Performance of a Mixed-Waste Landfill Amid Geologic Uncertainty—Learning from a Case Study: Altamont Hills, California, U.S.A.

MICHAEL J. TAFFET and ALBERT L. LAMARRE
Lawrence Livermore National Laboratory
Environmental Restoration Division
Box 808, L-528
Livermore, California 94551, U.S.A.

JUNE A. OBERDORFER
Department of Geology
San Jose State University
San Jose, California 95133, U.S.A.

ABSTRACT / This paper presents a case study that illustrates how geologic factors, which are not always obvious without extensive study, may hamper later landfill performance. The site is Lawrence Livermore National Laboratory (LLNL) site 300. Two unlined landfills, opened in 1958, and 1968, contain small amounts of tritium, uranium-238, lead, and beryllium in a vast proportion of inert materials (gravel, wood, and plastic). Groundwater analyses indicate that tritium at activities up to 600,000 picoCuries per liter (pCi/l) is present in two plumes beneath and adjacent to the landfills within a perched water-bearing zone.

The affected water-bearing zone averages 2 m in thickness and occurs within the late Miocene Neroly Formation, which is composed of feldspathic sandstones and siltstones and interbedded claystones and conglomerates. Scanning electron microscopy (SEM) analysis indicates that diagenetic clays have occluded the porosity of much of the sandstones. However, abundant fractures appear to provide permeability.

Depth to the water table fluctuates greatly beneath the site but averages about 10 m. In the past, following heavy rains, groundwater levels rose into the landfill bottoms and mobilized the tritium. Rapid recharge and rise of water levels appear to have been enhanced by the funnelling of surface water by topography, direct infiltration through fractures and permeable landfill materials, and the low permeability of the geologic materials that comprise the water-bearing zone. These and other hydrogeologic conditions contributed to groundwater contact with landfill materials but were not known before landfill construction. Such information is important for siting landfills in the current regulatory environment. Contaminant transport modeling indicates that even if the perched water-bearing zone were continuous to the site 300 boundary, tritium activities would undergo radioactive decay to background levels by the time the tritiated water could reach the site boundary.

Introduction

Geologic factors that are often not obvious may have a profound effect on the integrity of a landfill; in the past these factors have rarely been considered prior to the siting of landfills. In this paper we present a case study that illustrates how waste constituents can be mobilized from landfills, and what hydrogeologic information was collected after an observed release of tritium to groundwater to determine how the geology and hydrology of the site influenced poor landfill performance.

LLNL site 300 is located in the Altamont Hills of the northern California Coast Range, about 105 km southeast of San Francisco between the towns of Livermore and Tracy (Fig. 1). The climate is moderately arid; rainfall averages 25 cm/yr and falls principally during winter. Site 300 is situated in Miocene volcaniclastic rocks and younger deposits of terrace remnants, alluvium, colluvium, and ravine fill. It is characterized by steep northwest–southeast trending hills and deep canyons. Site 300 was established in 1955 and is owned by the U.S. Department of Energy (DOE) and operated by the University of California to support national defense and other research. The study area, the pit 7 complex, is located in a valley in the northwestern part of site 300. Figure 1 is a geologic map of site 300 showing the location of the pit 7 complex. Explosives experiments, sometimes containing small quantities of tritium, uranium-238, beryllium, and lead, were conducted at two outdoor facilities, called firing tables, south of the pit 7 complex. From 1958 to 1978, debris from these experiments was disposed at landfill pits 3 and 5 in the pit 7 complex (Fig. 2). Pit 4 may also contain material equivalent to that disposed in pits 3 and 5. Pit 7 was opened in 1979 after most of the experiments using tritium were completed.

The firing-table wastes contain some low-level radioactive waste (LLW) constituents (tritium, uranium-238,
and thorium) and also metals that are considered hazardous by current regulatory standards (lead) (Code of Federal Regulations 1990). LLW is not classified as a high-level waste, transuranic waste, or spent nuclear fuel or byproduct material (NRC 1985). Currently, there are no waste-disposal facilities in this country licensed to accept wastes that contain radioactive and hazardous constituents.