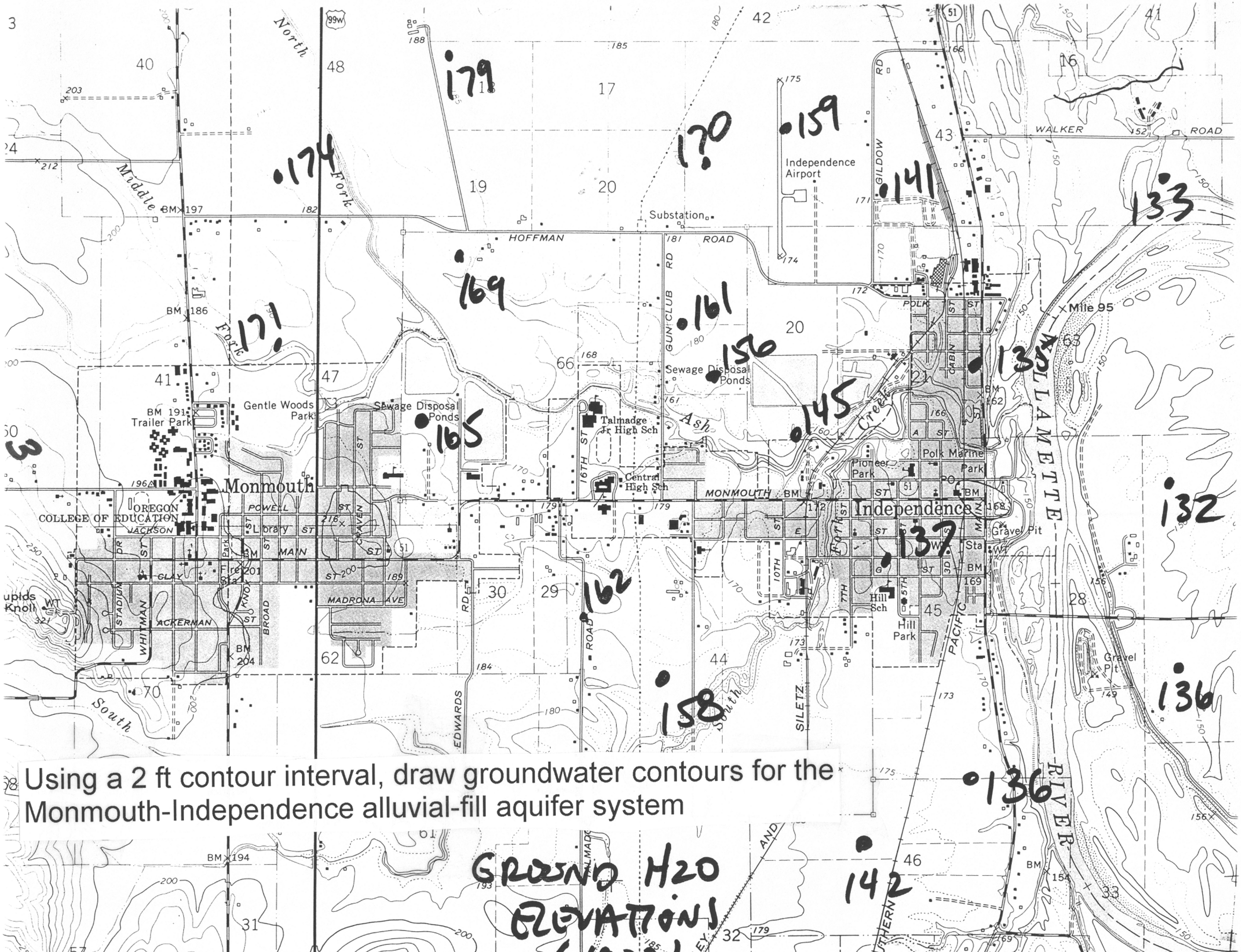
13. What is the direction of Groundwater flow and how does it relate to Willamette River?

14. What is the average discharge of Willamette River near Ind. Well Field?

15. Where is the 100-yr floodplain designation for the Willamette River in Independence? How does this relate to the Sewage sludge ponds?

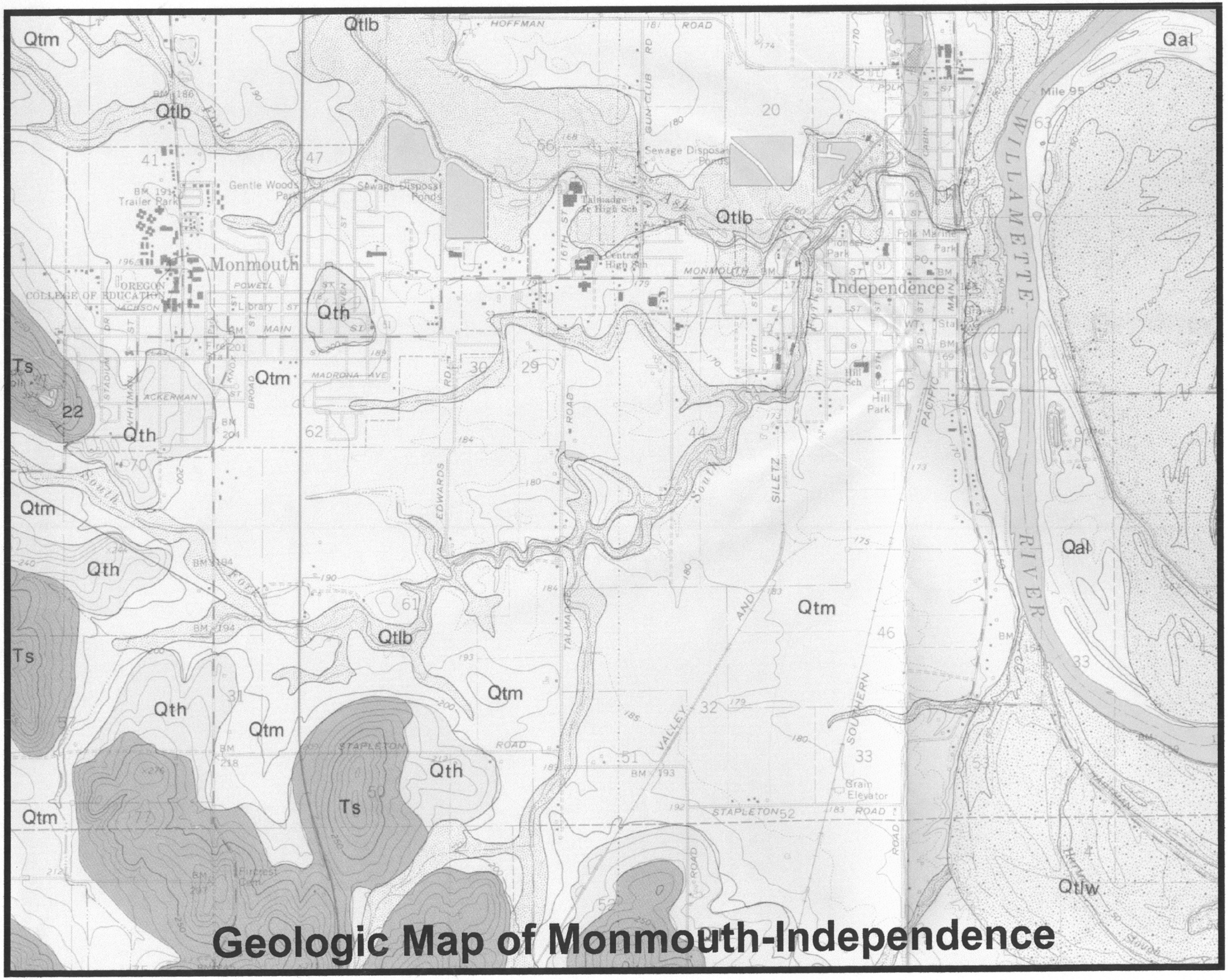
16. What is the elevation of the Will. River near Independence? What is the elevation of the sludge ponds? Of the well heads?

17. Summarize the hydrogeologic and surface water hydrology for the Independence water supply / sewage ponds.



Using a 2 ft contour interval, draw groundwater contours for the Monmouth-Independence alluvial-fill aquifer system

Hydrogeologic Setting of the Monmouth-Independence Alluvial Aquifer System


Geologic Map of Monmouth-Independence
Qtm
Qtlb
Qal
Qth
Ts
Qtlw
WILLAMETTE
RIVER
Monmouth
Independence
OREGON
COLLEGE OF EDUCATION
Sewage Disposal Ponds
Gentle Woods Park
Trailer Park
Talmadge Jr High Sch
Central High Sch
Polk Marine Park
Pioneer Park
Hill Park
Grain Elevator
Mile 95
HOFFMAN
ROAD
GUN CLUB
MONMOUTH
SILETZ
SOUTHERN
PACIFIC
VALLEY
STAPLETON
TALMADGE
EDWARDS
MADRONA AVE
ACKERMAN
WHITMAN
STADIUM
POWELL
JACKSON
BROAD
MAIN
KNOX
Library

MONMOUTH GEOLOGIC MAP

EXPLANATION

SURFICIAL GEOLOGIC UNITS

Qal — **Recent river alluvium:** *Unconsolidated cobbles, coarse gravel, sand, and some silt and clay within active channels of Willamette River. Generally 15-45 ft thick, consisting of stratified sands and well-rounded pebbles, gravels, and cobbles of primarily basaltic and andesitic composition; often overlain by 3-15 ft of light-brown sand and silt overburden. Characterized by low relief, point-bar and channel-bar deposits; many areas unvegetated, others support dense stands of brush and phreatophytes, such as willows and cottonwoods. Subject to major flooding, critical stream-bank erosion, and lateral channel migration; includes many areas located between 1852 meander line and present channel that illustrate possible extent of future changes*

Qtlw — **Lower terrace deposits of the Willamette River (Quaternary):** *Unconsolidated to semiconsolidated cobbles, gravel, sand, silt, clay, muck, and organic matter of variable thickness (30-50 ft) on the flood plain and lowland terraces immediately above the Recent river alluvium* (**Qal**)*; typically 5-20 ft of light-brown silt and clay or very fine sand overlying 10-45 ft of moderately well-sorted sand and locally cemented gravel. Surface topography characterized by a low, undulating, fluvial surface with abandoned channels, meander scrolls, oxbow lakes, and sloughs; subject to major and local flooding, some catastrophic channel migration of major scale, ponding, and high ground water. Flood-plain soils are predominantly well drained and somewhat excessively drained silty clay loams, silt loams, and sandy loams; good ground-water yields generally of 100-500 gallons per minute*

Qtlt — **Lower terrace deposits of tributary rivers and streams (Quaternary):** *Unconsolidated to semiconsolidated gravel, sand, silt, clay, and organic matter generally 15-30 ft thick on lowland terraces and flood plains immediately above major tributary rivers of the Willamette River. Gravel deposits are very thin to variable in thickness, according to tributary drainage source, generally limited to active stream beds or former meander channels, and located at or near bed rock beneath 20-30 ft of sand, silt, and clay. Somewhat tortuous meandering streams entrenched 15-45 ft, often flowing on Tertiary sedimentary bed rock or semiconsolidated older valley-fill alluvium. Surface topography characterized by a low, undulating fluvial surface of swell and swale relief, abandoned meander loops, and oxbow lakes; subject to high ground water and ponding and major and local flooding; flood-plain soils are predominantly well drained and somewhat excessively drained silty clay loams, silt loams, and sandy loams. Some soft, compressible organic soils of low shear strength may occur locally, particularly within abandoned channels and oxbows. Major stream-bank erosion commonly occurs at outer bends of meander loops by shallow earthflow and slump due to undercutting. Ground-water yields generally small*

Qtlb — **Lower terrace deposits of alluvial bottomlands (Quaternary):** *Flat, moderately to poorly drained areas with soft, organic compressible soils of low shear strength locally; characterized by low relief, ponding, and high ground water. Deposits typically consist of somewhat stratified very fine sands, silty sandy clays, silty clays, and silty clay loams, with slight to moderate plasticity (ML-CL); 4-12 ft thick along bottomlands of interior drainages of low, rolling sedimentary bedrock units. Deposits locally may represent somewhat thicker accumulations of silt and silty clay materials of fluviatile and/or loessal origin derived in part from Willamette Silts. Similar deposits along creeks are associated with deposits of units* **Qtm** *and* **Qth** *and are often modified by ditching and field drainage for agriculture; typical examples are deep (more than 60 in.) clay (CH), silty clay (CH), and silty clay loam (CL or ML) black Bashaw clay soils of Baskett Slough (Rickreall quadrangle). Similar thicknesses of reddish-brown sandy silty material (ML-CH) in basaltic terrain* (**Tcr**)

Qtm — **Middle terrace deposits (Quaternary):** *Semiconsolidated gravel, sand, silt, and clay forming very flat terraces of major extent along the Willamette River. Generally 10-30 ft of light-brown silty clay and interbedded very fine sand and silt (ML or CL-CH) surficial material; believed primarily related to Willamette Silts, including associated glacial erratics consisting of tiny fragments and pebbles up to boulders greater than 4 ft in diameter. Soils somewhat poorly drained and poorly drained silt loams and silty clay loams to moderately well-drained and well-drained silt loams subject to seasonal high ground water and ponding. Sand and gravel (GP, SM), where present, usually occur below 30 ft depth; locally more abundant near Monmouth-Independence and in the lower part of Ash Creek. Total thickness 0-85 ft, but often only 40-50 ft; within Rickreall 7½-minute quadrangle, 15-35 ft of brown clay or silt generally occurs above several to 30 ft of gravelly clay, black sands, and gravels. Generally small ground-water yields, except near Monmouth-Independence, where sand and gravel may yield up to 300 gallons per minute*

Qlg — **Linn gravel (Quaternary-upper Pleistocene):** *Stratified fine to coarse fluvial gravels deposited as an alluvial fan in the Stayton-Turner-Salem areas during an early stage of the Santiam River; of limited extent within the map area; uppermost few feet of gravels extensively oxidized and weathered, often chalky; thickness ranges from 30-40 ft to possibly as much as 300 ft. Regionally, the upper foot or so of gravel is cemented by an impermeable clay pan locally, which restricts drainage. Composition of gravels (mostly basalt, but also andesite, dacite, rhyolite, quartz, and diorite) essentially uniform. Within map area near Salem, soils are well drained and somewhat poorly drained gravelly silt loam and gravelly loam. Extensively utilized as source of sand and gravel. Good ground-water yields greater than 100 gallons per minute*

Qth — **Higher terrace deposits (Quaternary-middle Pleistocene):** *Generally semiconsolidated ligh
and clay of variable thickness (3-15 ft) on higher terraces and remnants of old higher t
sedimentary bedrock foothills; mantled by moderately well-drained and well-drained silt l
colluvium, slope wash, and alluvial fan deposits near sedimentary bedrock foothills; d
transitional with pediments. Material generally similar to unit* **Qtm**, *particularly in West
glacial erratics related to Willamette Silt but also some gravelly alluvium. Some higher terra
side of Salem Hills between Salem and Illahe Hill not shown due to scale. Also includes weath
cobbles and gravels which extend beyond the study area west of Rickreall (8-10 ft thick) a
margin of Sidney quadrangle (10-50? ft thick), where they are equivalent to the Leffler gravel
These deposits also mantled by 3-15 ft of light-brown silt loam and silty clay loam soils. Ge
ground-water yield*

BEDROCK GEOLOGIC UNITS

Tcr — **Columbia River Basalt Group (Miocene):** *Medium-gray to black, fine-grained, even-textur
phyritic basalt; unweathered flows generally dense, fairly crystalline, exhibiting massive colun
base to diced or hackly jointing in entablature. Unit consists of weathered and unweathered b
with interflow zones characterized by vesicular flow-top breccia, ash, and baked soils. Ma
generally ranges 400-600 ft, with thickness greatly modified by erosion and weathering
individual flows range from 40 ft to more than 100 ft in thickness.*

*Formations recognized within the Yakima Basalt Subgroup (Beeson, 1980, personal commu
(1) Grande Ronde Basalt: two to four "low Mg" N_2 flows, including one to two "Winter Wat
(typical exposure at Dairy Queen, West Salem); one to two thick "low Mg" flow(s), 100-150 ft
quarried throughout map area; one to two flow(s) of "high Mg" N_2 basalt, generally deeply wea
above the "Winter Water" flow(s); and (2) a thinner layer of younger Wanapum Basalt, represent
flow(s) of the Frenchman Springs Member, observed only in South Salem within the study area
occurs outside the map area in the vicinity of Turner.*

*Weathered flows consist of reddish-brown to grayish-brown, crumbly to medium-dense basa
variable and believed related to individual basalt flows; some exposures are altered to red clay (l
of 30 ft, and occasionally as deep as 60-175 ft, while others are only slightly weathered at surfac
in Salem Hills (generally between 500-900 ft elevation within area bounded by Pringle Scho
Jackson Hill) show extensive laterization which has resulted in deposits of bauxite (Corcoran an
Soils are reddish-brown, well-drained silty clay loams and gravelly silty clay loams. Unit yiel
quantities of ground water from permeable rubbly zones between flows*

Ti — **Intrusive rocks (Oligocene):** *Dense basalt, andesite, and gabbro dikes and sills of very limited
map area (Roby Hill, Sidney quadrangle); Roby Hill quarry geochemically not part of Colum
Group (Beeson, 1980, personal communication). Another limited exposure of porphyritic intr
flow rock, with vertical columns 1-2 ft in diameter in contact with claystone along east bank of L
near Buena Vista Road (river mile 3.2). Presumed post-Eocene (Oligocene?) age (Helm and*

Toe — **Eocene-Oligocene sedimentary rock (middle and lower Oligocene and upper Eocene):** *Equival
marine sedimentary rocks (Tts) of Baldwin and others (1955), Illahe tuffs (Tit) of Mundor
Formation (Ti) of Thayer (1939), Eocene-Oligocene marine sedimentary rocks (Tm) of Pr
undifferentiated Tertiary rocks (Tu) of Gonthier (in press). Consists of two lithologic and faun
Willamette River (Baldwin and others, 1955) but undifferentiated in this map due to poor expos
light-gray to tan sandy tuffaceous siltstone equivalent in age to early Oligocene Keasey For
section near border of Amity-Rickreall 7½-minute quadrangles, where approximately 1,000 ft t
Oligocene strata well exposed in Yamhill River near Yamhill locks, where steeply dipping and co
Younger unit is fine- to coarse-grained tuffaceous sandstone equivalent in age to middle Olig
Bluff Formation; basal stratum approximately 150 ft of dark-gray, coarse-grained, calcareous
sandstone, chiefly composed of detrital igneous rock fragments. White, fine-grained, massively
pumiceous volcanic glass approximately 250 ft thick exposed for 3 mi along hillside south of Fin
quadrangle); good exposures of pebbly tuff, tuffaceous conglomerate, and fine-grained platy tu
Hill Road in Sidney 7½-minute quadrangle.*

*Tuffaceous marine sandstone and siltstone of Oligocene sedimentary rock correspond to Ol
Formation described by Hickman (1969), which contains early to middle Oligocene molluscan
foraminiferal analyses (McKeel, 1980) of oil and gas wells within the study area indicate unit
2,000 ft of upper Refugian and Refugian strata (Reichhold-Merrill #1, Sidney quadrangle) an
basal siltstone, claystone, and shale of late Narizian (provincial West Coast late Eocene) age (R
and Reichhold-Merrill #1)*

Ts — **Upper Eocene sandstone:** *Equivalent to Helmick beds (Thb) of Mundorff (1939) and Spencer (
(in press); very fine- to medium-grained, thinly laminated (fissile) to thin-bedded, as well as pr
massive, light-gray to yellowish-brown moderately well-sorted micaceous, calcareous, lithic
(tuffaceous) sandstones; frequently interbedded with fine-grained marine tuffaceous siltstone, t
clay shale, and claystone; comprised of almost equal proportions of quartz, feldspar, and
cemented with calcite (in concretions); minor constituents include approximately 2% glauc
(biotite, muscovite, and chlorite), and less than 1% authigenic pyrite; well compacted; carbona
consisting of plant stems, leaves, and other organic fragments common; calcareous concretions,
containing carbonaceous material, prominent along Willamette River south of Buena Vista (M
rangle); pebbly lenses, abundant organic matter, and paleoecology indicate strandline environm
from chiefly volcanic terrain. Weathered outcrops of massive, very fine- to medium-grained s
friable, ranging in color from white to yellowish-brown, pale-brown, or yellowish-orange.*

*According to McKeel (1980), this unit is bracketed by upper Narizian strata in the Reichho
(Amity quadrangle), by upper Narizian and Narizian strata in the Reserve-Bruer #1 well (Amit
and by upper Narizian strata in the Reichhold-Merrill #1 well (Salem West quadrangle). Ave
about 800 ft*

Ty — **Yamhill Formation (middle and upper Eocene):** *Medium- to dark-gray, massive to faintly bedd
tuffaceous shale and siltstone. Occasional beds of medium-gray to greenish-gray, fossilifero
sandstone; minor limestone concretions.*

*According to McKeel (1980), this unit contains 2,000-3,000 ft of Narizian and lower Narizia
Reichhold-Finn #1 and Reserve-Bruer #1 wells, located in the Amity quadrangle. Shown only in th*

OTHER SYMBOLS

Lineament: *Selected major lineaments identified from 1:76,000 false-color infrared aerial phot
Army Corps of Engineers, 1978), orthophotoquads, and topographic maps. Features include a
major escarpments, concentric curvilinear drainages, aligned drainages across saddles, and par
ted are short linear segments along drainages of less than 1 mi length; general trends NE and
lineament features observed in western Oregon*

Landslide topography: *Large areas of deep bedrock failure characterized by irregular topogra
stratigraphy, overall anomalous moderate to shallow slope, prominent arcuate headscarps, b
blocks, springs, sag ponds, and disrupted drainage patterns. Most prominent along west side of S
south and west side of Eola Hills, where undercutting of soft marine sediments (Eocene to Oligoce
rock, unit* **Toe**) *has resulted in massive landsliding of blocks of more resistant unit* **Tcr**. *Subject
debris avalanche along oversteepened escarpments and to slump in some areas (bowed and tip*

Deep bedrock slides within upper Eocene sedimentary rock (**Ts**) *within Monmouth quadra
smaller than those associated with units* **Tcr/Toe**; *characterized by small knobby blocks of sea
within general hummocky terrain*

Landslide scarp: *Characterized by steep cliff, often arcuate, and backward-tilted block below*

bc — **Basaltic colluvium and/or landslide debris:** *Generally reddish-yellow or reddish-brown bas
and/or landslide debris, deeply weathered, overlying Oligocene sedimentary rock* (**Toe**), *ge
landslide topography or beneath steep cliffs capped by Columbia River Basalt Group* (**Tcr**); *includ
and some earthflow and debris-flow topography. Probably generally 6-35 ft thick but may include
basalt of greater thickness. Soils well-drained silty clay loams and gravelly silty clay loams ove
and clay*

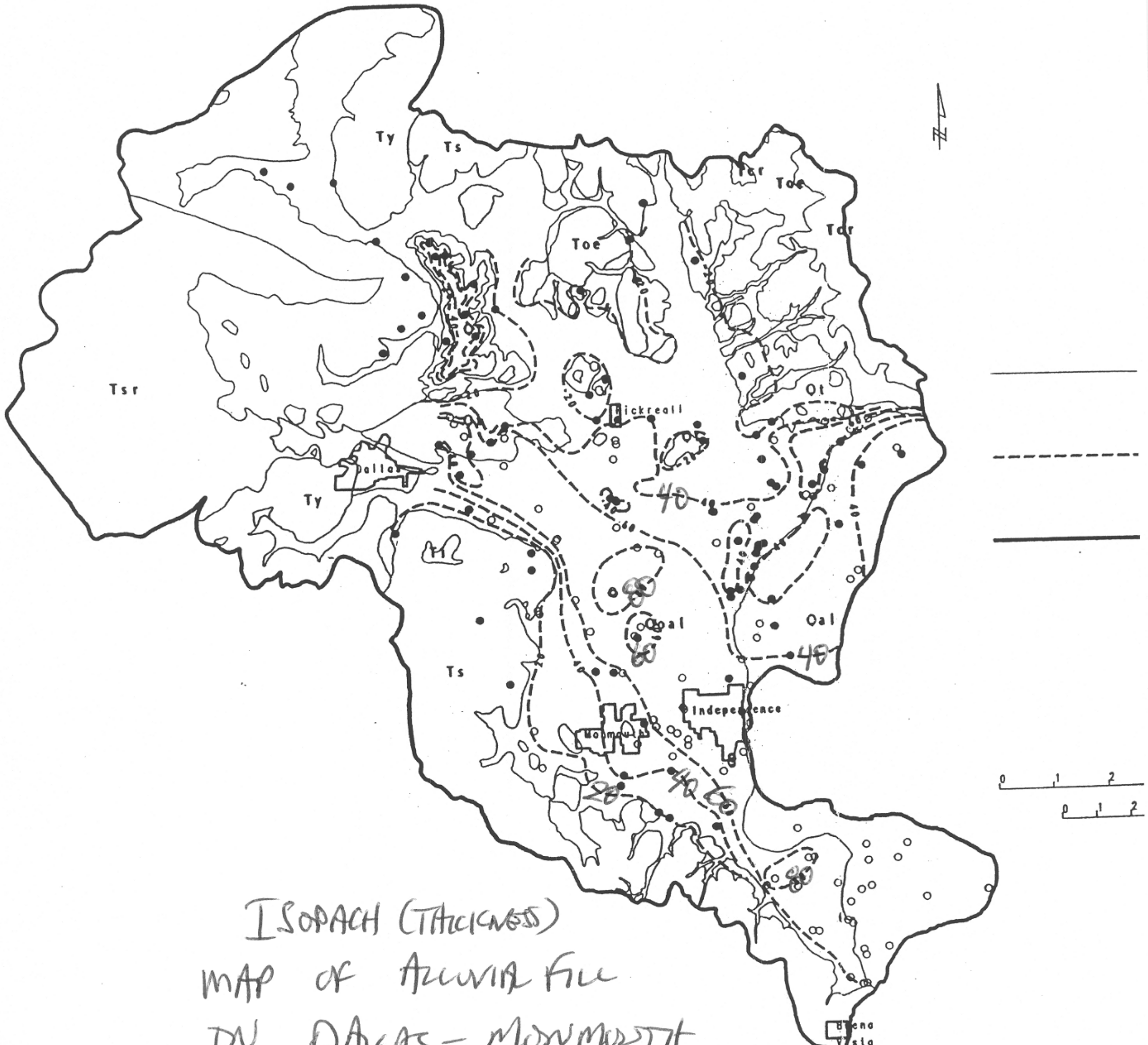
TABLE VII

HYDROGEOLOGIC CHARACTERISTICS OF THE GEOLOGIC/AQUIFER UNITS

AQUIFER	WELL DEPTH (ft) MEAN	STATIC WATER LEVEL (ft) MEAN	YIELD (gpm) MEAN	YIELD (gpm) MED.	SPECIFIC CAPACITY (gpm/ft) no. of wells	LOW	HIGH	MEAN	MED.	MED.*	HYDR.* CONDUC. (ft/d) MED.	STORAGE* COEFFI-CIENT	RE-* CHARGE (in)
Qal	48	19.5	302	75	36	1.10	607.1	59.9	40.0	40.0	170.0	0.2	8–15
Qoal	68	21.1	79	30	80	0.02	175.0	7.3	2.0	0.59	19.0	.001–0.2	2–5
Qt	95	12.8	13	8	13	0.04	2.4	0.5	0.3				
Toe	119	34.8	15	10	20	0.01	2.3	0.5	0.2	0.10	0.3	.00001–.001	2–5
Ts	134	37.9	11	8	41	0.01	30.0	1.6	0.1				
Ty	174	22.1	22	9	33	0.01	1.7	0.3	0.1				
Tsr	171	36.4	18	8	16	0.01	12.5	1.1	0.1	0.11	0.2	.00001–.001	2–5

*From Gonthier (1983)

The specific capacity of a well is defined as the pumping rate divided by the drawdown in the well (Freeze an



ISOPACH (THICKNESS)
MAP OF ALLUVIA FILL
IN DALLAS-MONMOUTH
AREA
(THICKNESS in ft, C.I. =20ft)

Figure 7. Isopach map of alluvial f

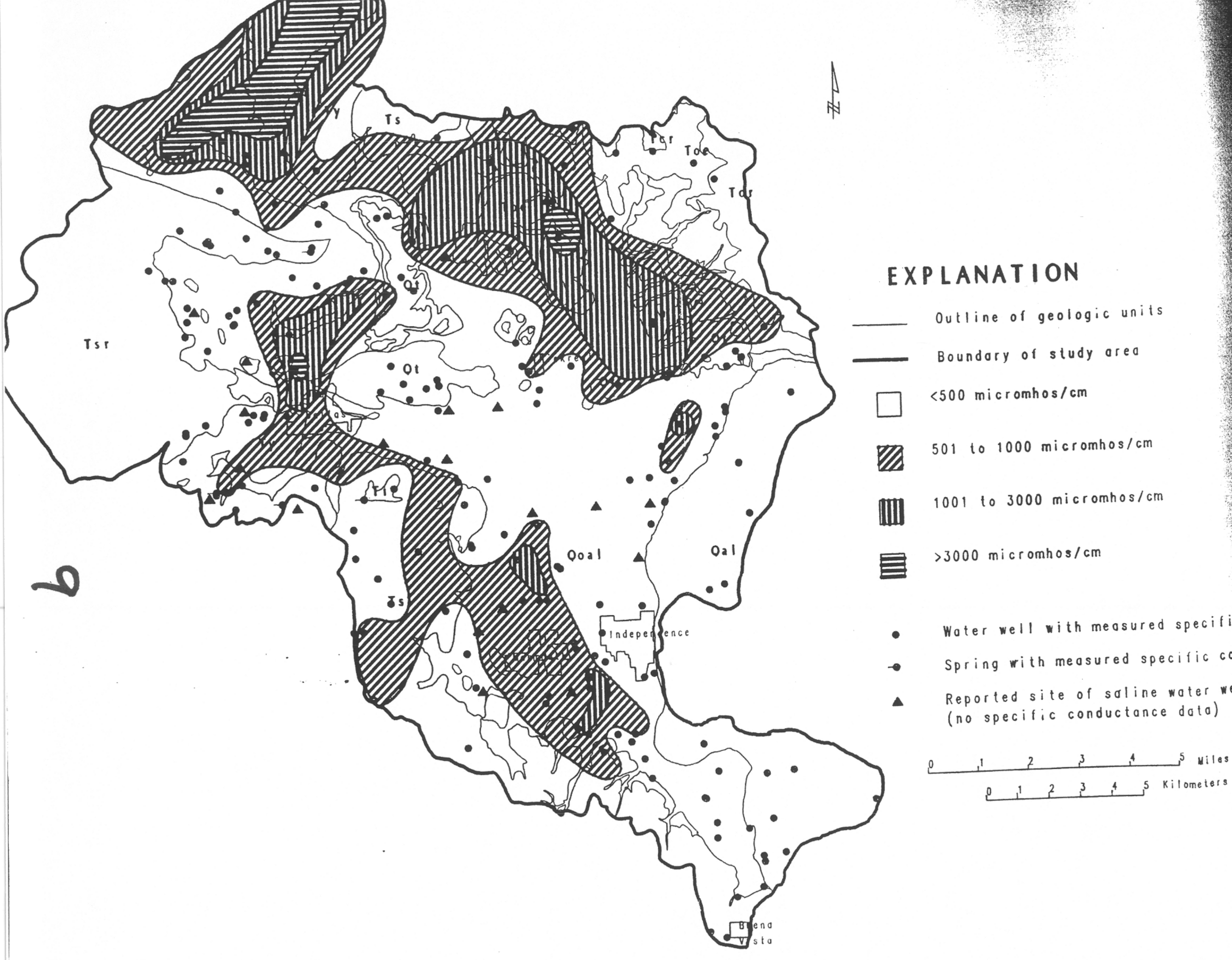


Figure 26. Groundwater salinity hazard map based on specific conductance measurements.

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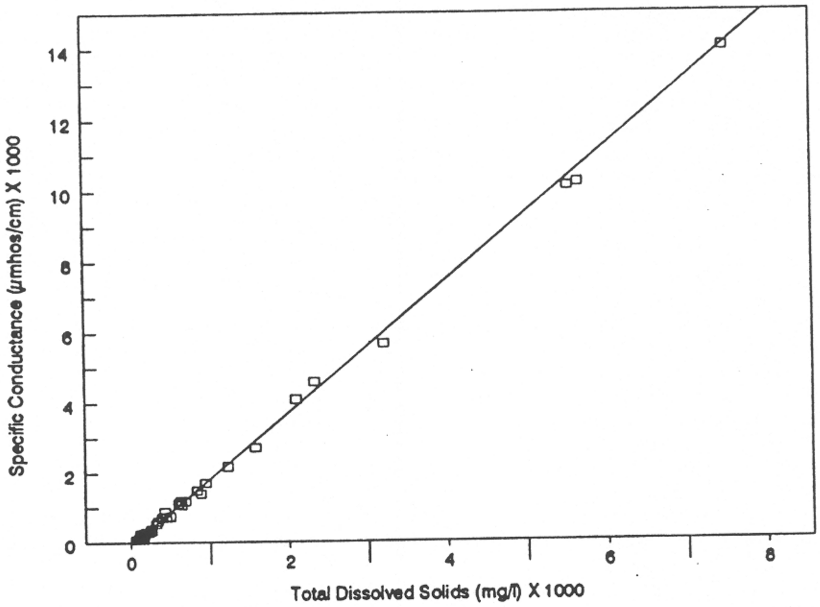
saline spring (6S/5W-21cad1), the oil and gas well (6S/4W-6bd), and ocean water plot below the best-fit line representing the more dilute waters.



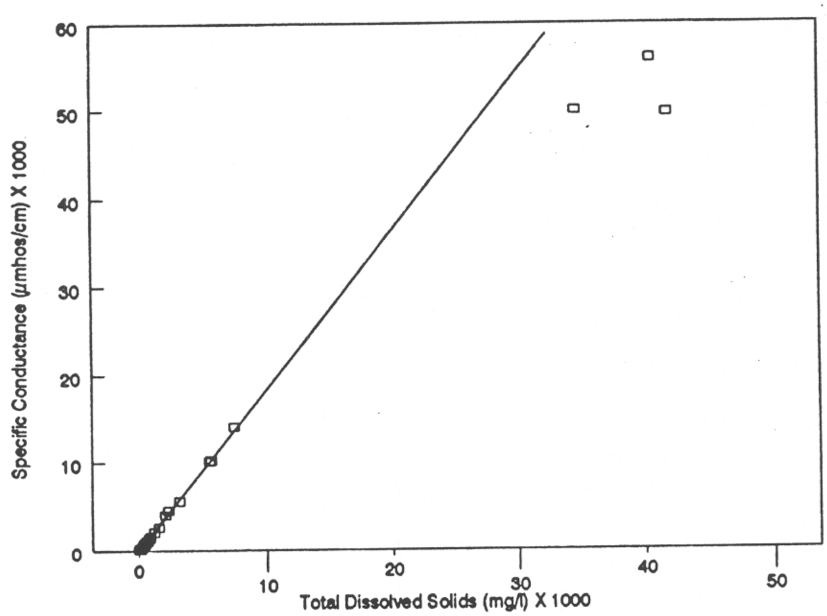


Figure 25. Plots of TDS versus specific conductance for Dallas-Monmouth area groundwater and seawater.

Sources of Groundwater Contamination

TABLE 4.1 Sources Of Ground Water Contamination

CATEGORY I	CATEGORY II	CATEGORY III
Sources designed to discharge substances	Sources designed to store, treat, and/or dispose of substances; discharge through unplanned release	Sources designed to retain substances during transport or transmission
Subsurface percolation (e.g., septic tanks and cesspools) Injection wells Land application	Landfills Open dumps Surface impoundments Waste tailings Waste piles Materials stockpiles Above ground storage tanks Under ground storage tanks Radioactive disposal sites	Pipelines Materials transport and transfer

CATEGORY IV	CATEGORY V	CATEGORY VI
Sources discharging as consequence of other planned activities	Sources providing conduit or inducing discharge through altered flow patterns	Naturally occurring sources whose discharge is created and/or exacerbated by human activity
Irrigation practices Pesticide applications Fertilizer applications Animal feeding operations De-icing salts applications Urban runoff Percolation of atmospheric pollutants Mining and mine drainage	Production wells Other wells (non-waste) Construction excavation	Ground water – surface water interactions Natural leaching Salt-water intrusion/ brackish water upcoming

Office of Technology Assessment, 1984

Figures 4.1 and 4.2 indicate the priority rankings of the sources and of the various contaminants as reported to Congress in 1990. Each section of this chapter discusses how the major sources of contamination may degrade ground water quality and provides the latest information about the scope of the problem. Figure 4.3 shows the various mechanisms of ground water contamination associated with some of the major sources, which include chemical and fuel storage tanks, septic tanks, municipal landfills, and surface impoundments. A wide variety of organic and inorganic chemicals have been identified as potential contaminants in ground water. These include inorganic compounds such as nitrates, brine, and vari-

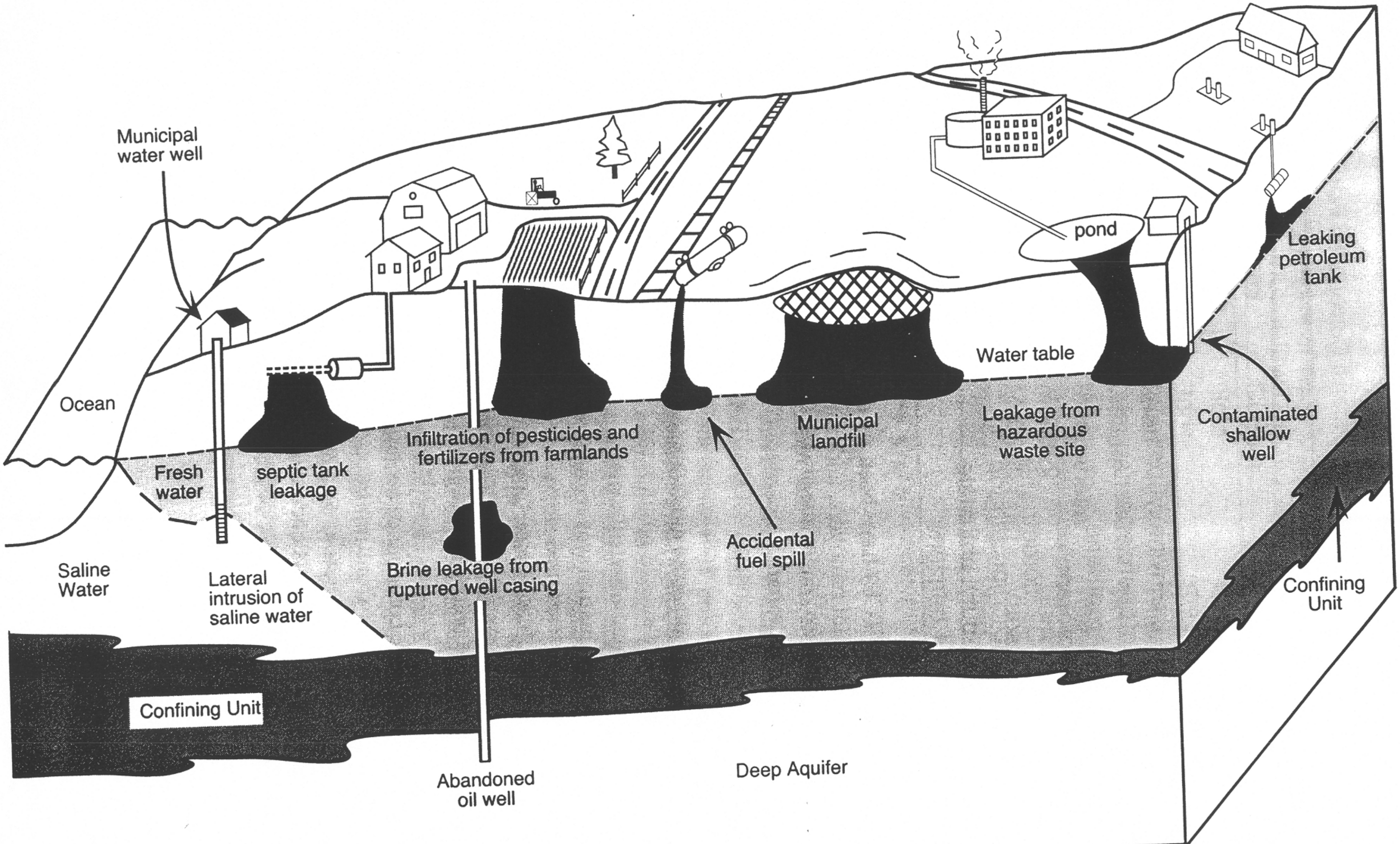


Figure 4.3 Mechanisms of ground water contamination.

...round water, especially in
...straints, resulting in high
...0 that ground waters con-
...nfants, and based on data
...exceed 10 mg/L in public

...netal pollutants of major
...ctices and discharges from
...lated industries. Many of
...nd mercury. Cadmium and
...d with industrial installa-
...piping. Mercury is associ-
...cides. Arsenic is produced
...lead refining.
...e acid-base and solubility
...und water of low pH and
... as the solid phase is ap-
...of ions, and nearly all the
...specially when complexa-
...cally combined forms and

...d water, and contaminant
...acilities where metal plat-
..., New York, was reported
.... Air Force Hughes Plant
...g more than 150 ft below
...ated via a pump and treat

...leaking organic contami-
...process area for chemicals

Source areas often leaked out organic and hazardous contaminants into shallow subsurface aquifers. Because of the slow rate of velocity in ground water compared to surface water (ft/day vs. ft/sec), it can take years or decades for contaminant plumes to migrate from a source area to a receptor off-site where contamination is first observed.

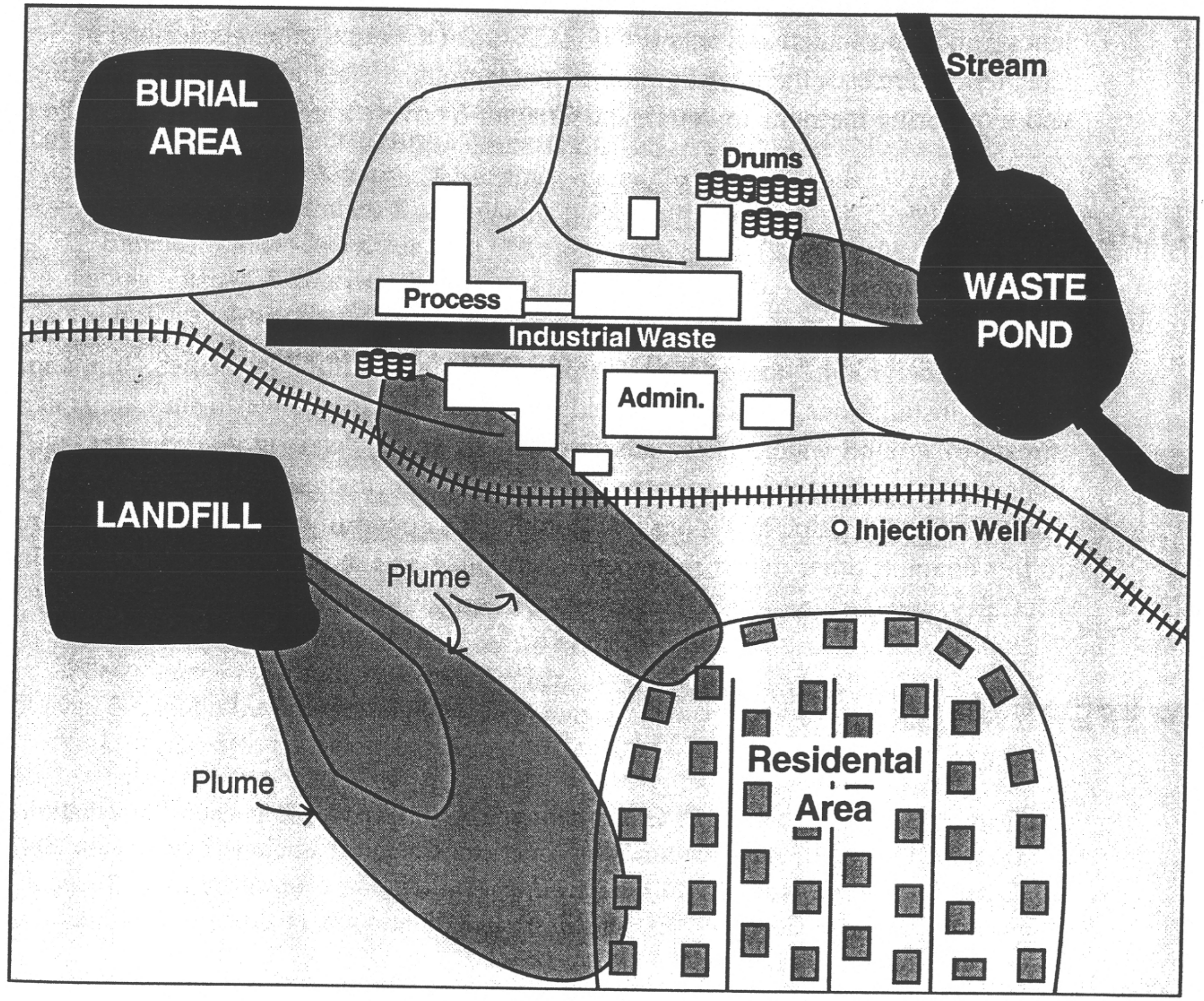


Figure 4.16 Typical contaminated industrial site.

Underground Storage Tank Issues

WHAT ARE THESE REGULATIONS ABOUT?

The U.S. Environmental Protection Agency (EPA) has written regulations for many of the nation's underground storage tank systems. This booklet briefly describes the new **technical requirements** for these systems, which include **tanks and piping**. You can find the complete regulations in the Federal Register. Properly managed, underground storage tank systems -- often called USTs -- will not threaten our health or our environment.

Why Has EPA Written These New Regulations?

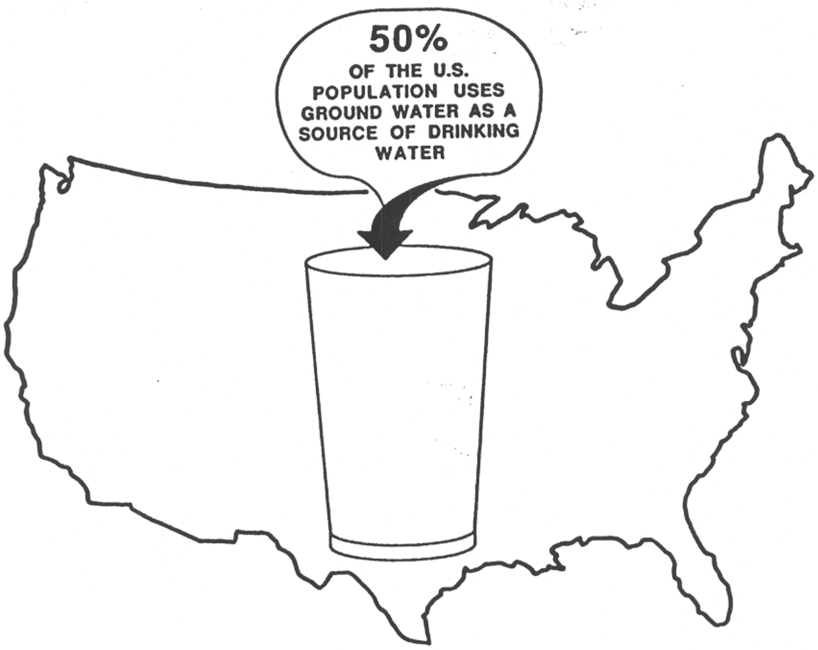
Several million underground storage tank systems in the United States contain petroleum or hazardous chemicals. Tens of thousands of these USTs, including their piping, are currently leaking. Many more are expected to leak in the future. Leaking USTs can cause fires or explosions that threaten human safety. In addition, leaking USTs can contaminate nearby ground water. Because many of us depend on ground water for the water we drink, Federal legislation seeks to safeguard our nation's ground-water resources.

Congress responded in 1984 to the problem of leaking USTs by adding Subtitle I to the Resource Conservation and Recovery Act (RCRA). Subtitle I requires EPA to develop regulations to protect human health and the environment from leaking USTs.

What Are The Goals Of The UST Regulations?

EPA has developed the UST regulations to make sure the following goals are reached:

- To **prevent** leaks and spills.
- To **find** leaks and spills.
- To **correct** the problems created by leaks and spills.
- To make sure that owners and operators of USTs **can pay** for correcting the problems created if their USTs leak.
- To make sure each State has a regulatory program for USTs that is as strict as or stricter than the Federal regulations.



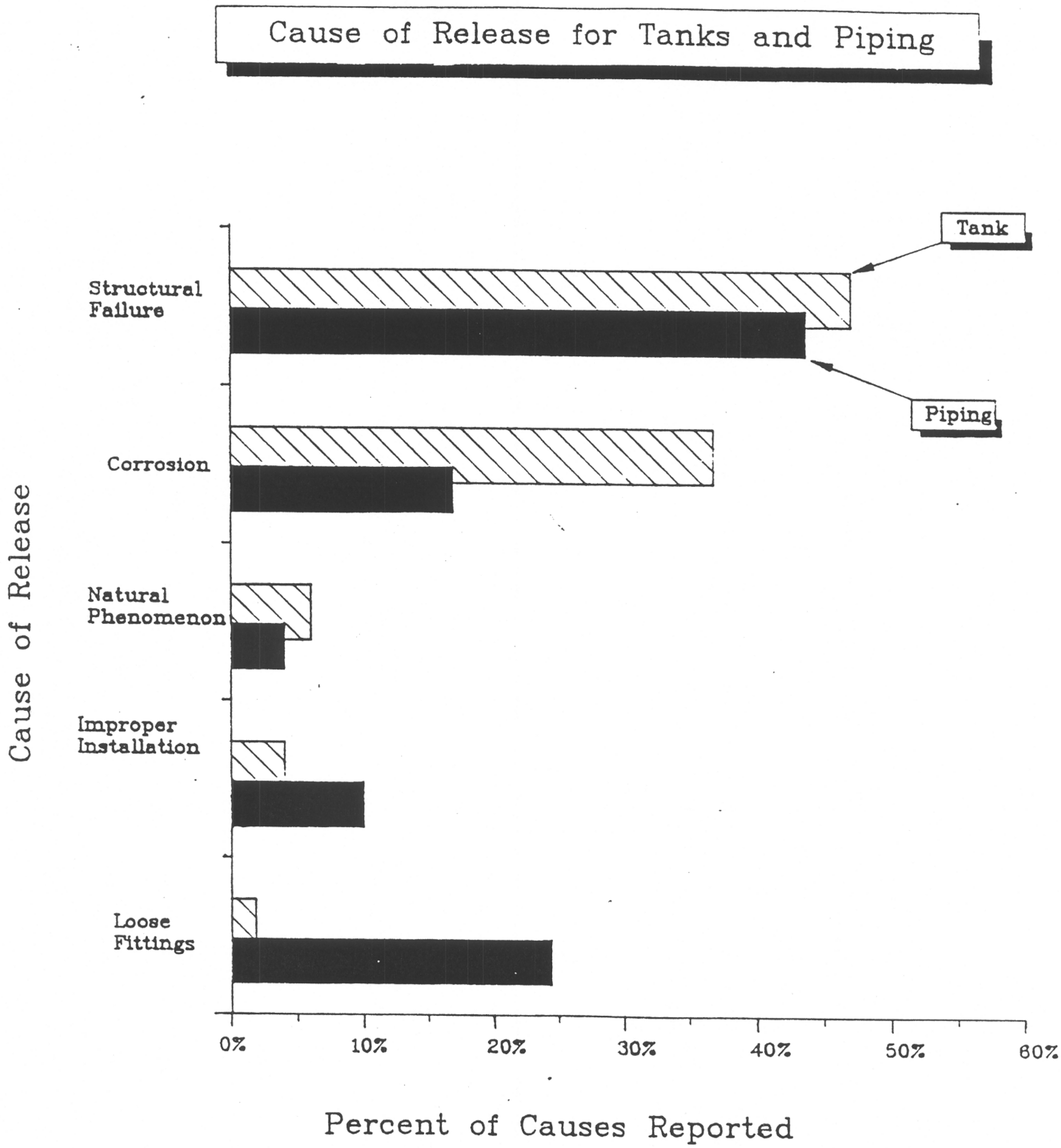

Cause of Release for Tanks and Piping
Tank
Piping
Structural Failure
Corrosion
Natural Phenomenon
Improper Installation
Loose Fittings
Cause of Release
0%
10%
20%
30%
40%
50%
60%
Percent of Causes Reported

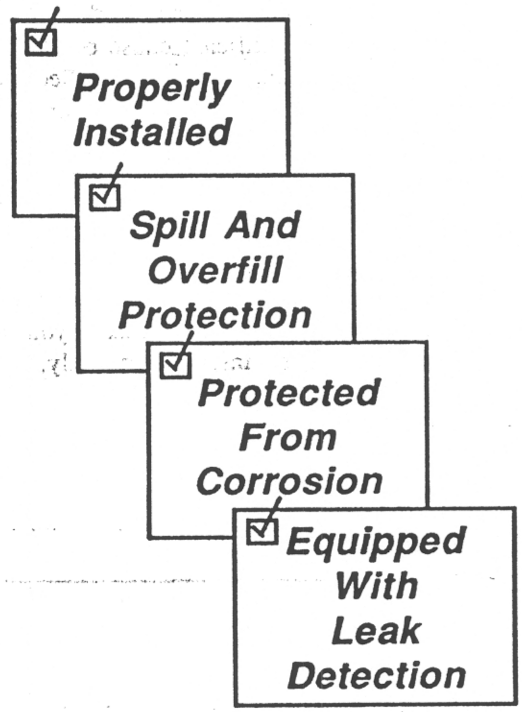
FIGURE 2

WHAT DO NEW PETROLEUM USTs NEED?

You must meet four requirements when you install a new UST system:

- You must certify that the tank and piping are installed properly according to industry codes.
- You must equip the UST with devices that prevent spills and overfills. Also, you must follow correct tank filling practices.
- You must protect the tank and piping from corrosion.
- You must equip both the tank and piping with leak detection.

The following sections provide basic information on these requirements. Also, see the "Technical Questions & Answers" section starting on page 31 for more information.



REMEMBER...

New UST systems are those that are installed after December 1988.

Those USTs installed between May 1985 and December 1988 must meet two minimum requirements:

- The UST must prevent releases due to corrosion or structural failure.
- The stored contents must be compatible with the tank's interior wall.

After December 1988, these older USTs must meet the requirements for existing USTs (see pages 13-17).

Detecting Leaks From Tanks

You must check your tanks at least once a month to see if they are leaking.

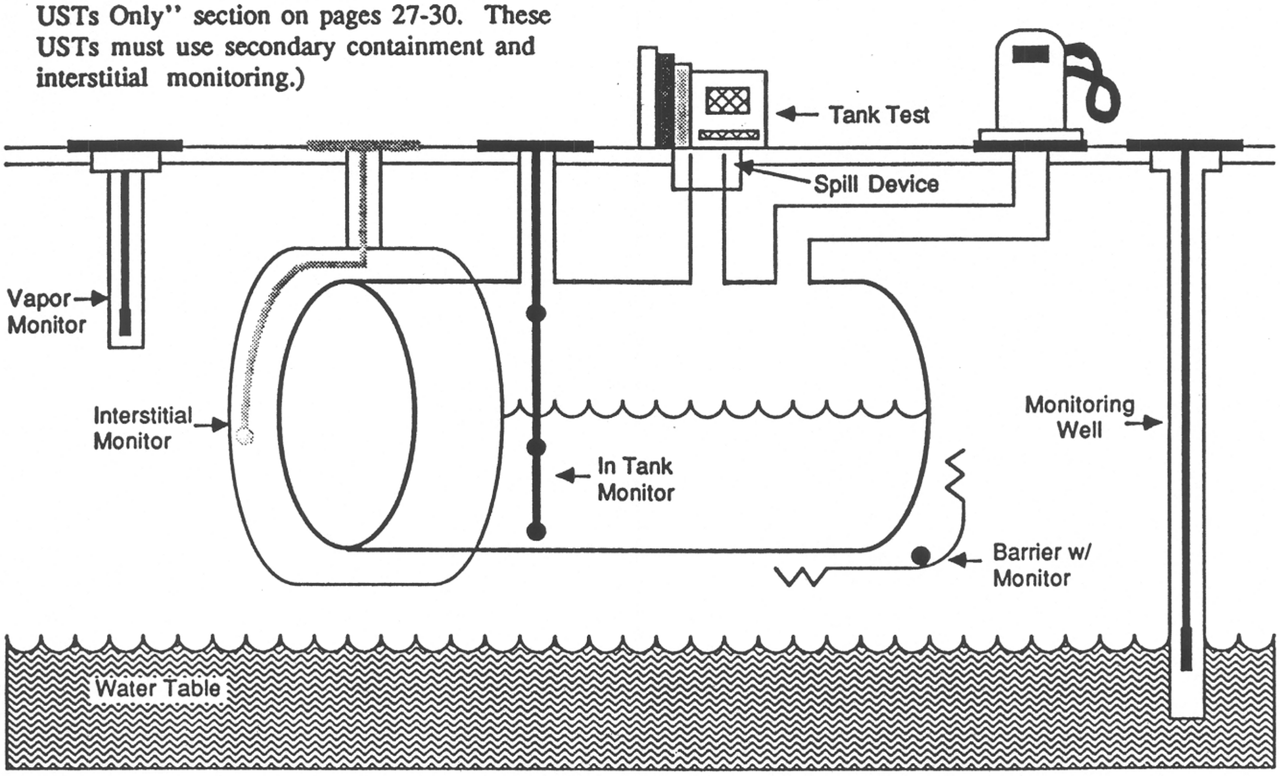
You must use one (or a combination) of the following monthly monitoring methods:

- Automatic tank gauging.
- Monitoring for vapors in the soil.
- Interstitial monitoring.
- Monitoring for liquids on the ground water.
- Other approved methods.

Information on these leak detection methods appears in the "Technical Questions & Answers" section on pages 34-35. (Special requirements for USTs containing hazardous chemicals are described in the "For Chemical USTs Only" section on pages 27-30. These USTs must use secondary containment and interstitial monitoring.)

For Young Tanks... An Alternate Leak Detection Method

You have one additional leak detection choice, but only for 10 years after you install your UST. Instead of using one of the monthly monitoring methods noted above, you can check for leaks by combining monthly inventory control with tank tightness testing every 5 years. After 10 years, you must use one of the monthly monitoring methods listed above.



Leak Detection Alternatives

Monitoring Well Systems

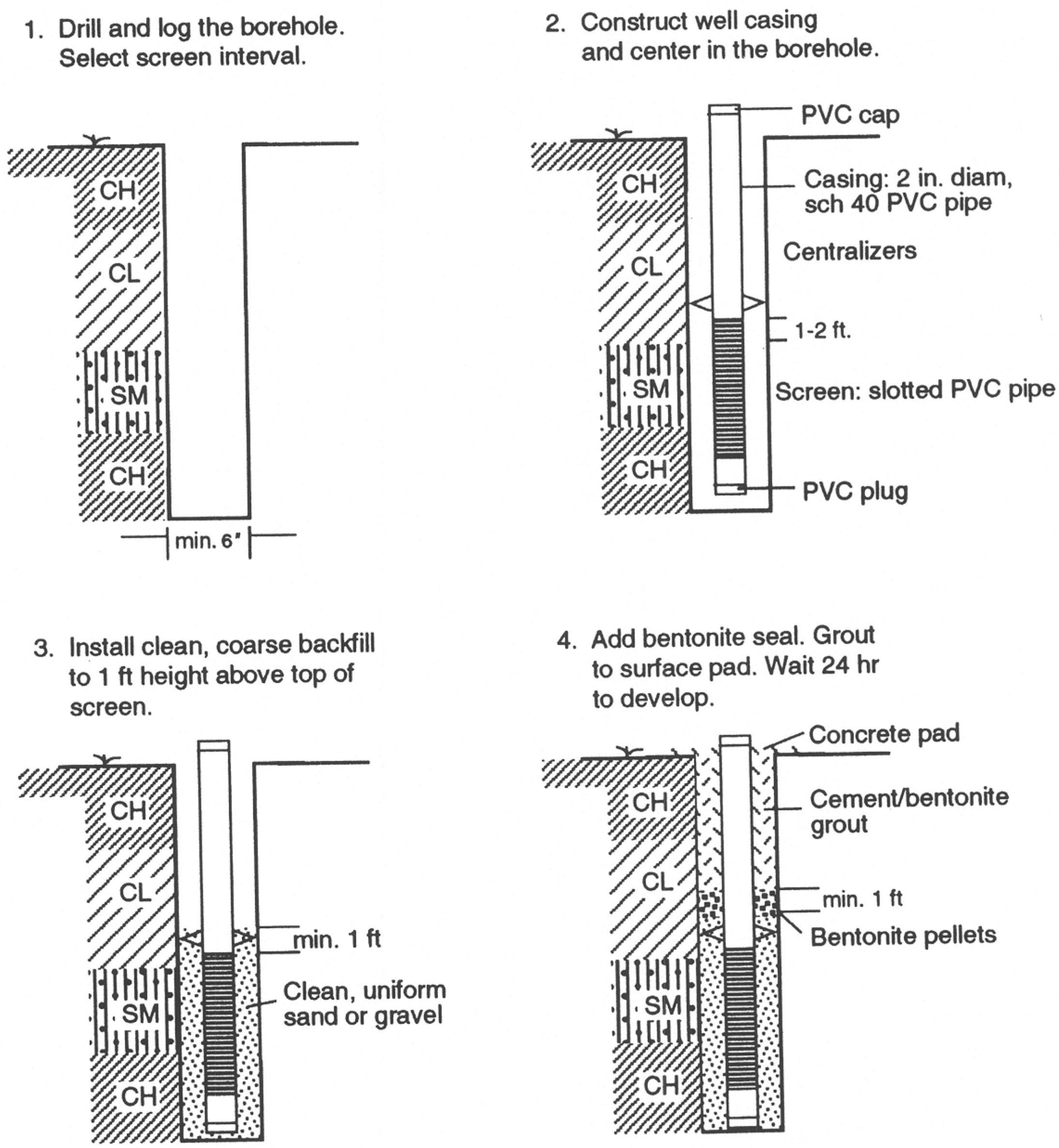


Figure 5.15 Typical monitoring well installation.

tion of the screen with the base of the aquifer is more appropriate. Long screen sections water samples representing an average of conditions across their length; shorter screens or less) yield more depth-specific data and are generally preferred, since low levels o tamination present over a limited depth interval may be overlooked due to dilution sample by uncontaminated water from elsewhere in the screen interval. In general scre excess of 15 ft are avoided. Well diameters of 2 in. and 4 in., installed in 6 in. and diameter boreholes, are most common.

To establish the vertical extent of ground water contamination, it may be necess drill monitoring wells through a contaminated upper zone into an uncontaminated zone. In such cases, it is necessary to first install isolation casing, consisting of a len blank pipe sealed in place with cement or grout to prevent entrainment of contaminant

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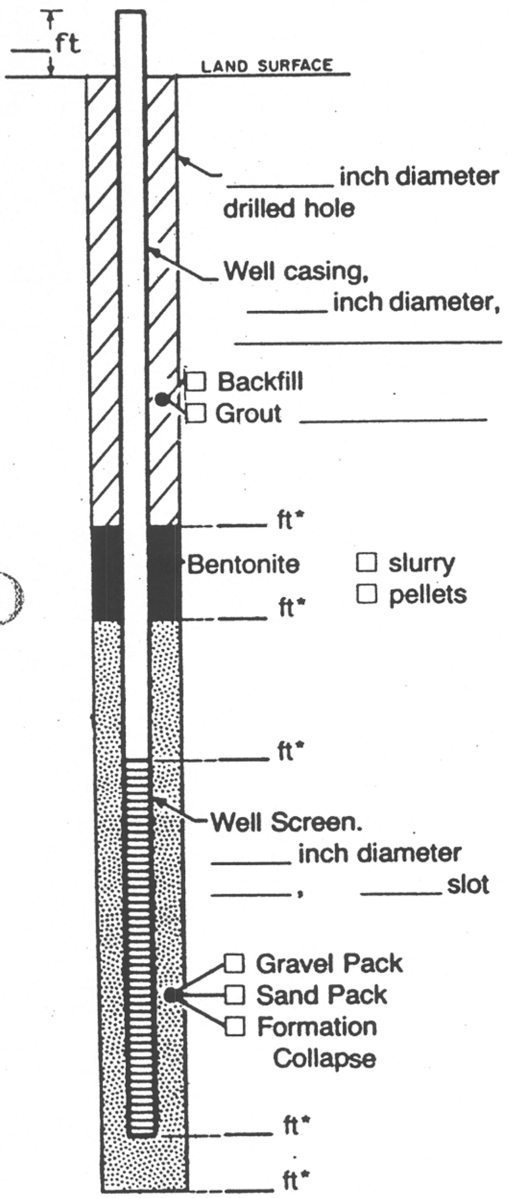
WELL CONSTRUCTION LOG



Measuring Point is Top of Well Casing Unless Otherwise Noted.

*Depth Below Land Surface

Project ________________ Well ________

Town/City ________________

County ________________ State ________

Permit No. ________________

Land-Surface Elevation and Datum ________ feet ☐ surveyed ☐ estimated

____

Installation Dates(s) ________________

Drilling Method ________________

Drilling Contractor ________________

Drilling Fluid ________________

____

Development Techniques(s) and Date(s)

____

____

____

Fluid Loss During Drilling ________________ gallons

Water Removed During Development ________________ gallons

Static Depth to Water ________________ feet below M.P.

Pumping Depth to Water ________________ feet below M.P.

Pumping Duration ________ hours

Yield ________ gpm Date ________

Specific Capacity ________ gpm/ft

Well Purpose ________________

____

____

Remarks ________________

____

____

____

____

____

Prepared by ________________

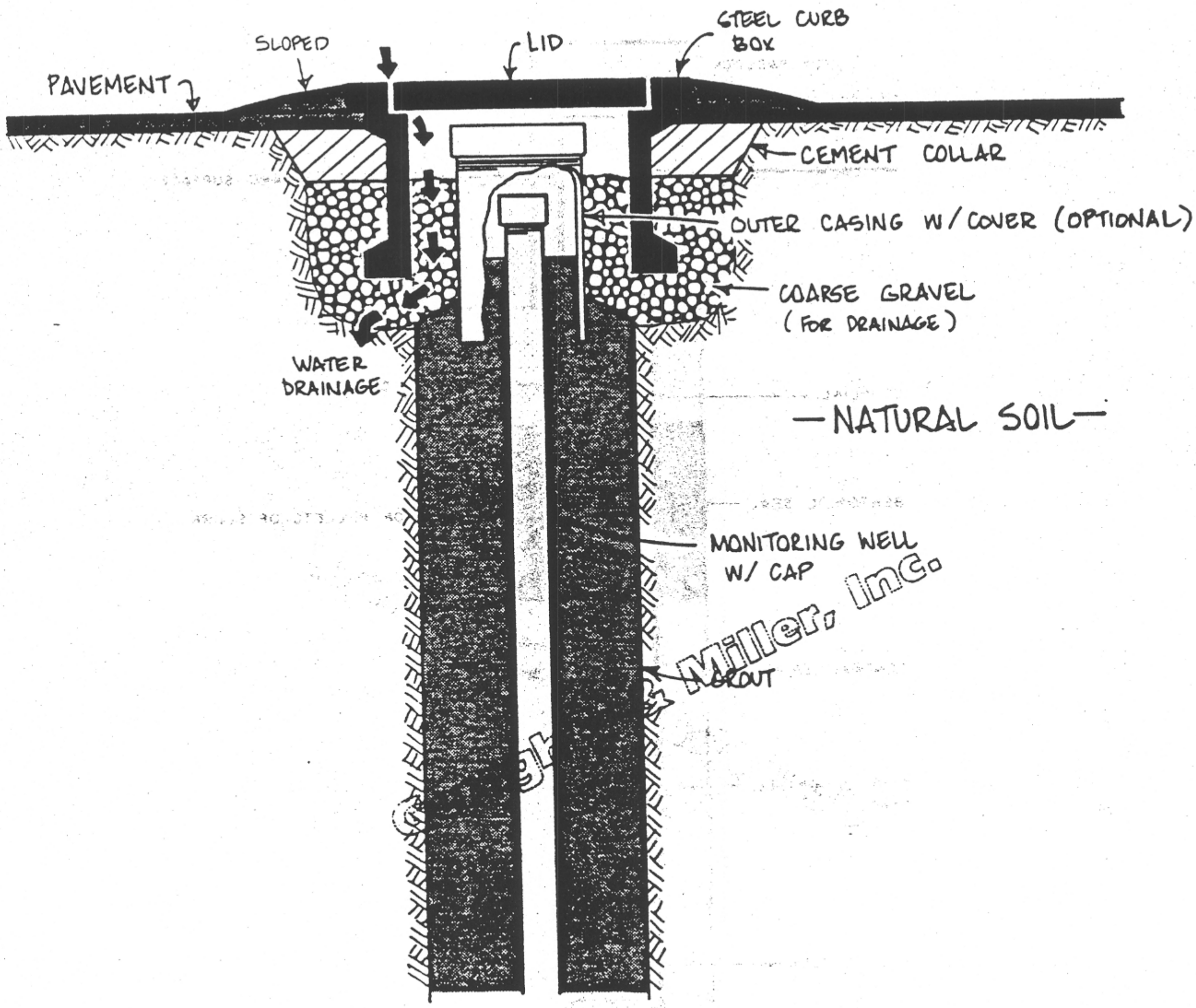


DIAGRAM OF SELF-DRAINING CURB BOX

FIGURE 8

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SAMPLING OF MONITORING WELLS DAILY CHECKLIST

PROJECT: ____________________ WELL(S): ____________

LOCATION: ____________________ DATE: ____________

G&M PERSONNEL ON SITE: ____________________ TIME: ____________

CHECKED BY: ____________________

ITEMS	OK/NA	COMMENTS
PRIOR TO SAMPLING:		
Health & safety precautions (HASP) received; equipment ready		
Sample containers, coolers, received from laboratory; ice or ice packs ready		
Sampling equipment and supplies inventoried, clean, and operational		
Checked in with client at site.		
Integrity of well noted		
Well area prepared for sampling; plastic placed around well; gasoline-powered pumps placed downwind.		
Well and water-level measurements made and recorded along with other pertinent field information on water sampling log.		
Field instruments calibrated.		
Sample containers labelled; preservatives added, if necessary.		
DURING AND AFTER SAMPLING:		
Well purged three to five times its volume		
Sample collected using a bailer or pump as per sampling plan.		
Measurement of field parameters recorded on sampling log.		
Sample containers filled according to collection protocol of analyses.		
Field and trip blanks collected; replicates or split samples collected as per sampling plan.		
Samples stored at 4°C in coolers for transport to lab.		
Water sampling log and chain-of-custody form completed.		
Reusable equipment decontaminated; non-reusable equipment disposed of in appropriate manner.		
Well secured and locked.		
Laboratory contacted to confirm receipt and condition of samples		

Additional Comments:

Instructions: Original to Field Project File; copy to Project Manager and to QA Representative.

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WATER SAMPLING LOG

Project/No. ______________________ Page ______ of ______

Site Location ______________________

Site/Well No. ____________ Coded/ Replicate No. ____________ Date ____________

Weather ____________ Time Sampling Began ____________ Time Sampling Completed ____________

EVACUATION DATA

Description of Measuring Point (MP) ______________________

Height of MP Above/Below Land Surface ____________ MP Elevation ____________

Total Sounded Depth of Well Below MP ____________ Water-Level Elevation ____________

Held ______ Depth to Water Below MP ____________ Diameter of Casing ____________

Wet ______ Water Column in Well ____________ Gallons Pumped/Bailed Prior to Sampling ____________

Gallons per Foot ____________

Gallons in Well ____________ Sampling Pump Intake Setting (feet below land surface) ____________

Evacuation Method ______________________

SAMPLING DATA/FIELD PARAMETERS

Color ____________ Odor ____________ Appearance ____________ Temperature ______ °F/°C

Other (specific ion; OVA; HNU; etc.) ______________________

____

Specific Conductance, umhos/cm ____________ pH ____________

Sampling Method and Material ______________________

Constituents Sampled	Container Description From Lab ______ or G&M ______	Preservative

Remarks ______________________

Sampling Personnel ______________________

WELL CASING VOLUMES				
GAL./FT	1-¼" = 0.077	2" = 0.16	3" = 0.37	4" = 0.65
	1-½" = 0.10	2-½" = 0.24	3-½" = 0.50	6" = 1.46

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Environmental Property Assessments

CHECKLIST FOR ENVIRONMENTAL SITE INSPECTIONS

Due to an increase in the environmental awareness of industries, developers and financial institutions, the demand for environmental site inspections is rapidly growing. Geraghty & Miller, Inc. staff are commonly requested to perform inspections of a wide variety of industrial/commercial facilities. To assist in the completion of a thorough environmental inspection of a facility, a detailed checklist has been developed.

An environmental inspection can be divided into four major phases:

- Phase I - Preliminary Date Acquisition
- Phase II - Interviews with Plant Personnel
- Phase III - Site Tour
- Phase IV - Report Preparation and Recommendations

The following checklist outlines each phase of the inspection process in detail.

PHASE I - PRELIMINARY DATA ACQUISITION

Prior to conducting a site inspection, the following materials should be acquired.

- Topographic map of the site
- Historical aerial photographs
- Map of the facility
- General information relevant to plant operations (i.e. iron foundry, petroleum refinery, injection molding facility, etc.)
- Review general plant processes and associated wastes (U.S.E.P.A. Treatable Manual, Volume II)

In addition, local agencies should be discreetly contacted in order to gather information relevant to any potential environmental concerns in the vicinity of the site (i.e., landfills, known ground-water concerns, dump sites, etc.).

PHASE II - INTERVIEWS

Prior to touring the site, interviews with the plant manager and/or other employees knowledgeable about past and present plant operations should be conducted. Following is a listing of all the topics which should be addressed.

Site Description

1) What does the site manufacture? ______________________________
____
____
____

2) How large are the site and associated buildings? ______________
____
____
____

3) How long has the current operation been active at the site? ____
____
____

4) What processes are currently used at the site? ________________
____
____
____
____
____

5) What processes have been discontinued? _______________________
____
____
____

6) What are the main and backup power supplies at the site? ______
____
____
____

7) Are PCB bearing transformers/capacitors or asbestos used at the site? ____

8) Is the site serviced by sanitary and storm sewer systems? ______
____
____

9) What is the source of water for the facility? _________________
____
____
____

10) What types of industrial facilities border the site? __________
____
____
____
____

Site History

1) How old is the site?____

2) When was the site acquired by the present operator?
____

3) Who were the previous operators and what processes did they utilize?
____
____
____

4) Has the current operator implemented any expansion/ construction activities at the site?
____
____
____

5) What type of fill material is present beneath the site?
____
____
____
____
____

Site Geology & Hydrology

1) What is known about the soils and geology beneath the site (i.e. clay, bedrock, water table, etc.)?
____
____
____
____

2) Are there any water supply wells or ground-water monitoring wells located on or near the site?
____
____
____
____

3) Are any boring logs or well logs available?________________
____

4) Have any subsurface investigations been conducted at the site in the past?____
____
____
____

Raw Materials and Bulk Storage

1) What are the raw materials used at the site? (i.e., metals, paints, solvents, cleaning solutions, caustics, acids, oils, greases, etc.)

____
____
____
____
____

a) How are these materials shipped?_______________________
____
____

b) How are they stored? (Detailed questions to follow)
____

c) What quantities are used?
____
____

d) Which of these materials are considered hazardous?
____
____
____
____

e) Have any releases of materials occurred in loading/ unloading areas?
____
____
____
____

2) Are underground storage tanks utilized at the facility or have they been utilized in the past? If so,

a) How old are the tanks and where are they located?
____
____
____

b) What are they constructed of?
____
____
____

c) What type, if any, of protection is used? (i.e. cathodic, double-walled tanks, etc.)
____
____
____
____

d) What chemicals are stored in each tank?
____
____
____
____
____

e) What is the storage capacity of each tank?

---

f) Have the tanks been tested?

---

g) Is there any evidence of tank leakage?

---

h) If the tanks are no longer in use, how were they abandoned? Was there any evidence of potential concerns? (i.e. corrosion, stained soil, free product in excavation, odors, etc.)

---

3) Are above-ground storage tanks utilized at the facility or have they been utilized in the past?

---

a) How old are the tanks and where are they located?

---

b) What are they constructed of?

---

c) Are there any secondary containment features? (i.e. berm, double-walled tanks)

---

d) Is there a leak detection system?

---

e) What chemicals are stored in each tank?

---

f) What is the storage capacity of each tank?

---

g) Have any instances of leaks or releases occurred?

---

h) If the tanks are no longer in use, how were they abandoned? Was there any evidence of potential concerns?

---

4) Are there underground/above-ground pipelines at the site?

---

a) What materials do they transfer?

---

b) Are they tested?

---

c) Have any releases of chemical occurred?

Waste Streams

1) Does the facility have a RCRA permit for the storage, treatment, or disposal of hazardous waste? If so, what is the permit number?

____

2) Does the facility have a hazardous waste generator's permit? If so, what is the permit number?

____

3) What solid waste materials are generated by the facility (i.e. sludge, scrap metals, foundry sand, etc.)?

____
____

a) What quantities of each type of solid are produced?

____
____
____
____
____

b) Are any of these wastes considered hazardous?

____
____
____

c) Are solid wastes stored on-site prior to disposal? If so, where? How long?

____
____
____

d) How are these wastes disposed? Who is the hauler? Where does it go?

____
____
____

e) Is the solid waste tested before disposal? If so, by whom? What parameters are tested?

____
____
____

4) What liquid waste streams are generated at the facility (i.e. discharge water, spent solvents, used oils, etc.)?

____
____
____
____

a) Does the facility have a discharge permit (NPDES)? What is the number?

____

b) What processes produce wastewater?

____
____
____

c) Where is the wastewater discharged (sanitary or storm sewer)?

____
____
____
____

d) Are the wastewater streams monitored? If so, how often? What parameters are tested?

____
____
____

e) Have there been any citations for permit exceedences?

____
____

f) Are any wastewaters pretreated and/or treated at the facility? If so, how? How are these processes monitored?

____
____
____
____

g) What types of waste chemicals are produced (spent solvents, acids, used oils, etc.)?

____
____
____
____

h) Are any of these liquids considered hazardous?

____
____
____

i) How are these chemicals stored (drums, holding tank, etc.) Where are they stored? How long are they stored?

____

____

____

____

j) How are they disposed? Who is the hauler? Where is it taken? Is it tested prior to disposal? Quantities disposed of?

____

____

____

____

____

____

____

k) Does the facility have floor drains, trenches, or sumps? If so, how are they used? Where are they located?

____

____

____

____

____

5) What are the sources of air emissions at the site?

____

____

____

a) Does the facility have an air emission permit? If so, what is the number?

____

b) Are any air pollution control devices operated at the plant?

____

____

____

____

c) Are air emissions monitored? If so, how often? What parameters are tested?

____

____

____

____

____

d) Have any citations been issued for permit exceedences?

____

____

Review of Concerns

1) Have there been any spills, leaks, or the site?

2) Has the facility ever been cited for non-compliance with discharge/air emissions/hazardous waste permits?

3) Have any environmental or non-compliance actions been brought against the company by either a state or federal regulatory agency (i.e. Superfund notification, etc.)?

4) Are any environmental concerns evident at the site or in the surrounding area (i.e. buried drums, known ground-water problems, stained soils, etc.)?

5) Does the facility maintain Material Safety Data Sheets (MSDS) for all chemicals used at the site?

6) Has an Emergency Contingency Plan been developed for the facility?

PHASE III - SITE TOUR

A complete site inspection should include a tour of each building on the site. In addition, the outside grounds and the perimeter of the site should be walked. Following is a description of relevant features which should be noted during a site tour.

Inside the Facility

1) What is the condition of the plant floor? What material is the floor constructed of? Is the floor seal coated?

2) Where are the floor drains, trenches and sumps located? What are they connected to (sanitary, sewer, storm sewer, etc.)? Any evidence of spillage?

3) Note where particular processes are conducted with the plant (i.e. storage, painting, finishing). Is there any evidence of spillage? If solid, liquid or gaseous waste is produced by any of these processes, how is it removed?

4) Note all chemical storage areas. Where are these areas located? How are chemicals stored? How long are they stored? What are the chemicals? What quantities? Are they hazardous? Are storage areas and individual drums properly marked? Are secondary containment features present? Are the chemicals stored on a paved surface? Are floor drains nearby? Are flammable, hazardous materials stored in a secure, fire-proof room? Is the air properly ventilated? Any evidence of product spillage in the area, etc.?

5) Note the general housekeeping practices of the facility. Was the facility kept clean and orderly? Were storage areas well organized. Were waste materials allowed to accumulate throughout the facility? Was the air quality poor? Were there odors or smoke in the plant? Were noise levels high?

6) Note whether common safety precautions were being taken, such as, safety glasses, steel-toed boots, ear plugs, hard hats, face masks, etc.

Outside Grounds

1) Note the general topographic and geographic features of the site (i.e. slope of the land, nearby streams, swamps or lakes).

2) Note all outside storage areas. Are these areas paved? Are chemicals stored there? How are they stored? Any evidence of stained soils? What other materials are stored there?

3) Note the location of all underground and above ground storage tanks, and associated piping.

4) Note all areas of stained soil. Look closely at all loading/unloading areas.

PHASE IV - REPORT PREPARATION AND RECOMMENDATIONS

The report should include a detailed summary of each phase of the site inspection process. All areas of potential environmental concern which have been identified should be documented. In addition, a focused field investigation should be recommended in order to investigate areas of potential concern.

Environmental Aspects of Agricultural Practices in the Mid-Willamette Valley

Table 8. Estimated nominal rate of application of herbicides to crops in study subbasins during Phase III of the Willamette River Basin Water Quality Study, Oregon, 1996

[Units are in pounds of active ingredient per acre. Compounds analyzed (table 3) that had no estimated application to crops in the basin are not included. Rates are adjusted for percent of acreage applied to. See table 4 for method to determine nominal rate of application. "—", not applied. Rates for 2,4-D and MCPA are for reference purposes only; either 2,4-D or MCPA would be used on grass seed crops, but not both. Sources: Rinehold and Witt, 1989; Rinehold and Jenkins, 1993a, 1993b, 1994, 1996, 1997]

Crop type	2,4-D	2,4-DB	Alachlor	Atrazine	Bentazon	Bromoxynil	Butylate	Chloramben	Clopyralid	Dicamba	Dichlobenil	Diuron	EPTC	Ethalfluralin	MCPA	Metolachlor	Metribuzin	Napropamide	Norflurazon	Oryzalin	Pendimethalin	Pronamide	Simazine	Terbacil	Triallate	Triclopyr	Trifluralin
Alfalfa	—	0.05	—	—	—	0.01	—	—	—	—	—	0.55	0.35	—	—	—	0.15	—	—	—	—	0.07	—	—	—	—	—
Barley	—	—	—	—	—	.09	—	—	—	0.06	—	.71	—	—	0.49	—	.11	—	—	—	—	—	—	—	0.40	—	—
Snap beans	—	—	—	—	0.14	—	—	0.13	—	—	—	—	3.30	—	—	1.62	—	—	—	—	—	—	—	—	—	—	0.55
Beet seed	—	—	—	—	—	—	—	—	0.01	—	—	—	—	—	—	—	—	—	—	—	—	.75	—	—	—	—	—
Blueberries	0.02	—	—	—	—	—	—	—	—	—	0.20	.18	—	—	—	—	—	0.92	0.23	0.72	—	.03	0.12	0.04	—	—	—
Broccoli	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.20	—	—	—	—	—	—	—	—	.65
Caneberries	—	—	—	—	—	—	—	—	—	—	.04	.41	—	—	—	—	—	.32	.15	.03	—	.07	.59	.04	—	—	—
Cherries	.19	—	—	—	—	—	—	—	—	—	.02	—	—	—	—	—	—	—	.12	.66	.01	—	.56	—	—	—	—
Christmas trees	.02	—	—	0.29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.08	—
Clover	—	—	—	—	—	—	—	—	—	—	—	.66	.59	—	.09	—	—	—	—	—	—	.79	—	—	—	—	—
Corn	—	—	0.15	1.48	.20	—	0.08	—	—	—	—	—	1.11	—	—	.54	—	—	—	—	—	—	—	—	—	—	—
Fescue seed	.34	—	—	—	—	—	—	—	—	.13	—	2.02	—	—	.30	—	.05	—	—	—	—	—	—	—	—	—	—
Grapes	.01	.02	—	—	—	—	—	—	—	—	.05	.05	—	—	—	—	—	.01	—	.12	—	—	.31	—	—	—	—
Grass seed	.46	—	—	—	—	.01	—	—	.02	.13	—	1.43	—	—	.42	—	.03	—	—	—	—	—	—	—	—	—	—
Hay	—	.05	—	—	—	.01	—	—	—	—	—	.55	.35	—	—	—	.15	—	—	—	—	.07	—	—	—	—	—
Hazelnuts	.46	—	—	—	—	—	—	—	—	—	.08	.79	—	—	—	—	—	.04	.10	—	—	—	1.20	—	—	—	—
Hops	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.15	—	—	—	—	—	—	—	—
Meadowfoam	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mint	—	—	—	—	.75	.16	—	—	.10	—	—	—	—	—	—	—	—	.12	—	—	—	—	—	1.96	—	—	—
Mustard Seed	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nursery	—	—	—	—	—	—	—	—	.01	—	.20	—	—	—	—	.02	—	.65	—	1.03	.05	—	.38	—	—	—	—
Nursery, container	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.25	—	.60	—	1.65	1.04	—	.12	—	—	—	—
Oats	—	—	—	—	—	.09	—	—	—	.07	—	.75	—	—	.66	—	—	—	—	—	—	—	—	—	—	—	—
Orchard grass seed	.36	—	—	—	—	—	—	—	—	.14	—	1.95	—	—	.33	—	.06	—	—	—	—	—	—	—	—	—	—
Pasture	.07	—	—	—	—	—	—	—	.01	.01	—	—	—	—	.03	—	—	—	—	—	—	—	—	—	—	.01	—
Peaches	.03	—	—	—	—	—	—	—	—	—	.02	—	—	—	—	—	—	.04	—	.07	—	—	.12	—	—	—	—
Prunes	.07	—	—	—	—	—	—	—	—	—	.06	—	—	—	—	—	—	.03	—	.04	—	—	.14	—	—	—	—
Raspberries	—	—	—	—	—	—	—	—	—	—	.20	.35	—	—	—	—	—	.28	.12	.12	—	.11	.56	.17	—	—	—
Rye grain	.21	—	—	—	—	—	—	—	—	—	—	—	—	—	.01	—	—	—	—	—	—	—	—	—	—	—	—
Rears seed	.52	—	—	.02	—	.01	—	—	.04	.12	—	.99	—	—	.47	—	.02	—	—	—	—	—	—	—	—	—	—
Sod	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Squash	.07	—	—	—	—	—	—	.77	—	—	—	—	—	0.91	—	—	—	—	—	—	—	—	—	—	—	—	—
Strawberries	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2.80	—	—	—	—	.92	—	—	—	—
Tomatoes	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.24	—	—	—	—	—	—	—	—	.04
Vegetables	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Walnuts	.04	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Wheat	.03	—	—	—	—	.14	—	—	—	.06	—	.71	—	—	.53	—	.11	—	—	—	—	—	—	—	.43	—	.05

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Table 9. Estimated nominal rate of application of insecticides to crops in study subbasins during Phase III of the Willamette River Basin Water Quality Study, Oregon, 1996

[Values are in pounds of active ingredient per acre. Compounds analyzed (table 3) that had no estimated application to crops in the basin are not included. Rates are adjusted for percent of acreage applied to. See table 4 for method to determine nominal rate of application. —, not applied. Sources: Rinehold and Witt, 1989; Rinehold and Jenkins, 1993a, 1993b, 1994, 1996, 1997]

Crop type	Carbaryl	Carbofuran	Chlorpyrifos	Diazinon	Disulfoton	Ethoprop	Fonofos	Malathion	Methomyl	Methyl Azinphos	Methyl Parathion	Oxamyl	Parathion	cis-Permethrin	Phorate	Propargite	Terbufos
Alfalfa	0.02	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Barley	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Snap beans	1.05	—	0.05	0.38	—	0.33	0.17	0.04	—	—	—	—	—	—	—	—	—
Beet seed	.05	—	.50	.10	—	—	.10	—	—	—	—	—	—	—	—	0.07	—
Blueberries	.29	—	—	.48	—	—	—	.44	0.05	0.04	—	—	0.02	—	—	—	—
Broccoli	.15	—	1.60	.13	0.20	—	.62	—	.04	—	—	—	—	0.01	—	—	—
Caneberries	.82	—	—	.95	—	—	—	.53	—	.10	—	—	—	—	—	—	—
Cherries	—	—	.13	.65	—	—	—	3.62	—	.01	0.12	—	.86	—	—	—	—
Christmas trees	—	—	.06	.01	—	—	—	.01	—	—	—	—	—	—	—	—	—
Clover	—	—	.30	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Corn	—	—	.45	—	—	.50	.42	—	—	—	—	—	—	.03	—	—	0.01
Fescue seed	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Grapes	.06	0.01	—	—	—	—	—	.02	—	—	—	—	.04	—	—	—	—
Grass seed	—	—	.04	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hay	.02	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hazelnuts	.04	—	1.06	.07	—	—	—	—	—	.19	—	—	—	—	—	—	—
Hops	—	—	1.00	1.50	—	—	—	—	—	—	—	—	—	—	—	1.73	—
Meadowfoam	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mint	—	—	.78	—	—	—	1.42	.01	—	—	—	0.68	—	—	—	.57	—
Mustard seed	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nursery	—	—	.25	.11	—	—	.10	—	—	—	—	—	—	—	—	.05	—
Nursery, container	—	—	.40	.04	—	—	—	—	—	.03	—	—	—	—	—	—	—
Oats	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Orchard grass seed	—	—	.88	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pasture	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Peaches	—	—	—	.38	—	—	—	—	—	—	—	—	—	—	—	—	—
Prunes	.46	—	.30	.75	—	—	—	—	—	—	—	—	.25	—	—	—	—
Raspberries	.14	—	—	.77	—	—	—	.92	—	.02	—	—	.01	—	—	—	—
Rye grain	—	—	—	—	—	—	—	—	—	—	—	—	.05	—	—	—	—
Ryegrass seed	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sod	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Squash	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Strawberries	.18	.30	.72	.04	—	—	.02	.03	—	.22	—	—	—	—	—	.22	—
Tomatoes	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Vegetables	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Walnuts	—	—	—	.26	—	—	—	2.70	—	—	—	—	—	—	—	—	—
Wheat	—	—	—	—	.01	—	—	—	—	—	—	—	—	—	0.02	—	—

Table 10. Total mass of the 20 pesticides included in the study that were estimated to have the highest application quantities in the 16 agricultural study subbasins. Phase III of the Willamette River Basin Water Quality Study, Oregon, 1996

[Values are in pounds of active ingredient]

	Nonintensive, diverse subbasins					Intensive, diverse subbasins					Intensive, nondiverse subbasins						
Compound	UT Ash Swale	Baker	Chicken	SF Ash	Shafer	Senecal	UT S Yamhill	Deer	W Champoeg	WF Palmer	Simpson	Truax	UT Shedd	UT Flat	UT Oak	Lake	All Basins
Diuron	528	1,120	345	1,593	458	2,103	2,994	1,256	1,610	1,891	1,679	3,518	1,992	4,654	4,585	7,757	38,083
2,4-D	61	283	97	67	91	85	70	66	4	137	7	1,422	841	1,720	2,181	2,779	9,912
MCPA	128	331	38	383	1	782	1,232	503	553	761	412	48	1	41	0	192	5,405
EPTC	90	182	41	258	3	610	413	462	1,012	1,600	0	196	14	214	19	175	5,289
Chlorpyrifos	97	554	214	180	38	600	99	390	1,049	1,012	43	74	0	172	7	143	4,671
Dicamba	27	38	12	109	29	190	216	130	153	129	134	357	208	437	518	736	3,427
Diazinon	81	333	53	25	4	511	21	161	1,611	199	1	0	0	2	0	0	3,004
Atrazine	8	112	89	20	182	151	91	417	180	1,183	39	197	27	52	74	83	2,904
Simazine	148	790	266	171	3	344	9	266	76	372	5	0	0	30	0	0	2,480
Malathion	422	1,179	170	88	8	40	7	50	70	157	2	0	0	0	0	1	2,193
Propargite	0	4	6	0	1	416	1	16	1,666	14	24	0	0	0	0	40	2,189
Oryzalin	70	266	88	16	1	229	3	318	52	908	0	0	0	0	0	0	1,950
Metolachlor	0	1	1	0	0	264	9	210	467	733	0	55	0	0	0	0	1,740
Metribuzin	57	84	19	134	12	96	291	42	57	201	40	95	48	194	102	176	1,649
Napropamide	3	92	79	5	0	308	2	254	89	370	5	0	0	1	0	8	1,217
Carbaryl	10	110	24	20	1	216	37	131	307	215	0	2	1	13	1	0	1,088
Triallate	51	16	0	0	0	107	396	14	2	364	6	32	0	28	0	49	1,065
Fonofos	0	6	6	0	0	111	2	183	94	410	58	43	0	0	0	100	1,014
Pronamide	18	43	14	52	1	20	119	21	20	321	0	72	3	43	4	233	982
Ethoprop	0	0	0	0	0	87	2	137	138	432	0	51	0	0	0	0	847

surveys (Rinehold and Jenkins, 1993a, 1993b, 1994, 1996, 1997). Also, special registrations for other compounds may have been enacted since these estimates were published.

GENERAL WATER QUALITY FINDINGS

Water quality results are given here as an overview of the study's findings taken as a whole. These include summaries of concentrations, a comparison with other studies, an evaluation of the conformance to water quality standards and criteria, and implications for toxicity in the study streams. Subsequent sections address specific findings regarding pesticide detections at certain sites, land use and seasonal components of the data, and the relation between estimated pesticide applications and occurrence in streams.

Pesticide Detections and Concentrations

A total of 36 pesticides (29 herbicides and 7 insecticides) were detected during the Phase III study (table 11). There were slightly fewer than 100 samples (5 at each of the 20 sites) because 5 sites (UT Shedd, UT S Yamhill, Lake, UT Oak, and SF Ash) were dry or had no flowing water during the summer. As a result of analytical interferences, pesticide concentrations for some compounds were occasionally censored at MDLs that deviated from the standard MDLs listed in tables 2 and 10; for four of these compounds the highest reported MDL was within the range of detected concentrations that included the lowest percentile shown in table 11. In these four cases the percentile statistics were computed using a statistical procedure that fits a probability distribution to the data set using both the detections and the nondetections (Helsel and

Table 11. Summary statistics for pesticides detected during Phase III of the Willamette River Basin Water Quality Study, Oregon, 1996

[All samples are included in calculations. One microgram per liter (µg/L) is equal to one part per billion; The method detection limit (MDL) is defined as the concentration at which there is a 99% chance that a detected compound is actually present, and a 50% chance that a nondetected compound is actually present; *, Compound had nondetections censored at values interspersed within a range of detected concentrations above the lowest indicated percentile, so summary statistics were computed according to Helsel and Cohn (1988); <, not detected at the MDL]

Compound	MDL (µg/L)	Number of samples	Number of detections	Detection frequency (percent of samples)	Concentration at indicated percentile (µg/L) 25	50	75	90	Maximum (µg/L)
Atrazine	0.001	95	94	99	0.027	0.071	0.26	1.3	90
Desethylatrazine	.002	95	88	93	.006	.012	.033	.1	.24
Simazine	.005	95	81	85	.008	.022	.069	.41	1.0
Metolachlor	.002	95	81	85	.004	.017	.14	.96	4.5
Diuron	.020	94	69	73	<	.26	1.5	4.2	29
Tebuthiuron *	.010	95	35	37	<	<	.021	.078	.32
Pronamide	.003	95	34	36	<	<	.01	.084	.62
Prometon *	.018	95	33	35	<	<	.013	.019	.046
Metribuzin	.004	95	29	31	<	<	.029	.17	5.3
Diazinon	.002	95	25	26	<	<	.007	.031	.31
Triclopyr	.050	94	22	23	<	<	<	.55	6.0
EPTC	.002	95	21	22	<	<	<	.016	.89
Ethoprop	.003	95	21	22	<	<	<	.014	.44
2,4-D	.035	94	20	21	<	<	<	.22	10
Dichlobenil *	.020	93	20	21	<	<	<	.036	.23
Terbacil	.007	95	15	16	<	<	<	.019	.97
Bromacil	.035	94	14	15	<	<	<	.31	51
Chlorpyrifos	.004	95	13	14	<	<	<	.009	3.3
Triallate	.001	95	12	13	<	<	<	.008	.070
Carbaryl *	.003	95	12	13	<	<	<	.027	.11
MCPA	.050	94	9	10	<	<	<	<	.98
Trifluralin	.002	95	6	6	<	<	<	<	.023
Dicamba	.035	94	5	5	<	<	<	<	14
Oryzalin	.019	94	4	4	<	<	<	<	3.2
Carbofuran	.003	95	4	4	<	<	<	<	.084
DCPA	.002	95	4	4	<	<	<	<	.003
Napropamide	.003	95	4	4	<	<	<	<	.011
Fonofos	.003	95	3	3	<	<	<	<	.012
Propachlor	.007	95	3	3	<	<	<	<	.051
Bentazon	.014	94	3	3	<	<	<	<	.24
Malathion	.005	95	1	1	<	<	<	<	.030
Alachlor	.002	95	1	1	<	<	<	<	.005
Norflurazon	.024	94	1	1	<	<	<	<	.02
Dinoseb	.035	94	1	1	<	<	<	<	.19
Bromoxynil	.035	94	1	1	<	<	<	<	.22
Propanil	.004	95	1	1	<	<	<	<	.066