TESTIMONY REGARDING THE ADOPTION OF RULES REGARDING THE CHIHUAHUAN DESERT AREA.

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I. QUALIFICATION OF THE WITNESS

I received a doctorate in low-temperature physics from the University of Wisconsin in 1964. From 1968 to 1993, I was employed at the Los Alamos National Laboratory (LANL) where I conducted research in thermal physics and thermal engineering. During my last three years at LANL, I conducted research on contaminant migration and vapor extraction for the remediation of contaminated soils. I also managed a RCRA Facility Investigation of disposal sites containing radioactive and hazardous wastes, including subsurface plumes of organic vapors and tritium. Since retiring from LANL in 1993, I continue research and consulting on air motion in the vadose zone and its effect on the transport of volatile organic compounds. I also serve as a public interest representative on the national governing board of State Review of Oil and Natural Gas Environmental Regulations (STRONGER), a nonprofit corporation funded by the federal government and industry to assist states in improving their regulatory programs.

II. BACKGROUND OF THE ORGANIZATION

The New Mexico Citizens for Clean Air & Water, Inc. was founded in the late 1960's in response to air pollution from the Four Corners power plant and potential pollution from a pulp mill. The organization has continued to address pollution from smelters, regional haze, gravel mining in the Rio Grande, mine tailings, air and water quality standards, and, more recently, petroleum issues. Our activity often involves technical review of industrial and environmental processes.

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III. PRESENTATION OF CONCERNS

We appreciate this effort by OCD to improve the environmental protection during petroleum exploration and production (E&P) in the desert area. In its statements and actions, OCD's environmental effort is often focused on "protectable water," namely ground water and surface water. Our concern is also with the landscape, and with the pore water in the soil, upon which plant life and the ecology of the landscape depend. We encourage attention to the second Department goal, which does not focus exclusively on water:

> *"to protect the environment and ensure responsible reclamation of the land and resources affected by mineral extraction ... ."*

Our presentation today is concerned with three impacts of E&P activities: 1) land disturbance; 2) burial of wastes; and 3) salt releases. The proposed new regulations address each of these three concerns to some degree.

1. LAND DISTURBANCE

The proposed rule would prohibit pits, which contribute to the large land disturbance. **Photo 1** and **Photo 2** show part of the large land disturbance associated with one well site. The land was bladed to the level of what is apparently a native clay. Reportedly, the reserve pit was in the middle of this area. **Photo 3** shows a person standing in an erosion gully that originates behind the camera, in the vicinity of the filled pit. In effect, the pad is slowly washing into the adjacent arroyo. It is clear that this land cannot recover from the disturbance. Furthermore, it appears that the erosion will breach the pit in a few years. We therefore support a prohibition on pits, but we would prefer also to prohibit this size of disturbance to the land. It is not any one drill site that concerns us; rather, it is the fact that tens of thousands of sites can exist in one county.

Photo 4 shows a small segment of the white clay berm around a large evaporation pit. The berm apparently covers more ground area than the pit itself. Storm water runoff is eroding the berm. The runoff gathers in a ditch at the bottom of the berm, from which it is discharged in a concentrated stream, eroding a gully below the pit. The operator made several attempts to rectify the gully by pushing dirt and logs into dikes, as shown in the bottom of **Photo 4** . However, the dikes were obviously breached by a rainstorm. Windblown salt spray has killed vegetation around the pit. In the arid San Juan basin, this growing insult to the landscape is unlikely to heal; it would probably never heal in the desert area. **Photo 5** provides a view of a larger portion of the berm and the downstream area. **Photos 1-5** illustrate why we feel a prohibition on pits is appropriate in arid and desert regions, where the landscape does not easily recover from disturbance.

2. BURIAL OF WASTES

It is the practice in New Mexico to bury wastes in pits. NMCCA&W supports the proposed prohibition of pits, in part because it would reduce the practice of on-site disposal of wastes. The petroleum industry is allowed to dump its wastes on site because the industry enjoys a unique exemption from the waste-handling requirements of RCRA, requirements which apply to almost all other industries. Indiscriminate on-site burial stretches the credibility of that exemption. We do not object to burial of harmless minerals, particularly if those minerals originate on site. We do object to the burial of salts, toxic chemicals, and petroleum. Although it may be argued that petroleum is never placed in unlined pits or buried, **Photo 6** shows a small unlined pit that accepts overflow or blowdown, possibly from the tank behind the pit. The pit obviously serves to collect petroleum.

A. Migration of wastes from pits.

Soluble materials left in closed pits will eventually migrate, even if the pits are lined. Polymer liners have finite lifetimes and are often destroyed when pits are closed. Clay liners can develop fractures or channels when drying. In Texas, the industry argued against a requirement to maintain liner integrity at pit closure, thus indicating the industry's opinion of maintaining liner integrity. Thus, because liners degrade and because integrity cannot be guaranteed as a pit is closed, the contents of a closed pit will not be reliably retained by a liner. Some people believe a clay cap will prevent percolation of rainfall into a closed pit, and thereby assure that buried contaminants will not migrate. However, soluble contaminants do not require that the soil be saturated with water in order to move. Unsaturated transport can occur in any direction, up, down, or sideways. For example, so-called alkali pans are often areas where soil moisture has moved upward to evaporate at ground surface, where it leaves its dissolved minerals. Thus, even though a closed pit may be capped with clay to retard the infiltration of rainwater, contaminants in that pit are likely to move upward or outward in time.

To understand how wastes can migrate from closed pits, it is necessary to understand a little unsaturated hydrology. This discussion is somewhat repetitious of my testimony presented at the hearing of November 13, 2003, regarding pits. It is necessary to place this information also in the record of this hearing, because the decision must be based on evidence of record.

B. Unsaturated hydrology.

Most of us think of environmental water as either ground water or surface water. However, almost all non-aquatic life, including soil bacteria and plants, depends directly or indirectly on water in the pores of the vadose (unsaturated) zone. I will therefore present a short review of water motion and contaminant transport in the unsaturated zone.

Fig. 1 presents an example of the moisture content as measured in dry porous rock. Borehole 1009 was drilled beneath asphalt pavement, which covered and extended beyond a closed evaporation pit. Some 10 or 15 years after the evaporation pit was closed and the surrounding area covered by asphalt, the influence of either the pit or the asphalt can be seen to a depth of 100 ft. I point out that a pit can influence the subsurface to a depth exceeding 100 feet, because OCD's risk ranking criteria officially regard the threat of a release to the environment as zero if the depth to ground water is greater than 100 feet. The OCD ranking criteria are reproduced in the table below. Saturated flow occurs in preferential channels, fractures, or so-called "fast paths." I suspect the moisture profile of Figure 1 illustrates the moisture that remains in the porosity of the rock, more than a decade after the "fast paths" had ceased delivering their flow to even greater depths.

Ranking criteria to determine threat to the environment (OCD)

Depth to ground water (ft)	Ranking score
<50	20
50-100	10
>100	0

Suction. Why doesn't the pore water illustrated in **Fig. 1** simply drain away rapidly? Water in unsaturated ground is held in suction by capillary forces, like water in a sponge, as illustrated in **Fig. 2**. Suction means one must expend energy to force the water out of the porosity of the soil. Technically, *suction* is the energy per unit volume required to extract the water. Suction is expressed in units of pressure, or equivalently, as the negative height (head) of a hypothetical column of water that would generate a pressure of that magnitude.

Potential. Water below the surface of the ground has a *negative* potential energy--that is, one must expend energy to lift the water to ground surface. The total *potential* at any depth in the ground is the energy required to extract a unit volume of water from the pores of the soil, and to lift it to ground surface. Potential is expressed as a negative pressure or negative head, like suction. Water moves toward lower (more negative) potential. In other terms, water in the vadose zone moves according to the combined forces of suction and gravity. The left half of **Fig. 3** presents suction and moisture content versus depth at a particular borehole. The graph of potential shown on the right half of **Fig. 3** indicates that the pore water above a depth of 60 feet is moving downward toward lower potential. However, in most of the region between 60 and 90 ft of depth, water is moving *upward* toward lower potential. In this region, suction is pulling upward more than gravity is pulling downward.

Why does this science matter? In arid regions, most of the precipitation that soaks into the ground is returned to the surface by unsaturated flow and by plants, where it evaporates or transpires to the atmosphere. Unsaturated flow can bring soluble contaminants to the root zone and to the surface. The few measurements that have been made in desert areas suggest that in many areas water is moving consistently upward from an ancient aquifer to ground surface. Thus, soluble wastes buried in shallow pits can and will migrate to the surface and to the surrounding soil. The transport rate is just a matter of time and weather. We are therefore generally opposed to the burial of wastes in closed pits.

3. SALT RELEASES

Salt, particularly sodium chloride, is a cumulative poison to the soil. Although most of a salt spill in a moist climate might be washed to a river and thence to the sea, in a dry climate the sodium may replace calcium in the clay particles of the soil. This causes the soil to lose flocculence (or chunkiness), resulting in "sodic" soil that has the consistency of talcum powder, and that cannot hold moisture. NMCCA&W investigated the effects of road salting, using neutron activation analysis to prove that salt was the cause of tree death in Los Alamos. This, coupled with our review of the effects of road salting in other states, leads to our concern with burial of salt in pits and releases of produced water. Salt, buried or released in the desert area, could have a devastating effect on vegetation and wildlife.

IV. DISCUSSION OF THE PROPOSED RULE

We support the proposed prohibition of pits. We wish OCD could also address the extent of roads, size of pads, and the restoration of disturbed land. These disturbances cause impacts on the local environment.

In the San Juan basin, I have seen numerous above-ground small open tanks that are covered with a steel mesh. Although the rules require covers only for tanks with diameter larger than 16 feet, the covers on these smaller tanks exemplify good practice by the operators. I would like for OCD to require that *all* tanks are so covered, especially in the desert area.

The proposed rule specifies extra conditions on casing for injection wells. We support added protection for injection wells, but we are not able to comment on the technical adequacy of the proposed casings. We note that contamination from an injection well might reach an aquifer, not from the casing, but through fractures leading from the pressurized region in the disposal stratum. We suggest that each disposal well be evaluated for its potential to induce a fracture into an overlying aquifer. In particular, it would seem unwise to allow disposal wells in a karst formation.

The proposed rule specifies that produced water lines "*not laid adjacent to existing or constructed roads*" shall have double-wall pipe. This is not quite adequate. A leak from a buried salt water line could remain undetected for years, just as leaks from many underground fuel lines have released 100,000-gallon quantities of fuel before the leaks were accidentally detected. Therefore, we suggest that *all* produced water lines have double-wall pipe unless the line is above ground, visible along its entire length, and adjacent to a road.

The proposed rule specifies that all tanks be placed on an impermeable pad with impermeable secondary containment. We suggest that any underground lines that penetrate the containment should be sealed to that impermeable containment, much as, for example, the surface of a roof on a house is sealed to a vent or a chimney.. The purpose of such a seal is to prevent a leak in the secondary containment at the penetration. **Photo 7** shows a tank at which a continuous trickle from a leaking fitting simply follows the outer surface of the pipe down into the ground, within the containment berm. If the pipe were sealed to an impermeable secondary containment, this slow leak would be captured.

Photo 1. View of a drill pad, looking West.

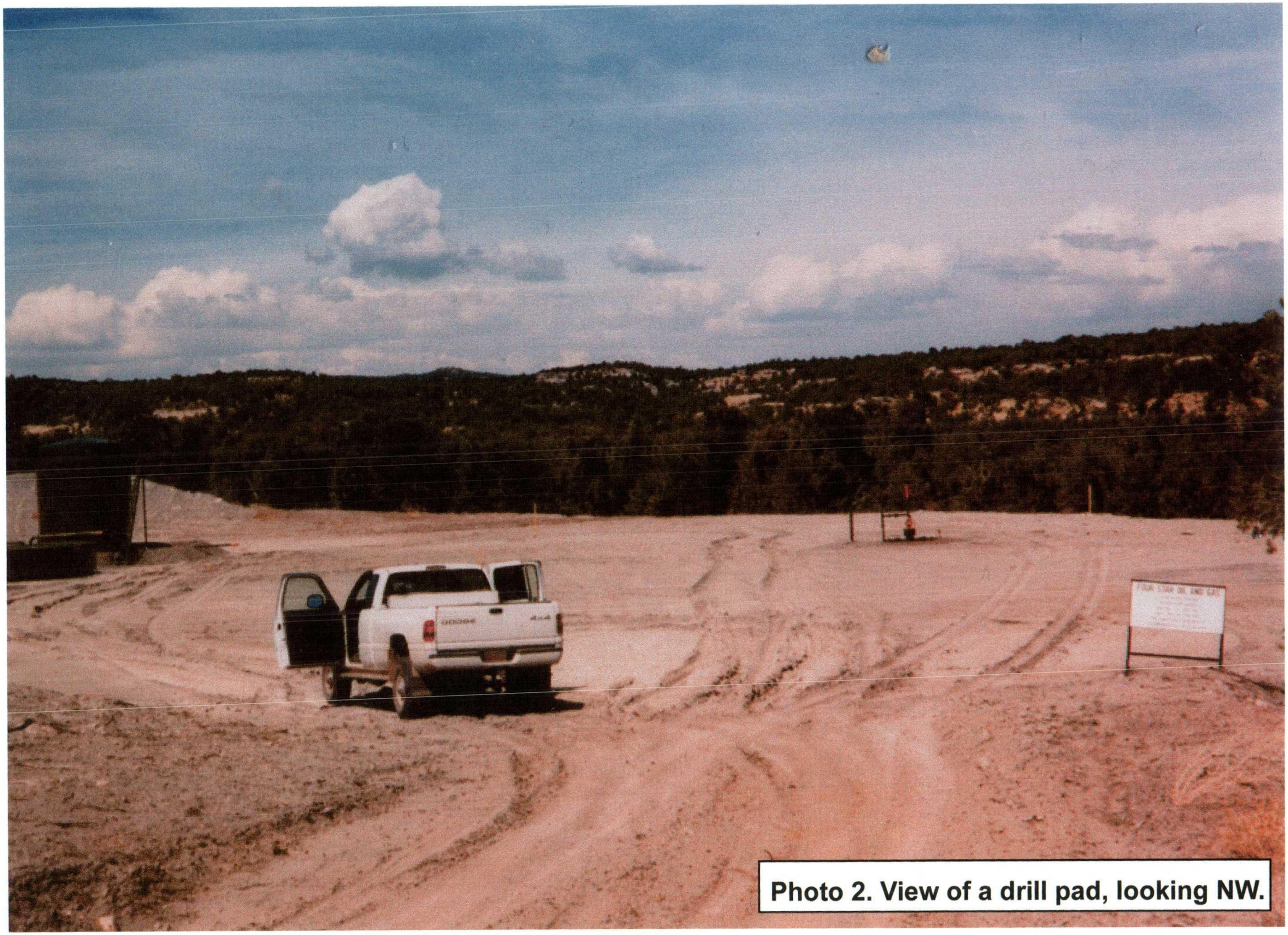


Photo 2. View of a drill pad, looking NW.

Photo 3. Erosion channel in drill pad. Note person.

Photo 4. Eroding white berm around large evaporation pit.

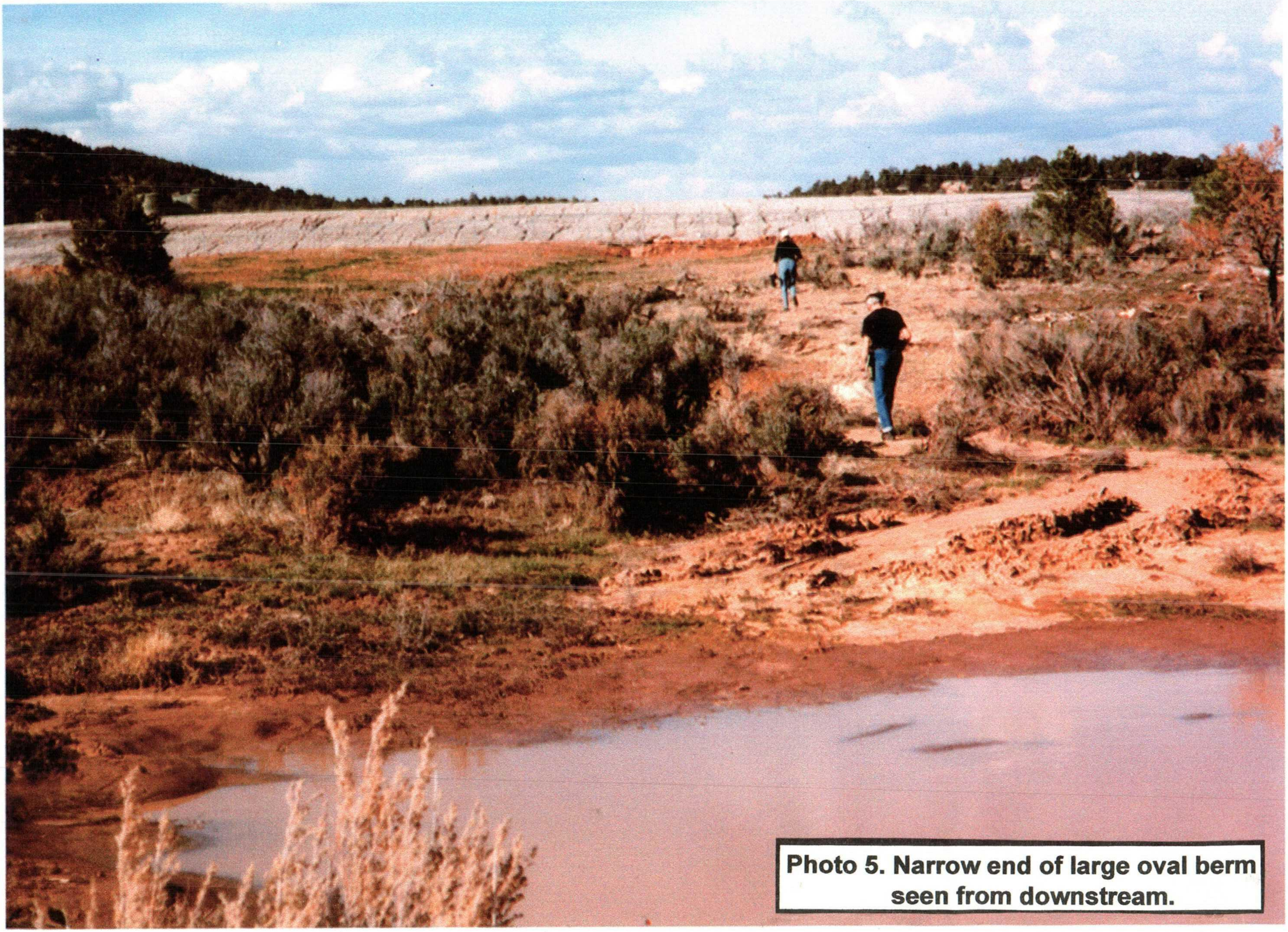
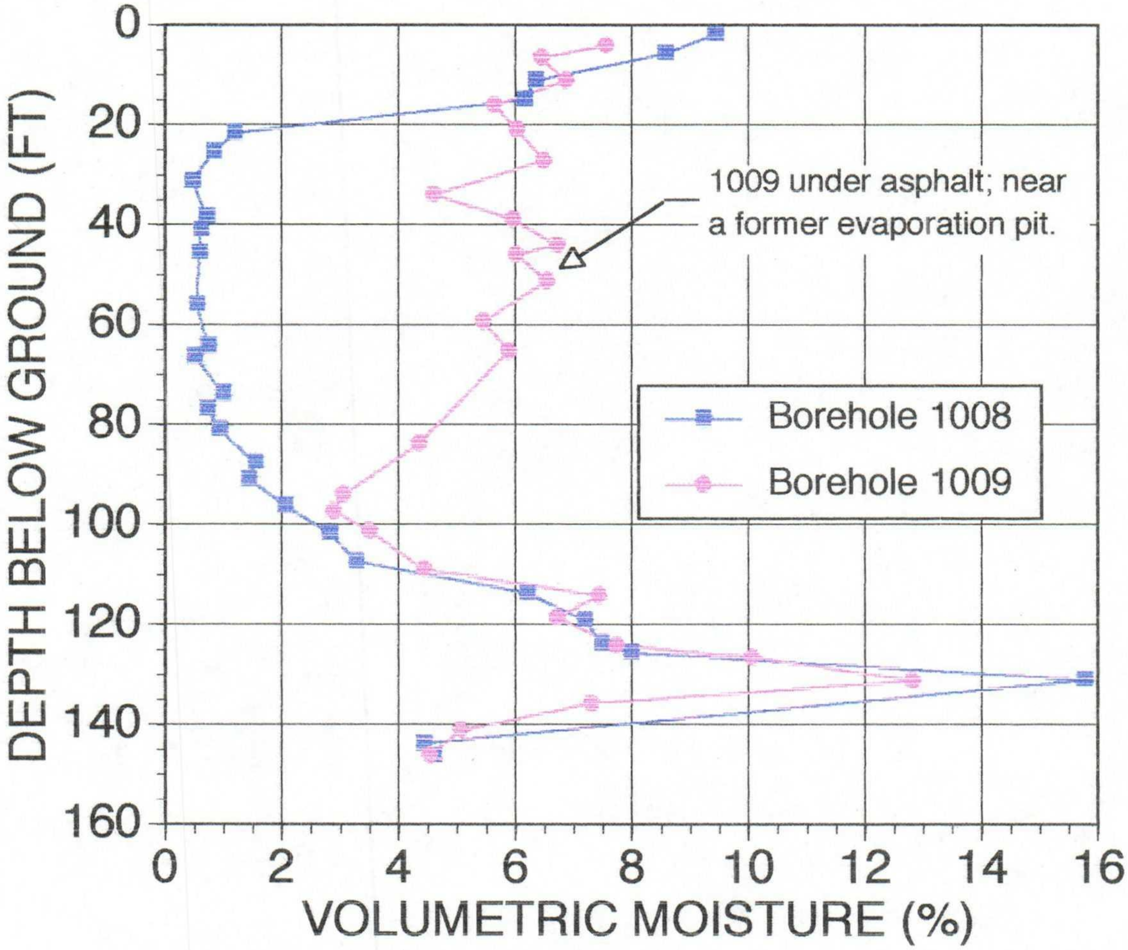


Photo 5. Narrow end of large oval berm seen from downstream.

Photo 6. Small unlined pit containing petroleum wastes.



Neeper & Gilkeson, 1996

Fig. 1. Volumetric moisture as a function of depth in dry porous tuff. Porosity is approximately 50%.

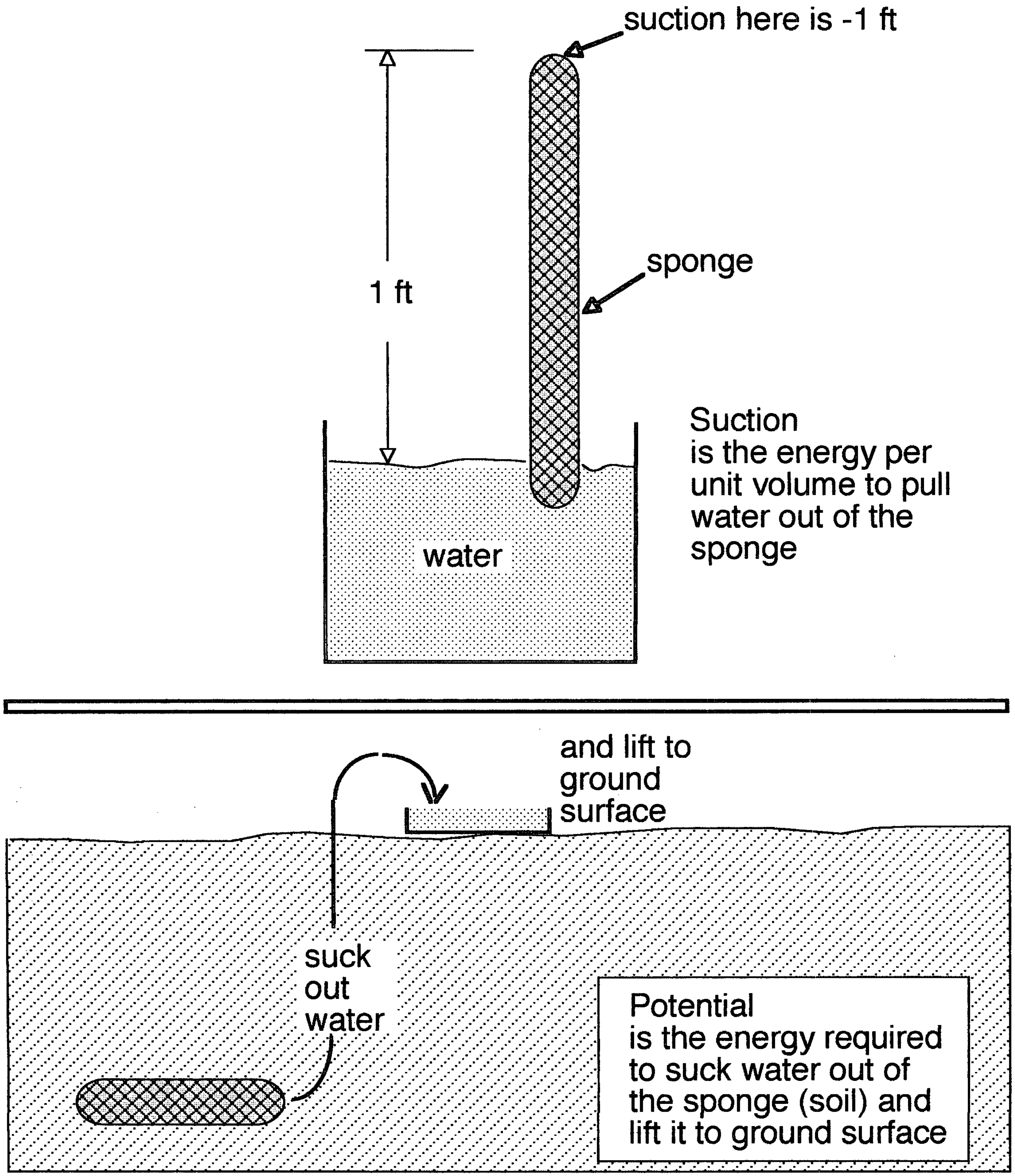


Fig. 2. Schematic diagrams of suction and potential.

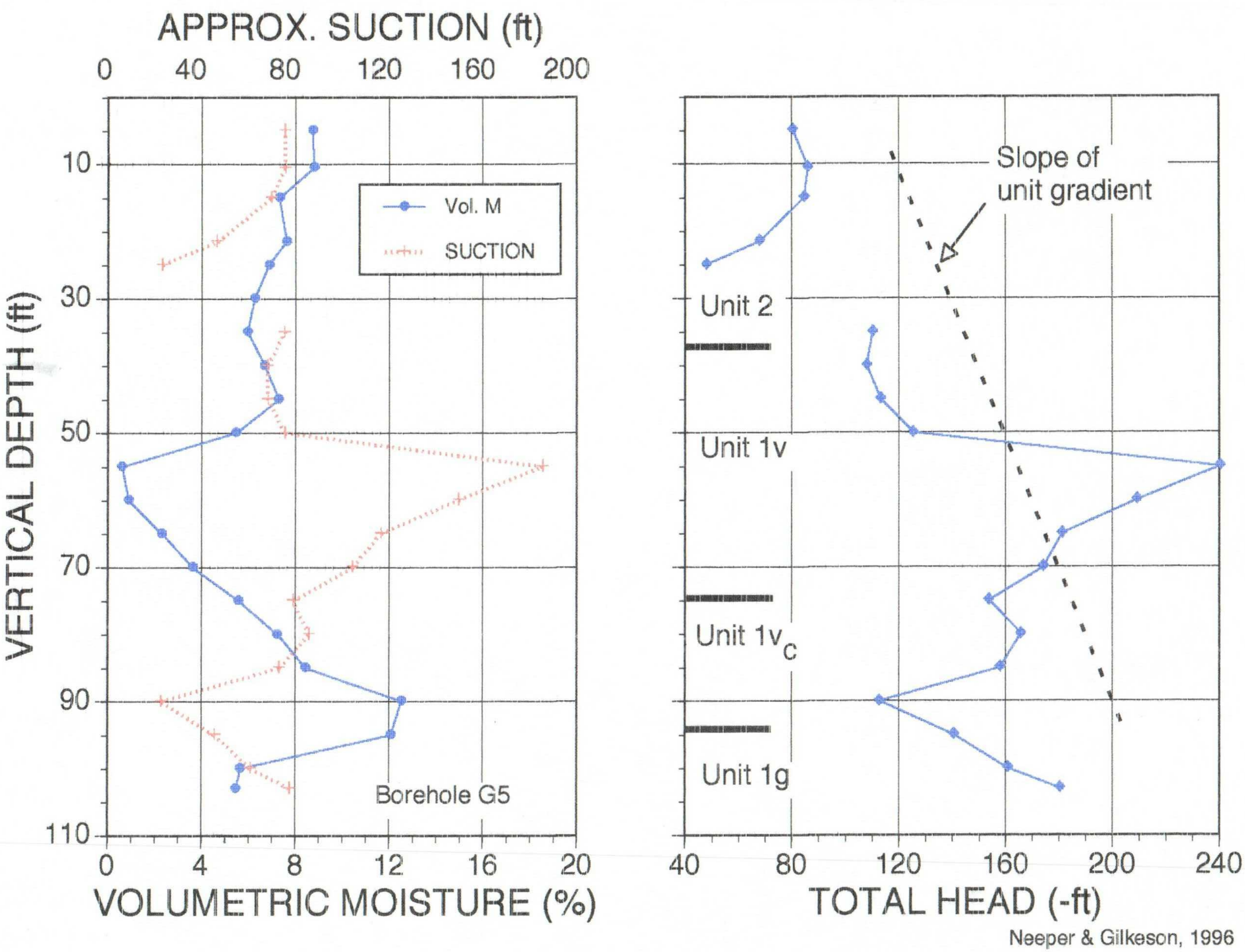


Fig. 3. Measured moisture, suction, and potential in a borehole.

Photo 7. Leaking pipe at a well site.