EXECUTIVE SUMMARY:

Lower Umatilla Basin Groundwater Investigation

A Groundwater Contamination Problem

In the Lower Umatilla Basin, local activities--such as irrigated agriculture, food processing, livestock operations, domestic sewage and military activities--have contributed to the degradation of area groundwater. The Oregon Department of Environmental Quality (DEQ) declared the Lower Umatilla Basin a "Groundwater Management Area" in 1990 when groundwater sampling during the mid-1980s found high nitrate concentrations in local groundwater.

The Oregon Groundwater Protection Act of 1989 requires Groundwater Management Areas to address confirmed contamination with nonpoint sources once the contaminant concentrations reach certain levels. Nitrate levels above 10 mg/L triggered the series of steps outlined by the legislation.

Nitrate concentrations in Lower Umatilla Basin groundwater exceed 10 and 20 milligrams per liter (mg/L) in many areas. These levels are of greatest concern for infants (less than six months of age), who may develop a blood disorder from ingesting excessive nitrates.

Addressing the Contamination

Five state agencies began coordinating a groundwater quality investigation in July 1990. State natural resource agencies, coordinated by the Oregon Strategic Water Management Group, appointed two local committees to review the investigation results and co-develop an Action Plan. A citizen committee and a technical advisory committee appointed to the Lower Umatilla Basin Groundwater Management Area began meeting in February 1991.

Nitrate contamination of groundwater within the Lower Umatilla Basin has been confirmed and investigated by these agencies:

- Oregon Department of Environmental Quality
- Oregon Water Resources Department
- Oregon Health Division
- Oregon Department of Agriculture
- Oregon State University

The investigation's findings, presented in the Investigative Overview and three technical chapters, are designed to assist in decisions that will address the groundwater contamination problem.

The local committees will co-develop an Action Plan for reducing the area-wide groundwater contamination to below 7 mg/L, the current trigger level. The state agencies will also co-develop the Action Plan, which must be approved by the Strategic Water Management Group.

The Action Plan will need to consider a number of complex factors that make the Lower Umatilla Basin's groundwater vulnerable to contamination. Given enough added moisture, basin soils allow contaminants to reach groundwater within months. Once in the groundwater, nitrate moves slowly, possibly taking decades to be discharged from the groundwater system. Clearly, the Action Plan won't be able to address the groundwater contamination with a "quick fix" solution.

A Thorough Investigation

Area of Investigation

The 550-square-mile investigation site is located in northern Morrow and Umatilla Counties between Willow Creek, Cold Springs Reservoir and the Columbia River. Affected communities include Boardman, Echo, Hermiston, Irrigon, Stanfield and Umatilla. Most of the area occupies a plain that gently slopes toward the Columbia River. The semi-arid area receives about 8 to 10 inches of annual precipitation.

Land Uses

A number of activities in the Lower Umatilla Basin have the potential to contribute nitrate to groundwater.

Irrigated agriculture, which has expanded to nearly 180,000 acres, is the dominant land use in the basin. Estimates indicate that irrigated agriculture releases the most nitrogen to the basin's land surface. Other studies conducted in the basin indicate some nitrogen escapes beyond the root zone at some irrigated fields, even under conservative management strategies.

Food processing facilities in the basin have expanded quickly since the 1970s to meet the economic demand for processed foods, particularly potato products. Wastewater management at food processing facilities has undergone successive adjustments to protect groundwater. Nutrient-rich food processing wastewater is land applied. A first, crop needs, acreage and growing seasons received inadequate consideration. Efforts to protect groundwater by better managing wastewater continues.

Animal feeding operations, particularly those with large numbers of animals confined to a small area, have the potential to release nitrogen to groundwater. The amount of animal waste stockpiled, stored and land applied has varied greatly from year to year, with some waste management problems noted.

Domestic sewage sludge and wastewater, when stored in lagoons or disposed of on or beneath the ground, can contribute nitrates to groundwater. Nitrate from domestic sewage is a concern mainly in areas with a high density of on-site systems.

Extensive military activities, involving metals, nitrogen, explosives and chemicals, have occurred over 180 square miles. Cleanup is the current focus of the military sites, with nitrate and other contaminants a concern at the U.S. Army Umatilla Depot.

Landfills and other disposal sites, particularly those without liners, could contribute nitrogen to groundwater. Electricity producers, facilities handling hazardous waste, area accidents or spills and groundwater recharge projects, were investigated and found to contribute little or no nitrogen.

Natural sources of nitrogen were also investigated. Background levels and a federal study support the finding that the natural contribution is very low.

The Scientific Approach

This investigation set out to determine which activities are responsible for the nitrate contamination.

To understand the distribution and source of nitrate contaminated groundwater in the Lower Umatilla Basin, various state agencies and area facilities participated in four types of groundwater sampling.

- Reconnaissance sampling (1990-1991) improved on existing data and dictated additional sampling locations.
- Bimonthly sampling of the same 35 to 40 wells from 1991 to 1994 offered a view of seasonal and long-term trends.
- Synoptic water level measurements and sampling provided basin-wide results for an understanding of groundwater flow paths and nitrate concentrations.
- Nitrogen-isotope sampling verified and improved on nitrate source information gathered in the other sampling.

The sampling results were evaluated through statistics, chemical constituent maps, graphs, computer modeling, and nitrogen isotopic analyses.

Sampling Results

State agencies collected nearly 850 groundwater samples from 252 sites in the Lower Umatilla Basin study area between June 1990 and March 1993. The sampling results for nitrate could almost be divided into thirds, with about 30 percent containing nitrate concentrations exceeding 10 mg/L, 26 percent less than 2 mg/L, and the remainder somewhere between 2 and 10 mg/L.

The groundwater samples were analyzed for a variety of other constituents to help identify contamination sources. A few samples contained agricultural or industrial chemicals. Eighty-five percent of the project's groundwater samples had sodium exceeding 20 mg/L, the concentration at which individuals on a physician-prescribed sodium-restricted diet should notify their doctors.

Graphs showed a basin-wide relationship between nitrate and total dissolved solids (TDS). Analysis indicate multiple land uses affect groundwater throughout the basin.

Evaluating chemical constituent relationships helped distinguish between potential sources. For example, the influence of septic systems could be distinguished from other potential sources based on potassium-bromide-chloride relationships, while food processors may be distinguished based on magnesium and bromide.

The Role of Geology

In the Lower Umatilla Basin, basalt lavas have been folded into a prominent trough between Arlington and Hermiston. Up to 250 feet of alluvial sediments have been deposited in this trough, mostly by catastrophic floods that swept down the Columbia River during the ice age.

The alluvial aquifer and the two or three upper basalt aquifers serve as the main sources of drinking water. The cities of Hermiston, Irrigon and Boardman draw water from the alluvial aquifer. Irrigation water is pumped from both the alluvial aquifer and the deeper basalt aquifers.

Soils in the alluvial aquifers allow rapid downward movement from excess water on land. Recharge to the alluvial aquifer comes primarily from canals, streams and reservoirs, with some deep percolation of irrigation water (varying with the irrigation practices) and very little from precipitation.

The aquifers generally discharge to the Umatilla and Columbia Rivers. Water in the alluvial and shallow basalt aquifers seem to be connected, based upon hydrogeological and groundwater chemistry evidence. Inadequate well construction allows additional mixing of alluvial and basalt groundwater.

Average groundwater flow velocities in the basin range from 0.0001 miles per year in silts to 0.5 miles per year in sands and gravels. Well pumping and recharge from surface water can affect groundwater movement, altering both the speed and the direction of the flow.

Travel time to groundwater appears short: one to eighteen months with sufficient moisture. The longer travel times were found mostly at sites with fine sediments and wells exceeding 100 feet in depth. Peak nitrate concentrations in the area generally occur from September through June. This possibly represents travel times to groundwater or deep percolation during the non-growing season. The influence of less moisture, crop uptake and evaporation may inhibit deep percolation during the summer months.

Nitrate Sources

Data analysis indicates no single source is responsible for the nitrate contamination in the basin. Nitrate can be attributed to commercial fertilizers, land application of food processing waste water, livestock waste, and lagoons at the U.S. Army Depot. Septic systems were found to influence nitrate in groundwater at lower concentrations, with some exceptions. Natural nitrogen sources are considered small.

This project identified nitrate contamination sources by considering groundwater chemistry, contamination distribution, land use activity distribution and estimated nitrogen use by each local land activity.

Threemile and Sixmile Canyon

This area yielded the highest total dissolved solids levels in the project samples and reported nitrate levels reached 70 mg/L. Analyses identify livestock waste and irrigated agriculture as sources of nitrate contamination. The source of nitrate at PGE's Ash Disposal area, while not from PGE activities, has not been resolved.

Boardman to West Umatilla

The highest nitrate concentrations in project samples came from this area. Project sampling detected nitrate exceeding 70 mg/L in the irrigated crop area between Irrigon and the Port of Morrow. The U.S. Army Depot reported nitrate exceeding 100 mg/L at several sites.

The Depot's explosive washout lagoon area caused the high nitrate concentrations in that area. A Depot source appears responsible for elevated nitrate in the Depot's active landfill area. Nitrate south of the Depot was linked to animal waste and crop irrigation. Nitrate along the west boundary of the Depot was linked to irrigated agriculture. Nitrate north of the Depot appears related to irrigation activity and septic systems.

High nitrates found in groundwater from alluvial and basalt wells south of Boardman are related to irrigated agriculture, livestock waste and septic systems. Nitrate concentrations exceeding 10 mg/L in alluvial groundwater at the Port of Morrow's and Lamb Weston's wastewater land application sites relates to these activities.

Butter Creek to Umatilla

Reported nitrate concentrations reached as high as 100 mg/L in this area. Peak elevated nitrate concentrations were found at the confluence of Butter Creek and the Umatilla River. Past food processing wastewater practices are responsible for elevated nitrates at land application sites. Septic systems affect the groundwater west of the Umatilla River and north of Interstate 84. Livestock and irrigated agriculture also contribute to the elevated nitrate concentrations.

Umatilla to Hat Rock and Echo Meadows Area

Nitrate concentrations did not exceed 31 mg/L and were below 10 mg/L in the Hermiston, Echo, Umatilla Meadows and Hat Rock areas. Nitrate levels for Hermiston's numerous unsewered homes were below 5 mg/L, possibly because of significant canal dilution.

Developing A Solution

Widespread groundwater contamination exists in the Lower Umatilla Basin. Groundwater supplies drinking water to the communities of Boardman, Hermiston, Irrigon, Stanfield, Echo and Umatilla and many rural residents.

Groundwater contamination occurs when water (or another liquid) and nitrate (or another contaminant) exceed what can be removed by vegetation or evaporation. Soil capacity is a factor in preventing deep percolation. Lower Umatilla Basin soils allow nitrate to migrate to groundwater when excess water is available to transport the contaminants.

A wide range of activities introduce water and nutrients to the basin's land surface. The Lower Umatilla Basin Groundwater Management Area Citizen and Technical Committees have the opportunity to address the nitrate sources through the Action Plan.

Steps have already been taken toward preventing nitrate contamination. Some irrigated crop fields already time water and nitrogen application to crop needs.

Food processors have gradually improved their land application techniques for wastewater. The Action Plan can consider if those efforts are sufficient.

Past practices may continue to contribute nitrate to groundwater if too much nitrate is stored in the vadose zone (the zone between groundwater and the land surface). This investigation did not thoroughly explore nitrate in the vadose zone. The committees will need to address the evaluation of different activities for their nitrate contribution to the vadose zone.

The Action Plan may also need to address land uses changes within the Lower Umatilla Basin. For example, septic systems could become a more significant source of nitrate if canal water is no longer available to dilute groundwater in high density areas of individual on-site systems.

Groundwater protection will benefit all Lower Umatilla Basin residents. The challenge lies in coordinating change among diverse land uses for long-term results.