GROUND WATER CONTAMINATION IN NEW MEXICO 1927-1986

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INTRODUCTION

More than one million New Mexicans rely totally upon aquifers for their water supply. Approximately 200,000 residents use private water wells. Unlike public water systems which are tested routinely pursuant to the federal Safe Drinking Water Act, private wells are tested rarely, if at all.

For the purpose of this document, ground water contamination is defined as a result of human activity involving either the increase in concentration of aqueous solutes or the introduction of unnatural material (dissolved, emulsified, immiscible or suspended).
Ground water contamination most frequently occurs in "vulnerable" aquifer areas where the water table is shallow (see Figure 1). (See Figure 2 for general map of New Mexico.)

At least 883 incidents of ground water contamination have been documented in the state from 1927 to 1986 (see Figure 3). These cases have contaminated 80 public water supply wells, most of which have been shut down and abandoned (see Figure 4). To date, 54 cases have received or will soon receive some degree of remediation (see Figure 5).

Slightly more than one half of all cases of ground water contamination in the state have been caused by non-point sources, predominantly household septic tanks or cesspools (see Figure 6). Non-point source contamination is caused by diffuse sources such as large numbers of small septic tanks spread over a subdivision, residual minerals from evapotranspiration, urban runoff or widespread application of agricultural chemicals.

Point-source contamination categories are shown in Figure 7. These sources are predominantly industrial in nature; other sources include publicly owned sewage treatment plants or landfills. Virtually all such cases result from:

* historical disposal practices;
* accidental discharges; or
* current unpermitted discharges.

In fact, only 5 of the 412 discharges permitted by N.M. Water Quality Control Commission regulations have caused ground water contamination. None of these cases

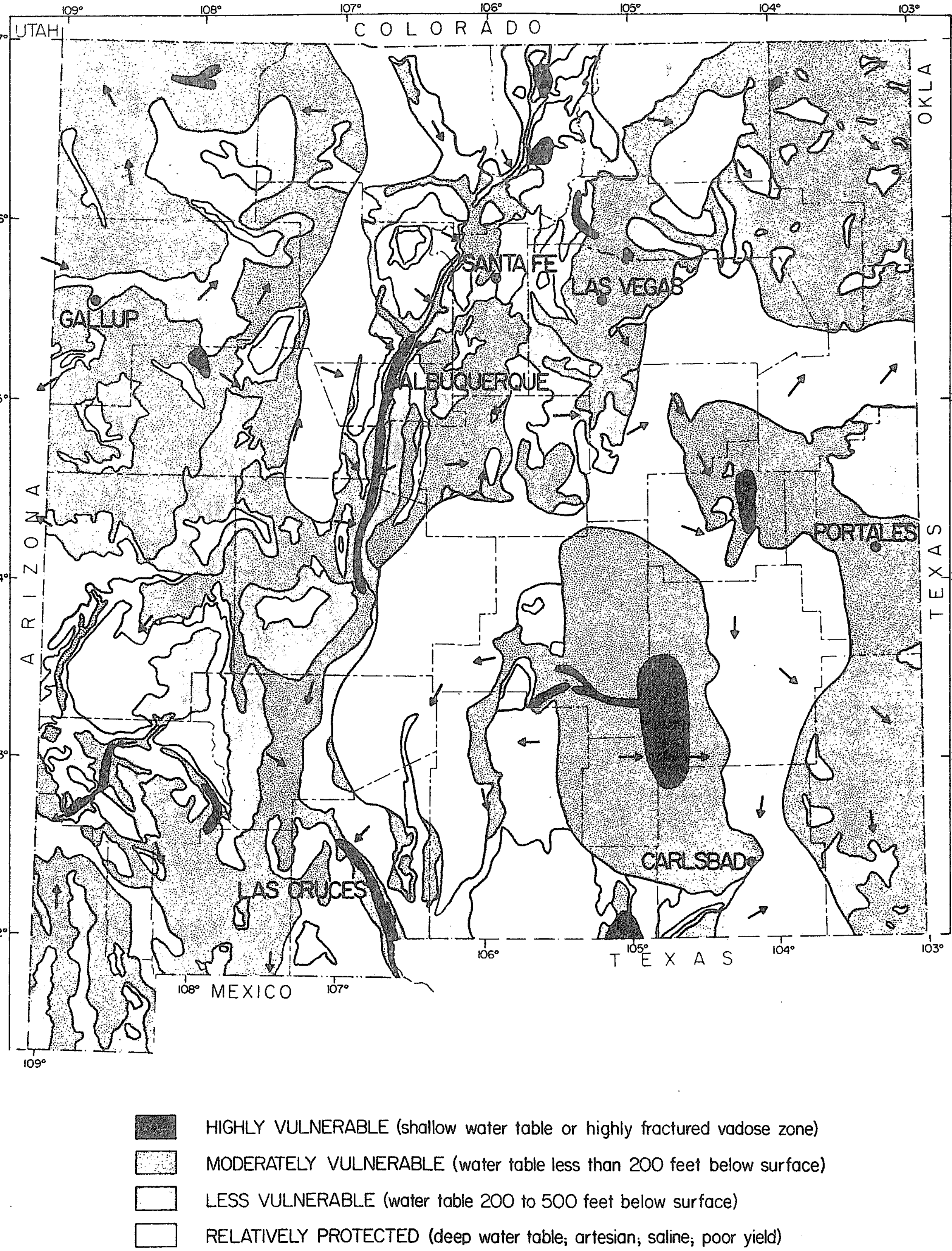

Figure 1. Relative Vulnerability of New Mexico Aquifers to Contamination from Surface Discharges

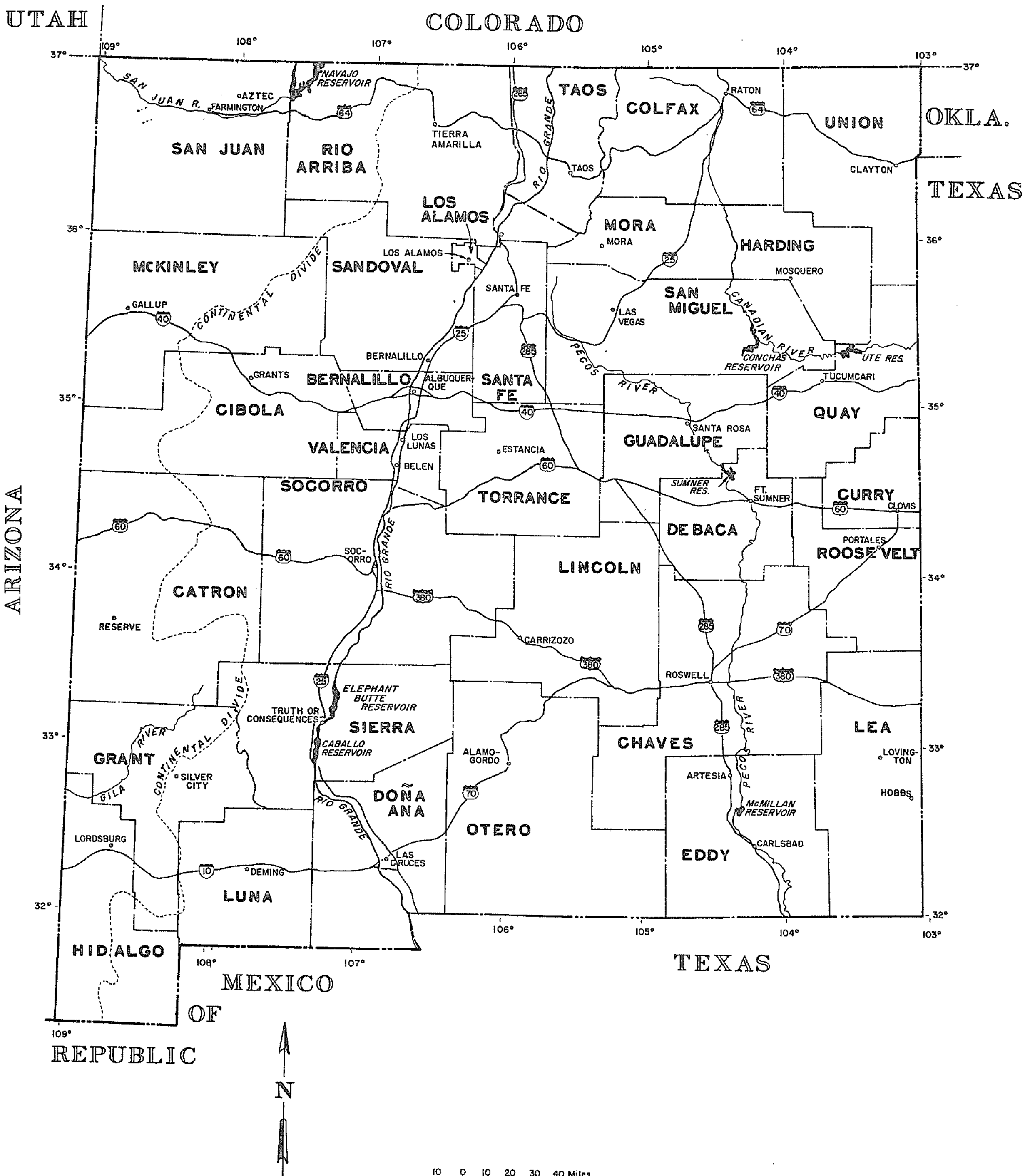

Figure 2. Map of New Mexico

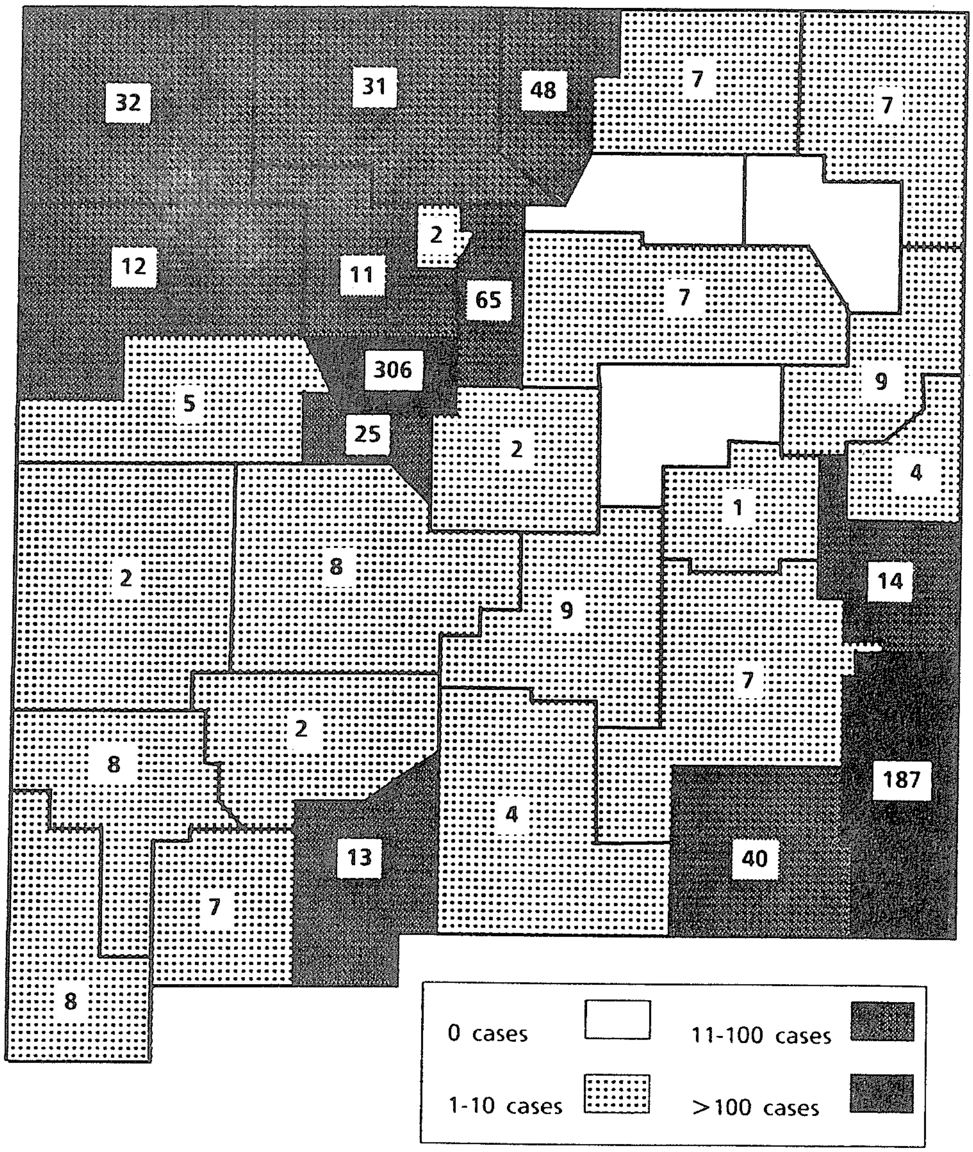

Figure 3. Ground Water Contamination

883 cases distributed by county

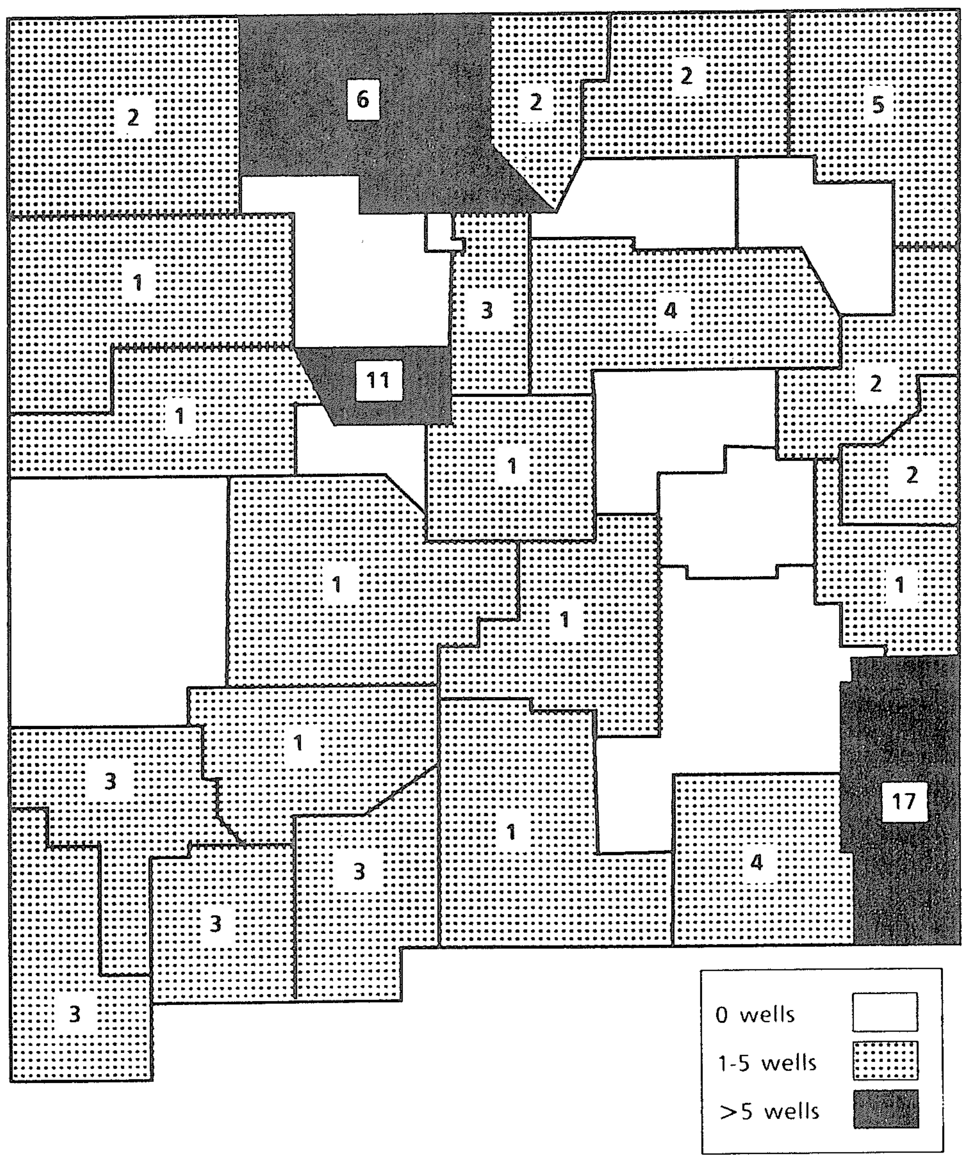

Figure 4. Contaminated Public Water-Supply Wells

80 wells distributed by county

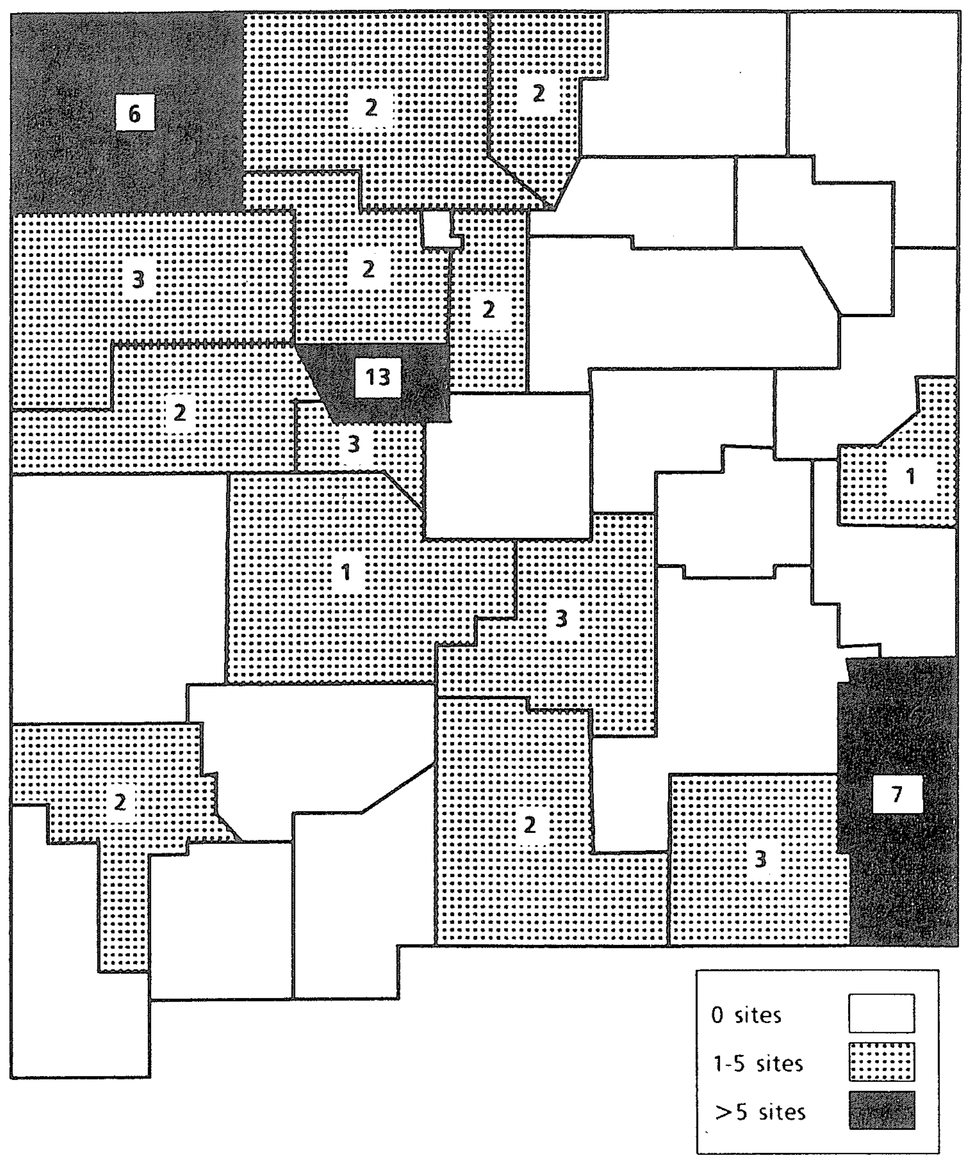

Figure 5. Remediation of Ground Water Contamination

54 sites distributed by county

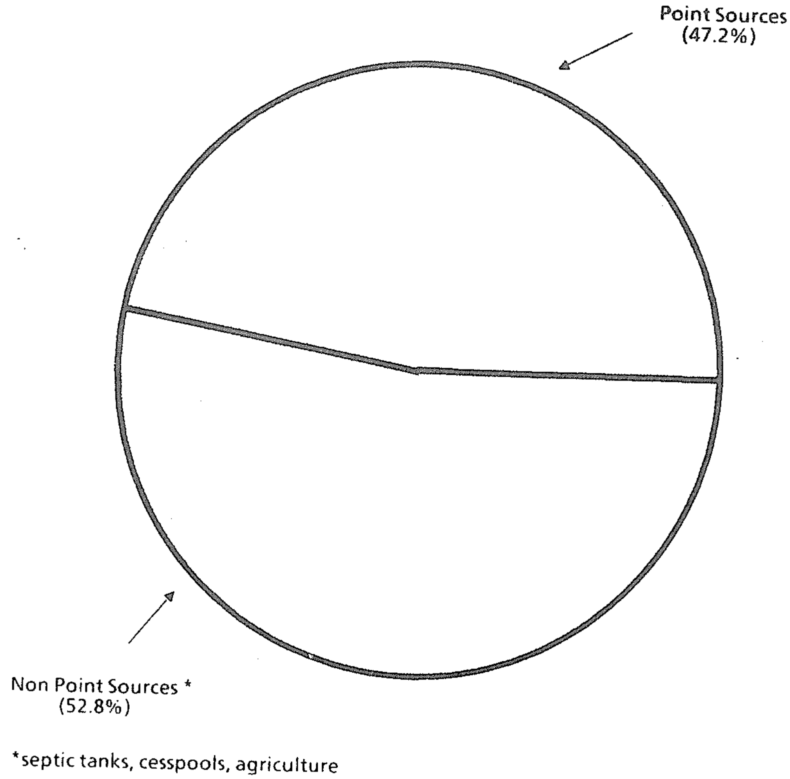

Figure 6. Total Ground Water Contamination Cases

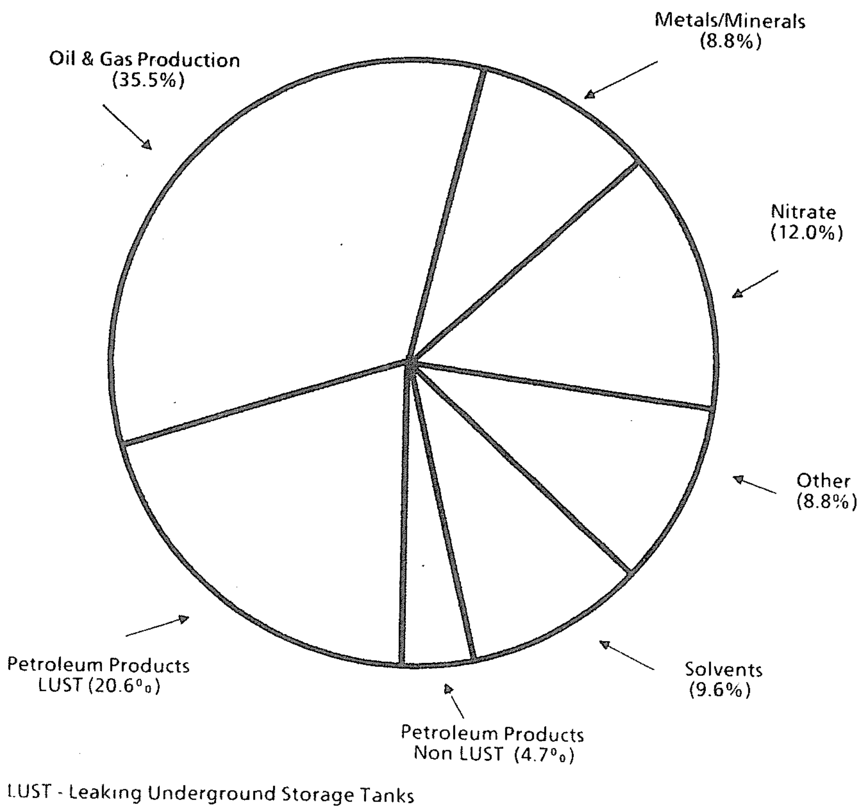

Figure 7. Point Sources of Ground Water Contamination

has impaired the beneficial use of ground water. No water-supply wells, public or private, have been contaminated by permitted discharges. Contamination has been documented only in monitoring wells.

NON-POINT SOURCES OF CONTAMINATION

Household Septic Tanks and Cesspools

An estimated 135,000 household septic tanks or cesspools in the state discharge approximately 25 million gallons per day of waste water to the subsurface. In shallow water-table areas, the effluent percolates rapidly to underlying aquifers. These systems can pollute ground water with the following contaminants:

* iron, manganese and sulfides (anoxic contamination);
* nitrate;
* potentially toxic organic chemicals; and
* bacteria, viruses and parasites (microbiological contamination).

Anoxic contamination causes taste and odor problems, and can stain laundry or porcelain, but it is not known to be hazardous to human health. Nitrate contamination, on the other hand, typically lacks such aesthetic problems, but can cause methemoglobinemia, a rare but potentially serious and sometimes fatal disease affecting infants. Questions have been raised as to whether nitrate can cause cancer in healthy adults. Ground water nitrate levels resulting from household septic tank contamination can be as high as 30 mg/l as N, three times the health standard.

Conditions of severe anoxic and nitrate contamination are mutually exclusive due to differences in the oxidation-reduction potentials of the ground water involved. Organic chemicals and disease-causing microbes, however, can occur in conditions of both anoxic and nitrate contamination.

Many household products, especially cleaners, contain organic chemicals. Trichloroethylene, in particular, is a well-known ground water contaminant released by septic tank discharges.

Microbiological contamination of ground water has caused outbreaks of shigellosis, gastroenteritis, viral hepatitis and paratyphoid fever in other states (Craun, 1984). An investigation of enteric illness in Albuquerque's South Valley, however, did not identify consumption of private well water as a risk factor for these diseases among residents (Gallaher, et al., 1987).

Household septic tanks and cesspools constitute the single largest source of ground water contamination in the state. Widespread nitrate contamination and/or anoxic conditions have been documented in Albuquerque, Belen, Bernalillo, Bosque Farms, Carlsbad, Corrales, Espanola, Hobbs, Los Lunas, Lovington, Santa Fe and Tesuque.

Proper septic-tank maintenance requires that accumulated solids periodically be removed. The disposal of this material, known as septage, is discussed in the point-source section below.

<u>Agriculture</u>

Evapotranspiration (ET) is a process in which water vapor enters the atmosphere either by direct evaporation or by transpiration from living plants. Residual minerals can increase the TDS of shallow ground water and form alkali deposits.

In the Rio Grande valley, for example, irrigation canals have diverted river water for hundreds of years. Percolating irrigation water has caused the shallow water table in many valley areas to rise and be more vulnerable to ET. This problem can be remedied by the construction of drains to lower the water table, as was done in Albuquerque in the 1930s.

Approximately 70 pesticides or pesticide decomposition byproducts have been detected in the nation's ground water (USEPA, 1986a,b). Seventeen such pesticides have contaminated ground water as a result of "normal" application practices (ibid).

Fumigant pesticides, halogenated methanes, ethanes and propanes, are common ground water contaminants in other states, but have not been used heavily in New Mexico. Fumigants are included in routine volatile organics analyses performed on ground water samples, but have not been detected in the several thousands of such analyses that have been conducted to date on New Mexico ground water.

Carbamate pesticides such as aldicarb, carbaryl, carbofuran and methomyl have caused ground water contamination in other states and are used in New Mexico; aldicarb and carbofuran have been used heavily in certain areas. New Mexico recently developed the capability to test for carbamates in water; the Environmental Improvement Division and the N.M. Department of Agriculture are conducting a cooperative reconnaissance program for carbamates in ground water. Heavy application areas located in shallow water-table environments have been identified and the first samples will be collected from shallow existing water wells later this year.

<u>Urban Runoff</u>

Very little monitoring of the ground water quality impacts of urban runoff has been conducted in New Mexico. At one site in Albuquerque, however, several pesticides were detected in both the sediments of a flood-control channel and in shallow ground water adjacent to the channel. The pesticides detected, relatives of DDT and Lindane at low ug/l levels, were accompanied by dissolved petroleum products. It appears that the petroleum hydrocarbons had a mobilizing effect on these normally hydrophobic pesticides due to the cosolvency phenomenon.

POINT SOURCES OF CONTAMINATION

Oil Field Sources

The most common cause of oil-field contamination is the past practice of produced-water disposal to unlined pits. Other causes include leaks of crude petroleum and/or produced water from pipelines and well casings.

Produced waters, often brines, can gravitate to the basal part of a fresh-water aquifer and migrate along a hydraulic gradient different from that of the aquifer. In addition to inorganic contaminants, such as chloride, most produced waters contain aromatic hydrocarbons that also can contaminate ground water. At the present time, 90% of the approximately 300 million barrels of water produced annually in the state is injected into deep wells for the purposes of secondary recovery, pressure maintenance or disposal.

Crude oil and natural gas condensate, if discharged in the liquid phase, will float atop the water table and their water soluble constituents will dissolve into ground water. Oil field contamination has been a more serious problem in southeastern production areas than in those in the northwest. This is due to the larger quantity and generally poorer quality of water produced in the southeast, as well as the relative vulnerability of southeastern aquifers (e.g. the Ogallala).

Refined Petroleum Product Sources

The most common cause of petroleum-product contamination in the state is leaky underground storage tanks (LUSTs). It is estimated that between one tenth and one third of the 14,000 underground storage tanks in the state are leaking. In cases where the cause of leaks has been determined, the following conditions have been identified:

CAUSE	% OF CASES KNOWN
faulty installation	37.3
tank corrosion	33.3
line corrosion	29.4

In addition to ground water contamination, LUSTs can cause explosive hazards when product vapors migrate to basements and utility corridors (see Figure 8).

Other sources of refined petroleum-product contamination include leaks and tank-bottom water discharges from above-ground storage tanks, leaks and hydrostatic test water discharges from pipelines, transportation accidents and waste oil disposal.

Nitrate Sources

Point sources of nitrate contamination include sewage treatment plants, dairies, slaughterhouses, explosives manufacturing or handling facilities, other industrial facilities and septic tanks serving restaurants, mobile home parks, etc. Industrial nitrate contamination, such as from explosives, can result in considerably higher concentrations (e.g. 500 mg/l as N) than those resulting from household septic tanks, which seldom exceed 30 mg/l as N (the health standard is 10 mg/l).

Solvent Sources

Halogenated or aromatic solvents are used by many different industries such as machine shops and electronics firms, and also occur in a variety of household products. The most common solvents being detected in the state's ground water are benzenes and chlorinated methanes, ethanes, ethylenes and propanes.

Metals/Minerals Sources

Contamination by metals and/or minerals is caused by mining and milling and by other industrial activity. Common contaminants include sulfate, TDS, heavy metals, radionuclides and other trace elements.

Ore refining mills produce large quantities of tailings, the raffinate of which typically contains elevated levels of metals/minerals. Due to engineering convenience and economic advantages, tailings impoundments are often located in alluvial valleys close to the mill, frequently causing ground water contamination.

Other Sources

Other point-source contaminants include microbes, oxygen demanding substances, pesticides, explosives and other synthetic organic chemicals.

Some point-sources of contamination may contribute various contaminants to ground water. Landfills and septage disposal are examples of such multi-contaminant sources.

Public Landfills

Concern about the potential for landfills to contaminate ground water has grown in recent years. Very little is known about the composition of wastes buried in landfills in the state. Constituents known to occur in landfill leachate include

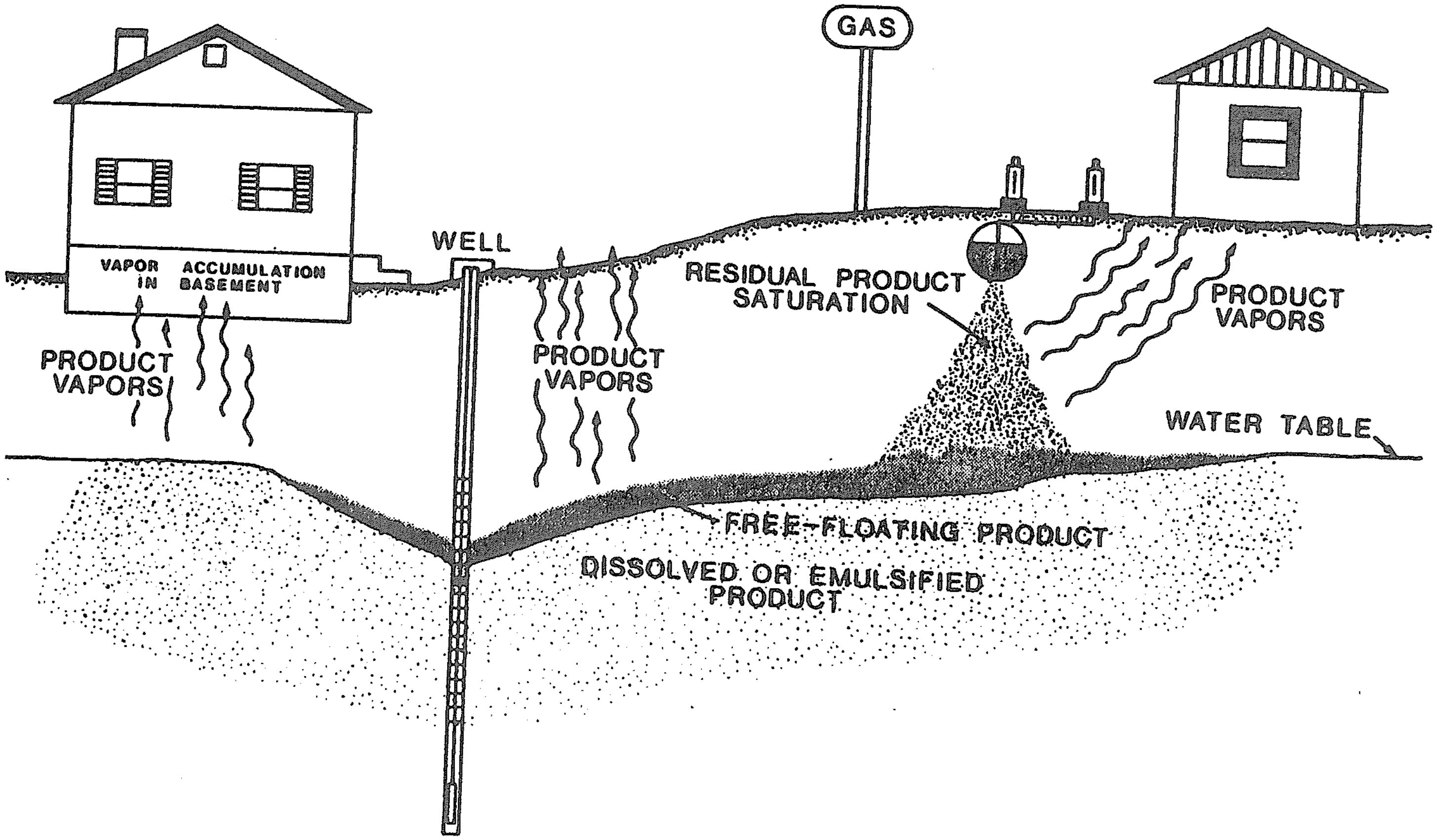

Figure 8. Overview of Underground Petroleum-Product Leakage and Subsurface Impacts

chloride, nitrogen species, solvents and a large number of other organic contaminants.

Household wastes alone contain a large number of leachable constituents. In Oklahoma, for example, more than 40 organic compounds, including phthalates and alkylbenzenes, were detected in ground water contaminated by a landfill that did not receive appreciable amounts of industrial waste (Robertson, et al., 1974). In an Albuquerque survey of household hazardous waste, more than 50% of the wastes identified were disposed of in area landfills, including more than 53,000 gallons of used motor oil per year (Salas, et al., 1983).

Large quantities of septage (solids and liquids pumped from septic tanks periodically) have been discharged to unlined pits at several landfills in the state. The septage in several cases has been comingled with industrial wastes such as produced water, waste petroleum products and chlorinated solvents.

The Environmental Improvement Division is conducting a limited study of the ground water quality impacts of landfills in the state. Ground water contamination has been documented at two landfills thus far.

Septage Disposal

Vacuum truck operators provide a vital service to septic tank owners by periodically removing accumulated solids. However, in many areas of the state, operators do not have a legal and environmentally sound mechanism to dispose of septage. Several septage disposal sites have been found to contain petroleum products, metals, minerals and solvents.

EXAMPLES OF GROUND WATER CONTAMINATION

Many population centers in the state have developed in vulnerable aquifer areas such as the Rio Grande valley (see Figure 2). Additionally, a number of mineral resource development areas also coincide with vulnerable aquifer regions. Not surprisingly, these areas have a high incidence of ground water contamination. The following examples have been selected to illustrate various kinds of problems.

Albuquerque South Valley

(from Gallaher, et al., 1987)

Albuquerque overlies one of the most precious fresh-water aquifers in New Mexico. Several thousand feet of fresh-water saturation reside within the Rio Grande valley fill. This aquifer is the city's sole source of drinking water and is highly vulnerably to contamination in the valley area. While humans have contaminated only a small fraction of ground water, recent trends suggest that the nature and extent of contamination may become more severe in the next decade due to increased industrialization and population growth.

A long history of human activity in a shallow water-table zone has left the Albuquerque valley with ground water contamination dating back to at least 1927. All known cases of ground water contamination in the South Valley are shown in Figure 9.

Two types of contamination exist in this area:

* regional contamination with anoxic conditions and/or elevated salinity and hardness; and

* numerous localized contamination cases involving constituents of health concern such as nitrate, gasoline, chlorinated solvents and pesticides.

Many valley areas were developed originally with private wells and septic systems and were later provided with municipal water and sewer facilities after contamination problems became evident. Septic tank and cesspools are major contributors to the problem of widespread anoxic conditions. Even if remaining areas were sewered immediately, it might take decades for natural purification processes to eliminate the contamination caused thus far. Septic tanks also are responsible for doubling and tripling nitrate levels in two areas west of Coors Boulevard since 1977.

Petroleum products have contaminated ground water in at least 20 sites in the South Valley. A soil gas survey along Isleta Boulevard (see Figure 9) showed evidence of gasoline contamination at 6 of the 17 underground storage tank facilities surveyed.

The San Jose area (see Figure 9) is one of New Mexico's four active Superfund sites. In this shallow water table environment, a city well field was developed in the 1930s. Industrial development (manufacturing industries, petroleum product and chemical handling) began in this area in the 1950s prior to the development of New Mexico's ground water protection program. In 1980, two city wells in this field were shut down after the detection of several chlorinated solvents in the wells. Subsequent investigations have identified multiple sources of contamination.

Historically, ground water contamination in the South Valley has been limited to depths of 100 feet or less below the land surface. It appears, however, that contaminants in the shallow zone are being drawn to greater depths by the pumping of deep wells. At one location, hazardous substances have been found at a depth of 220 feet below the surface. This vertical migration presents a long-term threat to all deep wells located in the valley, including those used by the City of Albuquerque for municipal water supply.

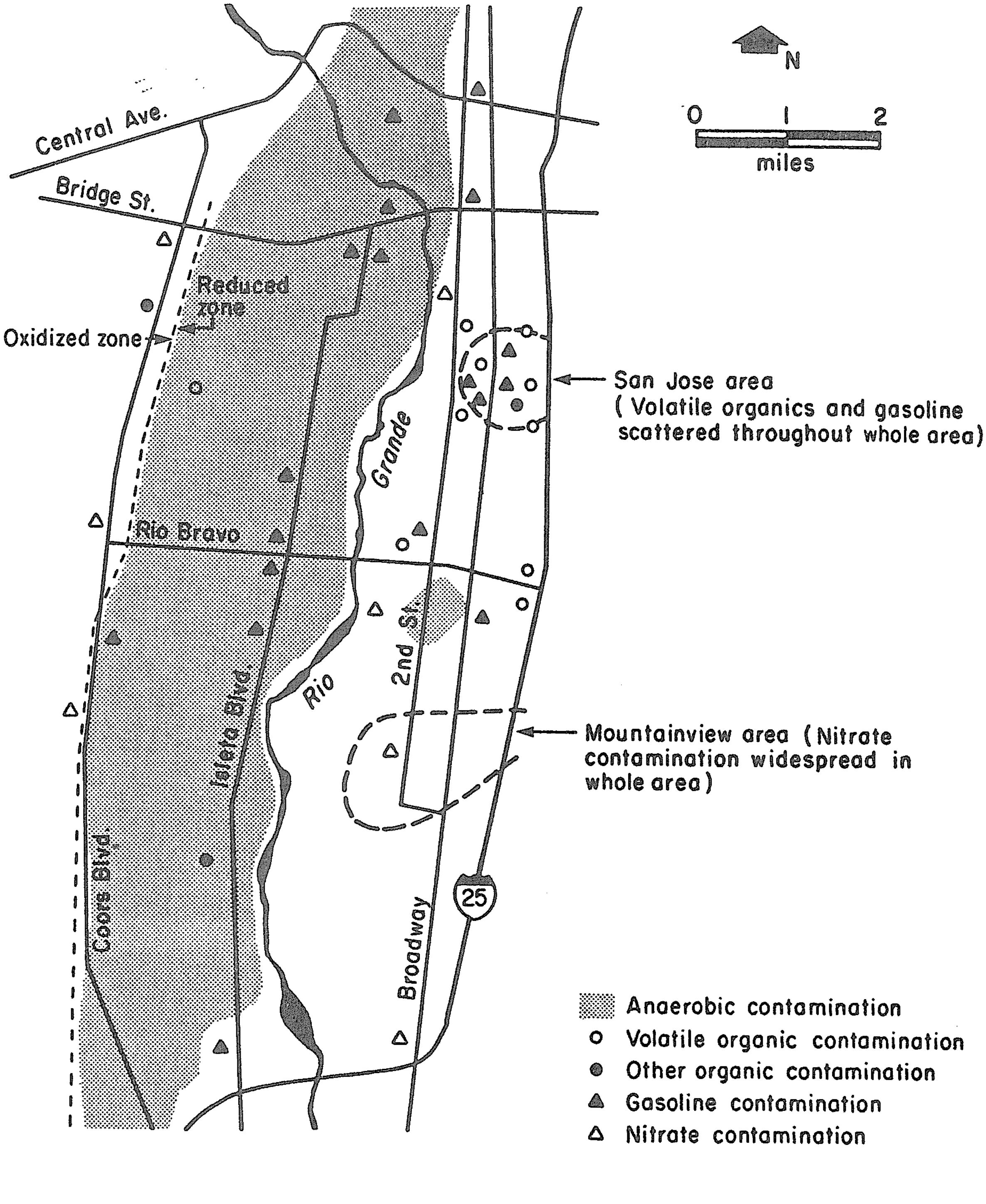

Figure 9. Ground Water Contamination in the Albuquerque South Valley

Espanola Valley

The Espanola area also is located in the Rio Grande valley and is similar in many ways to the Albuquerque valley. Espanola is far less populated and industrialized than Albuquerque, however, and contamination problems are less numerous and less severe.

Nitrate contamination and anoxic conditions have been caused by septic tank discharges in several areas (see Figure 10). Additionally, at lease two cases of LUST gasoline contamination are documented (see Figure 10).

It appears that more serious ground water contamination can be prevented if approriate safeguards are enacted. A number of rural areas, however, are currently undergoing rapid development with private wells and septic tanks upon minimal lot sizes and this may add to ground water contamination problems.

Lea County

The Ogallala Formation, composed of unconsolidated sand and gravel, is the principle fresh-water aquifer in this region. The depth to water ranges from 30 to 250 feet, with a maximum saturated thickness of 200 feet.

Lea County has been a major petroleum-producing area since the early part of this century. Large quantities of saline water are co-produced with the petroleum. The produced brine was commonly discharged to unlined pits prior to the 1960s when this practice was prohibited. Well casing leaks began to be discovered and repaired at least as early as 1934.

Oil-field contamination of fresh ground water resources became evident in the early 1950s (McGuinness, 1963). Cases of known and suspected contamination are shown in Figure 11. Documented contamination mechanisms include discharges to unlined pits and leaks from well casings and pipelines.

Nitrate contamination from septic tanks also has occurred in several areas of Lea County; anoxic conditions resulting from septic tank discharges have not been documented. Additionally, a variety of industrial facilities have contaminated ground water with nitrate, gasoline, waste oil, solvents and other organic contaminants.

Extensive ground water contamination has occurred in Hobbs, the largest city in Lea County (see Figure 12). Oil field contamination with brine, crude oil and natural gas exists in the western and southern areas of the city. In one area, more than 300,000 barrels of crude oil, lost from leaky production well casings, have been recovered from windmills and other shallow wells. Widespread nitrate contamination from septic tanks exists in the residential areas of northern Hobbs. Nitrate contamination also has occurred

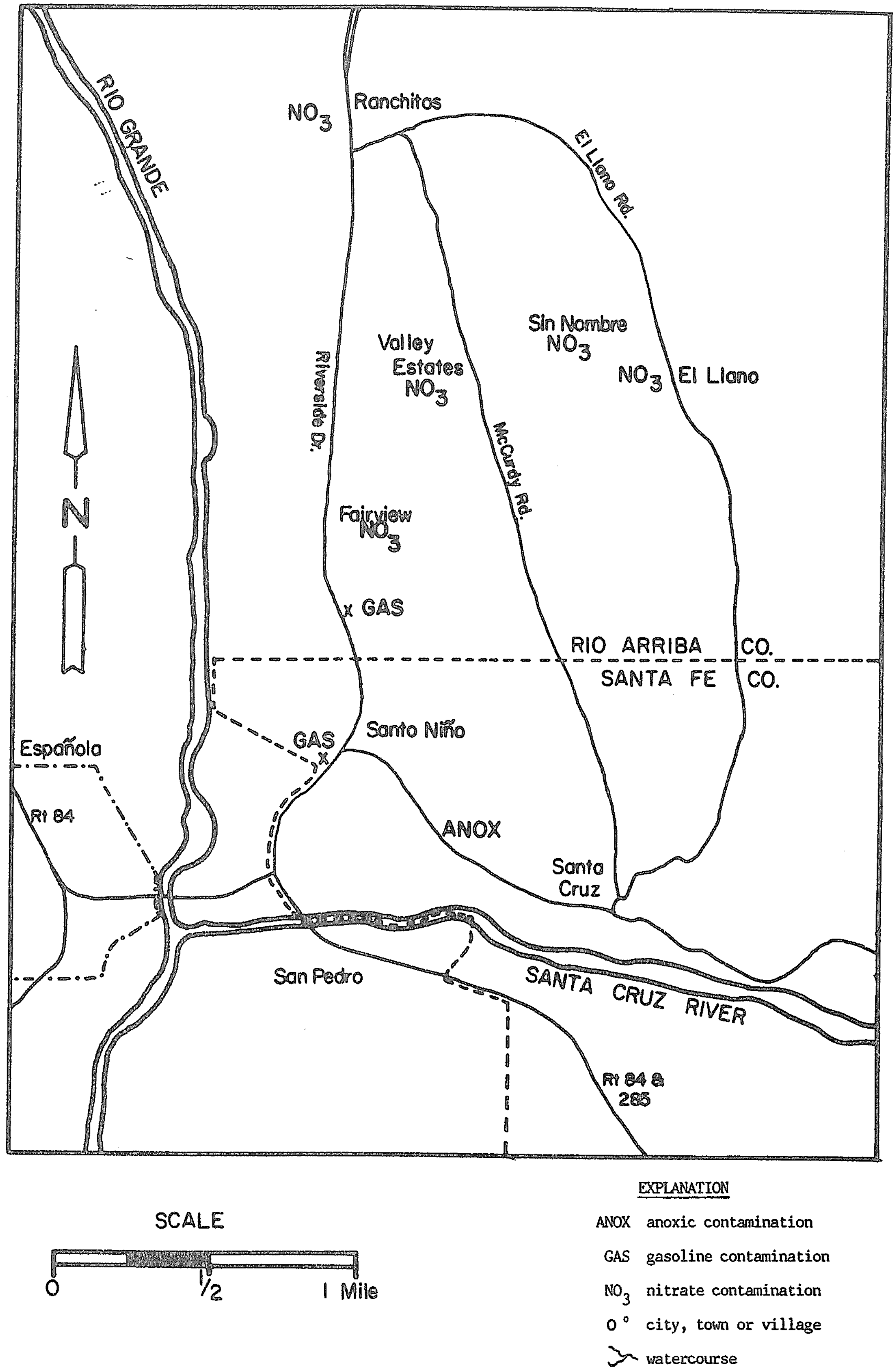

Figure 10. Ground Water Contamination in the Espanola Area

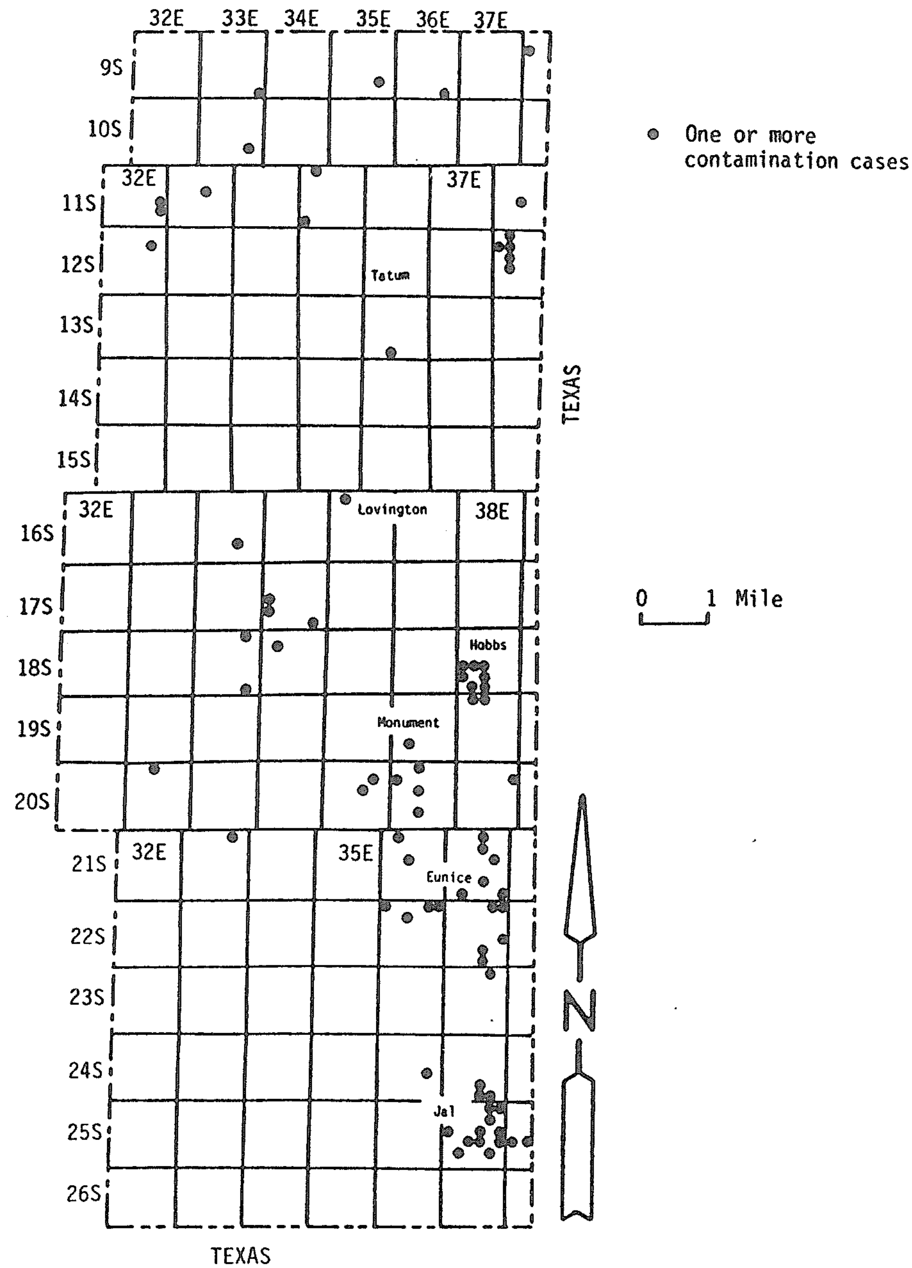

Figure 11. Known and Suspected Ground Water Contamination by Oil Field Activities in Lea County, New Mexico*

*Contaminants include crude oil, natural gas and produced water.

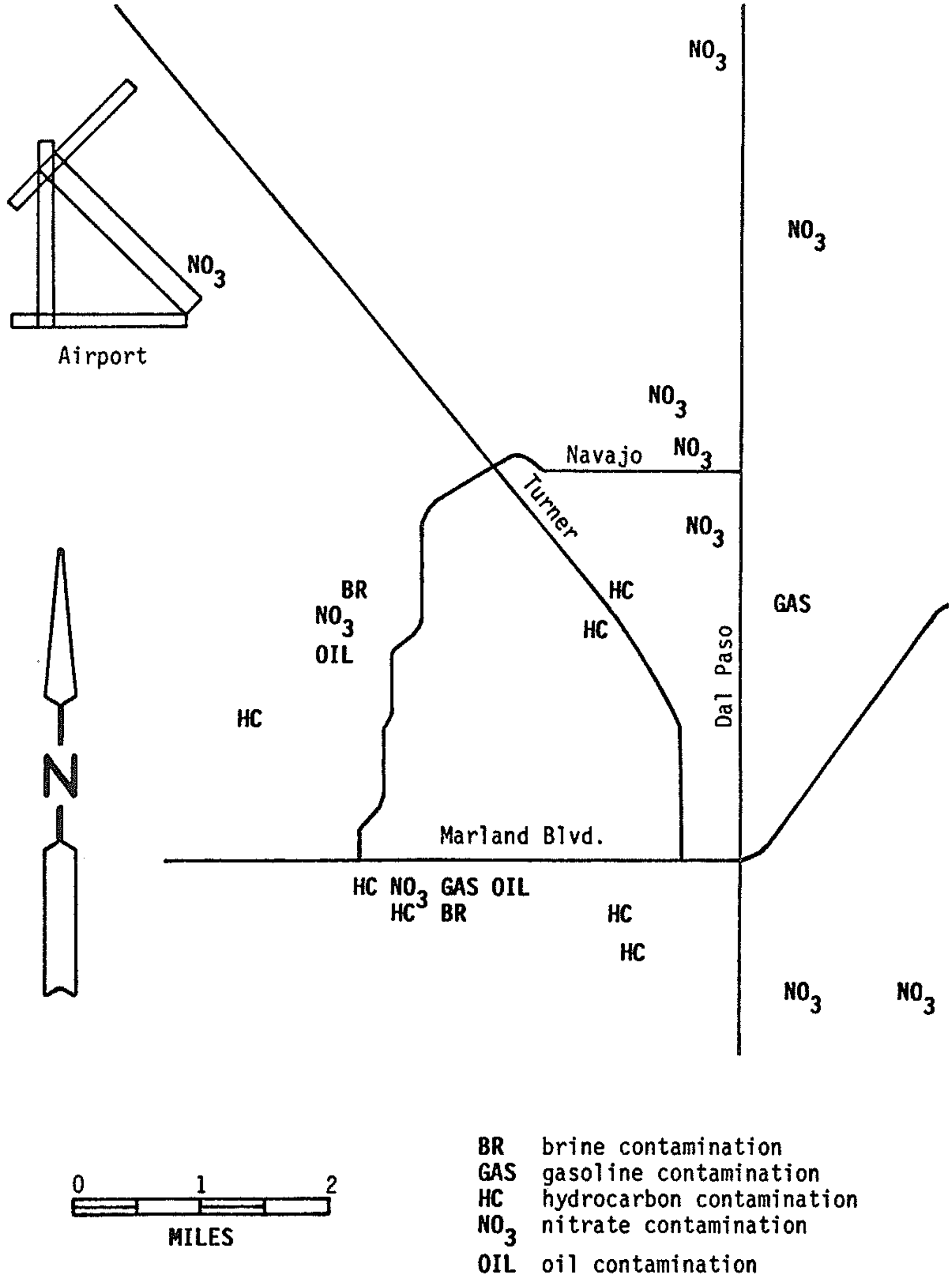

Figure 12. Ground Water Contamination in the Hobbs Area Lea County, New Mexico

at an explosives manufacturing plant, a sewage treatment plant and a slaughter house. Two cases of gasoline contamination, one caused by a LUST, also have been documented.

GROUND WATER POLLUTION CONTROL

New Mexico's authority to protect and maintain ground water quality is discussed in the paper by Maxine S. Goad, *Historical Overview of New Mexico Ground Water Quality Protection Programs.* Additionally, several federal statutes provide ground water protection in the state. These include:

1) the Comprehensive Environmental Response, Compensation and Liability Act (commonly called Superfund);
2) the Resource Conservation and Recovery Act;
3) the Uranium Mill Tailing Radiation Control Act; and
4) the Safe Drinking Water Act.

REMEDIATION OF GROUND WATER POLLUTION

For the purpose of this report, remediation is defined as either:

* removal of polluted ground water for beneficial use or recycling;
* removal of floating hydrocarbons; or
* purification of polluted ground water followed by recharge or diversion.

The above activities have occurred in the past, occur now or are expected to occur in the near future. To date, 68% of these activities are being done under the authority of the N.M. Water Quality Act (see Figure 13) and negotiated settlements that provide for a phased schedule of investigation and mitigation.

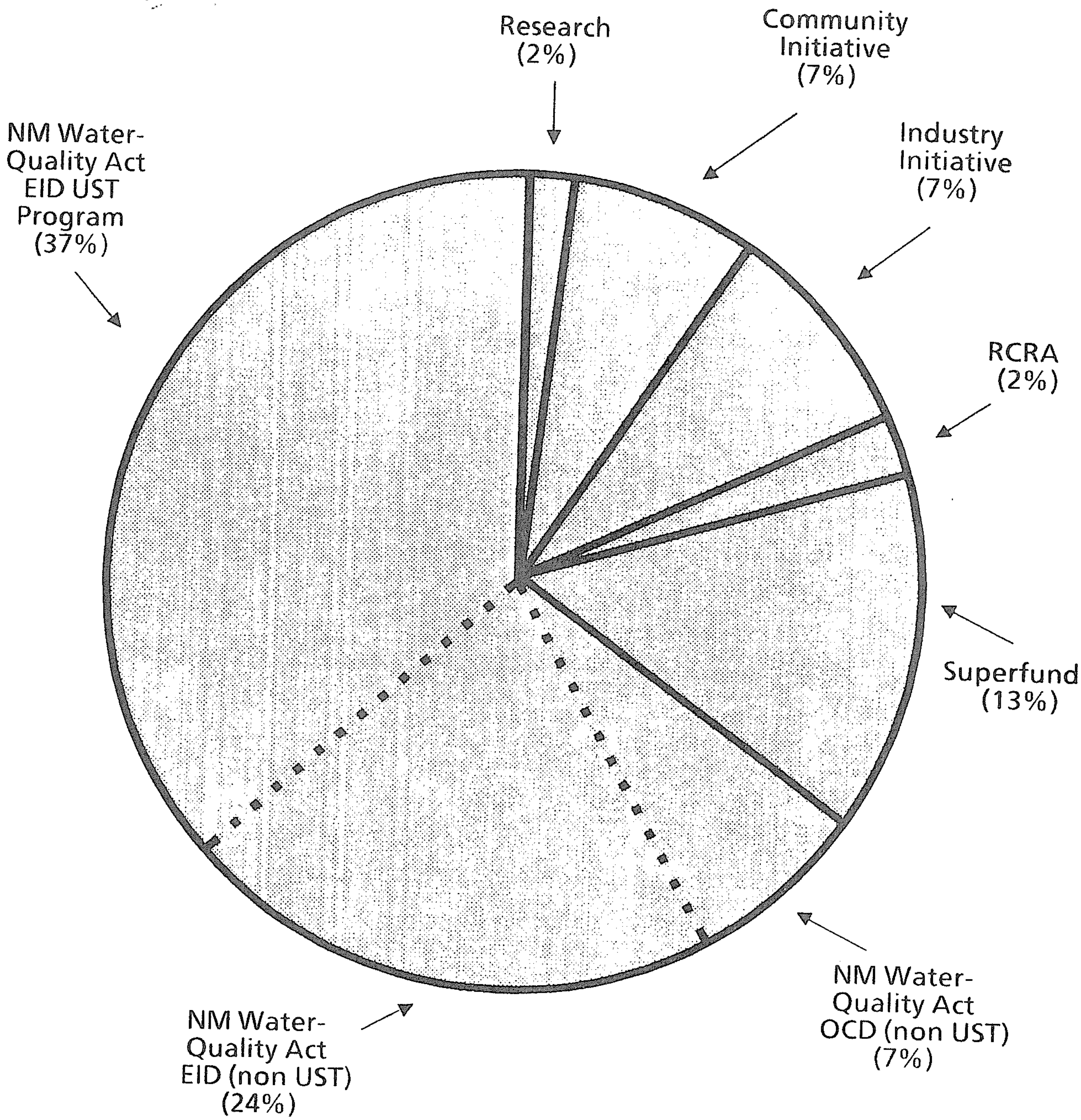

Figure 13. Remediation of Ground Water Contamination: by Regulatory Program or Initiative

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