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Rev. 1

Radioactive Material in the West Lake Landfill

1988

Summary Report

U.S. Nuclear Regulatory Commission

Office of Nuclear Material Safety and Safeguards

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Division of Industrial and Medical Nuclear Safety
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
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ABSTRACT

The West Lake Landfill is located near the city of St. Louis in Bridgeton, St. Louis County, Missouri. The site has been used since 1962 for disposing of municipal refuse, industrial solid and liquid wastes, and construction demolition debris.

This report summarizes the circumstances of the radioactive material in the West Lake Landfill. The radioactive material resulted from the processing of uranium ores and the subsequent sale by the AEC of processing residues. Primary emphasis is on the radiological environmental aspects as they relate to potential disposition of the material. It is concluded that remedial action is called for.

CONTENTS

1 INTRODUCTION AND BACKGROUND

This report summarizes the circumstances of the radioactive material in the West Lake Landfill (Figure 1), in particular, the radiological environmental aspects as they relate to potential disposition of the material.

The West Lake Landfill, Inc. property is a 200 acre tract in Bridgeton, St. Louis County, Missouri, on the outskirts of the city of St. Louis. It is about 4 miles west of St. Louis' Lambert Field International Airport, near the intersection of interstate highways I-70 and I-270. Limestone was quarried there from 1939 to 1987. Also on the property is an industrial complex where concrete ingredients are measured and combined, and where asphalt aggregate is prepared. Since 1962, portions of the property have been used as landfills for disposing of municipal refuse, industrial solid and liquid wastes, and construction demolition debris. In 1973, soil contaminated with radioactive material was placed in a landfill there.

The radioactive material originated with uranium-ore-processing residues which had been stored at Lambert Airport by the U.S. Atomic Energy Commission (AEC), and which were sold in early 1966 to the Continental Mining and Milling Company, of Chicago, Illinois. The AEC's invitation to bid listed the following residues for purchase: 74,000 tons of Belgian Congo pitchblende raffinate containing about 113 tons of uranium; 32,500 tons of Colorado raffinate containing about 48 tons of uranium; and 8700 tons of leached barium sulfate containing about 7 tons of uranium. The material was moved from the airport during 1966 to nearby 9200 Latty Avenue, Hazelwood, Missouri. In January 1967, the Commercial Discount Corporation of Chicago took possession of the residues to remove moisture and to ship the residues to the Cotter Corporation facilities in Canon City, Colorado. In December 1969, the remaining material was sold to the Cotter Corporation. In the following four years, the residues, with the principal exception of the 8700 tons of leached barium sulfate, were shipped to Canon City.[1]

In April 1974, Region III representatives of NRC's Office of Inspection and Enforcement visited the Cotter Corporation's Latty Avenue site to check on the progress of the decommissioning activities being performed there. This inspection disclosed that in 1973 Cotter Corporation had disposed of approximately 8700 tons of leached barium sulfate residues mixed with 39,000 tons of top soil at a local landfill.[1]

By letter dated June 2, 1976, the Missouri Department of Natural Resources (MDNR) forwarded to the NRC's Region III office newspaper articles which alleged that only 9000 tons of waste had been moved from the Latty Avenue site rather than 40,000 tons and that it was moved to the West Lake Landfill rather than to the St. Louis Landfill No. 1. Region III personnel investigated the allegations and found that 43,000 tons of waste and soil had been removed from the Latty Avenue site and had been dumped at the West Lake Landfill in Bridgeton, and that the waste was covered with only about 3 feet of soil.[1]

Discussion with the West Lake Landfill operators indicated that all of the material from Latty Avenue had been disposed of in one area; however, an aerial

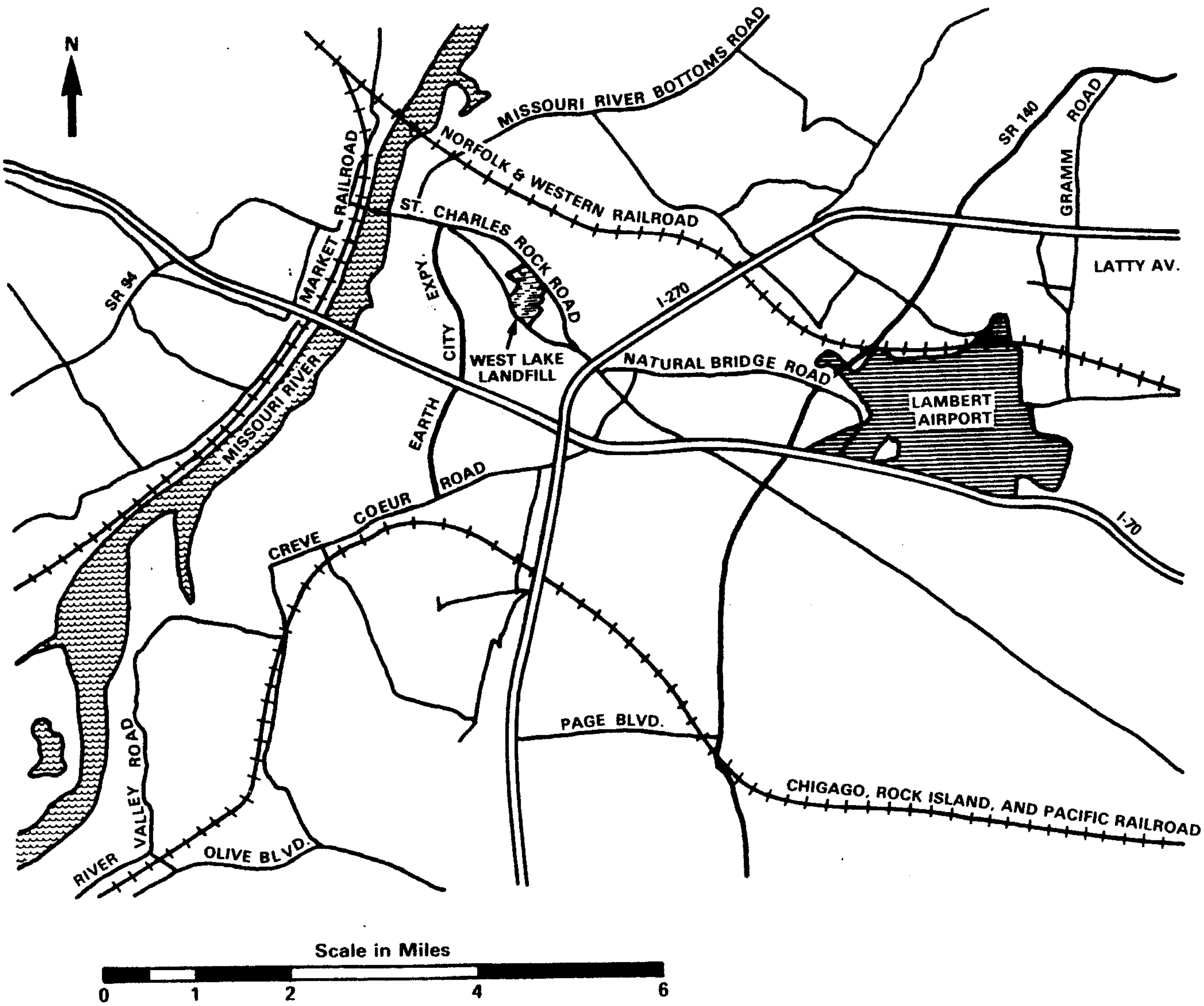

Figure 1 Location of West Lake Landfill

survey of the site identified two areas of contamination. The second contaminated area is identified as Area 1 in Figure 2.[2] Subsequently, the NRC sponsored other studies that were directed at determining the radiological status of the landfill. An extensive survey was initiated in November 1980 by the Radiation Management Corporation (RMC) under contract to the NRC. The findings were published in May 1982 in NUREG/CR-2722, "Radiological Survey of the West Lake Landfill, St. Louis County, Missouri."[3] In March 1983, the NRC through Oak Ridge Associated Universities (ORAU) contracted with the University of Missouri-Columbia (UMC), Department of Civil Engineering, to describe the environmental characteristics of the site, conduct an engineering evaluation, and propose possible remedial measures for dealing with the radioactive waste at the West Lake Landfill. In May 1986, ORAU sampled water from wells on and close to the landfill to determine if the radioactive material had migrated into the groundwater. A report is being prepared detailing the results of the investigations conducted by UMC and ORAU.[2]

Information from all these sources and from NRC site visits forms the basis for this report.

2 DESCRIPTION OF THE SITE

Location

The 200-acre West Lake Landfill site is situated on the southwest side of St. Charles Rock Road in Bridgeton, St. Louis County, Missouri (Figure 1).[2] It is about 16 miles northwest of the downtown area of the city of St. Louis, and about 4 miles west of Lambert Field International Airport (Figure 1). It is approximately 1.2 miles from the Missouri River.

History

The West Lake Landfill has been used since 1962 for the disposal of municipal refuse, industrial solid and liquid wastes, and construction demolition debris. Between 1939 and the spring of 1987, limestone was quarried there. Landfill operations filled in some of the excavated pits from the quarry operations. Also on the property is an active industrial complex in which concrete ingredients are measured and combined before mixing ("batching"), and asphalt aggregate is prepared.

The unregulated landfill, in which the radioactive material was placed in 1973, was closed in 1974 by the Missouri Department of Natural Resources (MDNR). Also in 1974, under an MDNR permit, a newer sanitary landfill was opened and now operates in an adjacent area on the West Lake Landfill property. The newer landfill is protected from groundwater contact. The bottom of the new landfill is lined with clay, and a leachate collection system has been installed. Leachate is pumped to a treatment system consisting of a lime precipitation unit followed in series by an aerated lagoon and two unaerated lagoons. The final lagoon effluent is discharged into St. Louis Metropolitan Sewer District sewers.[2]

Ownership

Since 1939, the West Lake Landfill has been owned by West Lake Landfill, Inc., of 13570 St. Charles Rock Road, Bridgeton, Missouri.

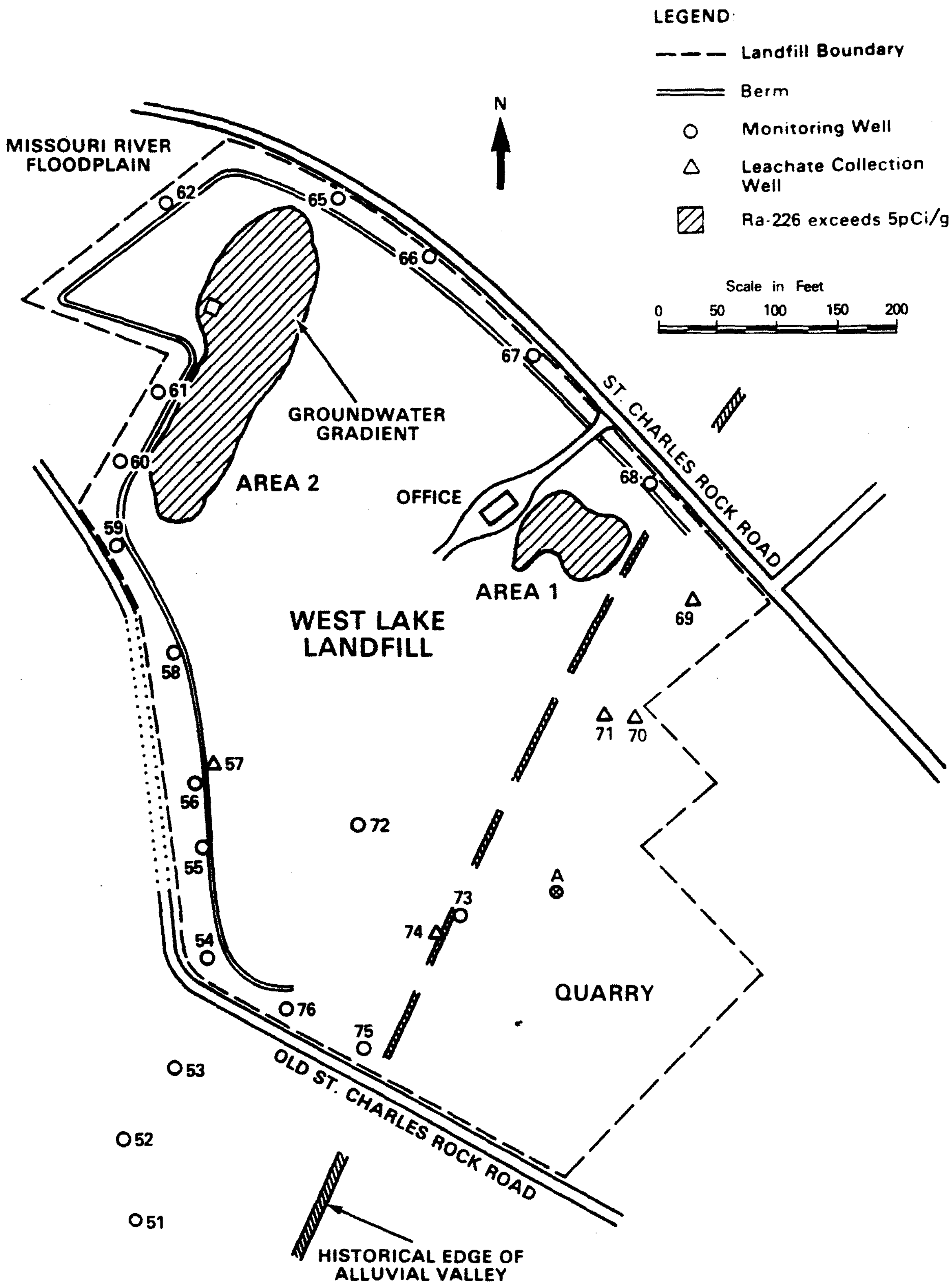

Figure 2 Site Details

Contaminated Areas

Radioactive contamination at the West Lake Landfill has been identified in two separate soil bodies (Figure 2).

The northern area (referred to as Area 2) covers about 13 acres[3] and lies above 16 to 20 feet of landfill debris. The contaminated soil forms a more or less continuous layer from 2 to 15 feet in thickness and consists of approximately 130,000 cubic yards of soil. Some of this contaminated soil is near or at the surface, particularly along the face of the northwestern berm. Beneath the landfill debris, the soil profile consists of 3 to 7 feet of floodplain top soil overlying 30 to 50 feet of sand and gravel alluvium.

The southern area of contamination (Area 1) covers about 3 acres[3] and contains roughly 20,000 cubic yards of contaminated soil. This body of soil is located east of the landfill's main office at a depth of about 3 to 5 feet and is located over a former quarry pit which was filled in with debris. The depth of debris beneath the contaminated soil is unknown but is estimated to be 50 to 65 feet. Limestone bedrock underlies the landfill debris.[2]

Topography

About 75 percent of the landfill site is located on the floodplain of the Missouri River (Figure 2) at about 440 feet above mean sea level (msl). The site topography is subject to change because of the types of activities (e.g., landfilling and quarrying) performed there. However, the areas containing the radioactive waste have their surface at about 470 feet (msl). The surface runoff in the area around the landfill follows several surface drains and ditches that run in a northwest direction and drain into the Missouri River.[2]

Geology

Bedrock beneath the West Lake Landfill consists of limestone that extends downward to an elevation of 190 feet msl. The limestone is dense, bedded, and except for intermittent layers that consist of abundant chert nodules, fairly pure. The Warsaw Formation, which lies directly beneath the limestone, is made up of approximately 40 feet of slightly calcareous, dense shale; this grades into shaley limestone toward the middle of the formation. Bedrock beneath the site dips at an angle of 0.5° to the northeast. Five miles east of the site, the attitude of the bedrock is reversed by the Florissant Dome.[2]

Since groundwater moving through carbonate rocks often creates channels for rapid water flow, the possibility of this occurring in the West Lake Landfill area was considered. Brief observation of the quarry walls at the landfill suggests that some of the limestone has dissolved. In a letter to West Lake Landfill, Inc., the Missouri Department of Natural Resources stated that the fact that grouting was necessary in the quarry area to block water inflow suggests that the limestone is at least somewhat solution weathered.[4] However, in the draft UMC report, the opinion is expressed that the solution activity has apparently been limited to minor widening of joints and bedding planes near the bedrock surface, and that, at depth and when undisturbed, the limestone is fairly impervious.[2] It is not clear whether the views represented by these statements are in conflict.

Soil material in the area may be divided into two categories: Missouri River alluvium and upland loessal soil. This demarcation is shown as the historical edge of the alluvial valley in Figure 2. The division is made on the basis of soil composition, depositional history, and physical properties. The West Lake Landfill lies over this transition zone.[2]

Hydrology

Groundwater flows in the area surrounding the West Lake site through two aquifers: the Missouri River alluvium and the shallow limestone bedrock. Although the limestone is fairly impervious and groundwater flows in most areas from the bedrock into the alluvium, contamination of water in the bedrock aquifer is possible. The base of the limestone aquifer is formed by the relatively impermeable Warsaw shale at an elevation of about 190 feet (msl). This shale layer has been reached, but not disturbed, by quarrying operations. Therefore, the Warsaw shale acts as an aquiclude, making contamination of the deeper limestone unlikely.

The deep Missouri River alluvium, which is under about 10 feet of more-recent alluvium, acts as a single aquifer of very high permeability. This aquifer is relatively homogeneous in a downstream direction and decreases in permeability near the valley walls.

The water table of the Missouri River floodplain is generally within 10 feet of the ground surface, but at many points it is even shallower. At any one time, the water levels and flow directions are influenced by both the river stage and the amount of water entering the floodplain from adjacent upland areas.

Water levels recorded between November 1983 and March 1984 in monitoring wells at the landfill, indicate a groundwater gradient of 0.005 flowing in a N 30°W direction beneath the northern portion of the landfill. This represents the likely direction of leachate migration from the landfill.

Since no other recharge sources exist above the level of the floodplain, the only water available to leach the landfill debris is that resulting from rainfall infiltrating the landfill surface. Because the underlying alluvial aquifer is highly permeable, there will be little "mounding" of water beneath the landfill. Also, the northern portion of the landfill has a level surface, and thus it is likely that at least half of the rainfall infiltrates the surface. The remaining rainfall is lost to evapotranspiration and (to a lesser degree) surface runoff.[2]

No public water supplies are drawn from the alluvial aquifer near the West Lake Landfill. It is believed that only one private well in the vicinity of the landfill is used as a drinking-water supply. This well is 1.4 miles N 35°W of the Butler-type building on the West Lake Landfill.

Because of the extremely low slope of the Missouri River floodplain surface, rain falling on the plain itself generally infiltrates the soil rather than running off the surface. The only streams present on the floodplain are those that originate in upland areas. Drainage patterns on the plain have been radically altered by flood control measures taken to protect Earth City and by drainage of swamps and marshes. Because of the relationship that exists between river level and groundwater level in portions of the floodplain near the river, streams may either lose flow (at low stage) or gain flow (at high stage).

The present channel of the Missouri River lies just under 2 miles west and northwest of the landfill. The Missouri River stage at St. Charles (mile 28) is zero for a water level of 413.7 feet (msl). Average discharge of the Missouri River is 77,338 cubic feet per second.

Water supplies are drawn from the Missouri River at mile 29 for the city of St. Charles, and the intake is located on the north bank of the river. Another intake at mile 20.5 is for the St. Louis Water Company's North County plant. The city of St. Louis takes water from the Mississippi River, which is joined by the Missouri River downstream from the landfill. The intake structures for St. Louis are on the east bank of the river, so that the water drawn is derived from the upper Mississippi.[2]

Demography

Two small residential communities are present near the West Lake Landfill: Spanish Lake Village consists of about 90 homes and is located 0.9 mile south of the landfill, and a small trailer court lies across St. Charles Rock Road, 0.9 mile southeast of the site. Subdivisions are presently being developed 1 to 2 miles east and southeast of the landfill in the hills above the floodplain. Ten or more houses lie east of the landfill, scattered along Taussig Road. The city of St. Charles is located north of the Missouri River, more than 2 miles from the landfill.[2]

Population density on the floodplain is generally less than 26 persons per square mile, but the daytime population (including factory workers) is much greater than the number of full-time residents. Earth City Industrial Park is located on the floodplain 0.9 to 1.2 miles northwest of the landfill. The Ralston-Purina facilities are located 0.2 mile northeast of the Butler-type building at the landfill. Considering that land in this area is relatively inexpensive and that much of it is zoned for manufacturing, industrial development on the floodplain will likely increase.[2]

3 RADIOLOGICAL SURVEYS

From August 1980 through the summer of 1981, the Radiation Management Corporation (RMC), under contract to the NRC, performed an onsite evaluation of the West Lake Landfill[3] to define the radiological conditions at the landfill. The results were utilized in performing this determination regarding whether or not remedial actions should be taken.

The area to be surveyed was divided into 33-foot grid blocks and included the following measurements:

(1) external gamma exposure rates 3.3 feet above the ground surface and beta-gamma count rates 0.4 inch above the surface;

(2) radionuclide concentrations in surface soils;

(3) radionuclide concentrations in subsurface deposits;

(4) total ("gross") activity and radionuclide concentrations in surface and subsurface water samples;

(5) radon flux emanating from surfaces;

(6) airborne radioactivity; and

(7) total activity in vegetation.

External Gamma

The two areas of elevated external (gamma) radiation levels, as they existed in November 1980 at the time of the preliminary RMC site survey, ~~both~~ contained places where levels exceeded 100 μR per hour at 3.3 feet. In Area 2, gamma levels as high as 3000 to 4000 μR per hour were detected. The total areas exceeding 20 μR per hour were about 2 acres in Area 1 and 9 acres in Area 2.[3] (The criterion of 20 μR per hour is derived from the NRC's Branch Technical Position, 46 FR 52061, October 23, 1981, which aims at exposure rates less than 10 μR per hour above background levels; background radiation was taken to be 10 μR per hour also.)

External gamma levels were measured in May and July of 1981. These levels were significantly smaller than the November 1980 values, especially in Area 1, because approximately 4 feet of sanitary fill had been added to the entire area, and an equal amount of construction fill was added to most of Area 2. As a result, only a few thousand square feet in Area 1 exceed 20 μR per hour. In Area 2, the total area exceeding 20 μR per hour decreased by about 10 percent, and the highest levels were about 1600 μR per hour near the Butler-type building.[3]

Surface Soil Analysis

A total of 61 surface soil samples were gathered and analyzed on site for gamma activity. Concentrations of U-238, Ra-226, Ra-223, Pb-211, and Pb-212 were determined for each sample. In all soil samples, only uranium and/or thorium decay chain nuclides and K-40 were detected. Offsite background samples were on the order of 2 pCi per gram for Ra-226. Onsite samples ranged from about 1 to 21,000 pCi Ra-226 per gram and from less than 10 to 2100 pCi U-238 per gram. In samples in which elevated levels of Ra-226 were detected, the concentrations of U-238 were generally one-half to one-tenth of those of Ra-226. In cases of elevated sample activity, daughter products of both U-238 and U-235 were found.[3]

In general, surface activity was limited to Area 2, as indicated by the surface beta-gamma measurements. Only two small regions in Area 1 showed surface contamination; both were near the access road across from the site offices.

In addition to onsite gamma analyses, 12 samples were submitted to RMC's radiochemical laboratories for thorium and uranium radiochemical determinations. The results of these measurements (Table 4 of NUREG/CR-2722) show that all samples contained high levels of Th-230. The ratio of Th-230 to Ra-226 (inferred from Bi-214) generally ranges from 4:1 to 40:1.

Subsurface Soil Analysis

Subsurface contamination was assessed by extensive "logging" of holes drilled through the landfill. Several holes were drilled in areas known to contain contamination, then additional holes were drilled at intervals in all directions until no further contamination was detected. A total of 43 holes were drilled (11 in Area 1 and 32 in Area 2), including 2 offsite wells for monitoring water. All holes were drilled with a 6-inch auger and were lined with 4-inch PVC (polyvinyl chloride) casing.[3]

Each hole was scanned with a 2-inch NaI(Tl) detector and rate meter system for an initial indication of the location of subsurface contamination. On the basis of the initial scans, 19 holes were selected for detailed gamma logging using the intrinsic germanium (IG) detector and multiple channel analyzer. Concentrations of Ra-226, as determined by the IG system, ranged from less than 1 pCi per gram to 22,000 pCi per gram.[3]

It was determined that the subsurface deposits extended beyond areas in which surface radiation measurements exceeded the reference level of 20 μR per hour. The lateral extent of material exceeding 5 pCi Ra-226 per gram, including both surface and buried materials, is shown on Figure 2. The total difference in areas is about 5 acres.

The surface elevations vary by about 20 feet, and the highest elevations occur at locations of more recent fill. Contaminated soil (>5 pCi Ra-226 per gram) is found from the surface to depths as great as 20 feet below the surface. In general, the contamination appears to be a continuous single layer ranging from 2 to 15 feet thick and covering 16 acres.[3]

Nonradiological Analysis

Six composite samples were submitted to RMC's Environmental Chemistry Laboratory for priority pollutant analysis. Five samples were taken from auger holes (one from Area 1 and four from Area 2) and the sixth was taken from sludge from the West Lake Landfill leachate treatment plant. The analysis shows organic solvents present in the Area 2 samples. Positive results were reported for 25 listed organic compounds. Chromium, copper, lead, nickel, and zinc were the predominant elemental priority pollutants detected. The analysis of the sample from the leachate treatment sludge showed that it had smaller pollutant concentrations than the samples from the auger holes.[3]

Chemical analyses of material from the radioactive layer from both areas were also performed by RMC's laboratory. In most cases, elevated levels of barium and lead were found.

Background Radioactivity Measurement

Several offsite locations (within a few miles of the West Lake Landfill) were selected for reference background measurements. Background values were all within the normal range. The gamma exposure rates were 8 and 10.6 μR per hour. Radium-226 concentrations in soil were 2.5 and 2.6 pCi per gram. Radon flux from the ground surface was 0.50 and 0.58 pCi per square meter-second; working level values were 0.0011, 0.0017, and 0.005 WL.[3]

Airborne Radioactivity Analysis

Both gaseous and particulate airborne radioactivity were sampled and analyzed during this study. Since it was known that the buried material consisted partially or totally of uranium ore residues, the sampling program concentrated on measuring radon and its daughters in the air. Two methods were used: the first was a scintillation flask (accumulator) method for radon gas, and the second was analysis of filter paper activity for particulate daughters. A series of grab samples using the accumulator method were taken between May and August of 1981. A total of 111 samples from 32 locations were collected. Measurable radon flux levels ranged from 0.2 pCi per square meter-second in low background areas to 865 pCi per square meter-second in areas of surface contamination.[3]

At three locations, measurements were repeated over a period of 2 months. Significant fluctuations were observed at two locations. The fact that these fluctuations were real and not measurement artifacts was later confirmed by duplicate charcoal canister samples.

A set of 10-minute, high-volume, particulate, air samples was taken to determine both short-lived radon daughter concentrations and long-lived gross alpha activity. The highest levels (0.031 WL) were detected in November 1980, near and inside the Butler-type building. These two samples approximately equal NRC's 10 CFR Part 20, Appendix B, alternate concentration limit of one-thirtieth WL for unrestricted areas. In addition to the routine 10-minute samples, five 20-minute, high-volume, air samples were taken and counted immediately on the IG gamma spectroscopy system to detect the presence of Rn-219 daughters. All samples were taken near surface contamination. Concentrations of Rn-219 daughters ranged from 6×10^{-11} to 9×10^{-10} µCi per cubic centimeter.[3]

Vegetation Analysis

Vegetation samples collected by RMC included weed samples from onsite locations and farm crop samples (winter wheat) near the northwest boundary of the landfill. This location was chosen because water could run off from the fill onto the farm field. No elevated activities were found in these samples.[3]

Water Analysis

A total of 37 water samples were taken by RMC and analyzed for gross alpha and beta activity. Four samples were taken in the fall of 1980 and the remainder in the spring and summer of 1981. One sample was equal to the U.S. Environmental Protection Agency (EPA) gross-alpha-activity standard for drinking water of 15 pCi per liter and that was a sample of standing water near the Butler-type building. Several samples, including all the leachate treatment plant samples, exceeded the EPA drinking water action level for gross beta activity. Subsequent isotopic analyses indicated that the beta activity could be attributed to K-40. None of the offsite samples exceeded either EPA standard.[3]

In 1981, the Missouri Department of Natural Resources collected 41 water samples that RMC analyzed for radioactivity. Of these samples, 5 were background, 10 were onsite surface water, 10 were shallow groundwater standing in boreholes, and 16 were landfill leachate. From these data, background activity is estimated as 1.5 pCi gross alpha activity per liter and 30 pCi gross beta activity per liter. One groundwater sample was at 15 pCi gross alpha per liter, and one surface water sample was 45 pCi per liter. Most of the leachate samples were above 50 pCi beta per liter.[3]

In addition, groundwater samples in 11 perimeter monitoring wells at the West Lake Landfill were taken by the Reitz and Jens Engineering firm on November 15, 1983, and by University of Missouri at Columbia (UMC) personnel on March 21, 1984. In both sampling times, one well, but not the same one, exceeded the EPA's drinking water standard of 15 pCi per liter (18.2 pCi per liter in 1983 and 20.5 pCi per liter in 1984). On May 7 and 8, 1986, Oak Ridge Associated Universities (ORAU) personnel took water samples from 44 perimeter wells; only one (by Old St. Charles Rock Road) with 17 pCi alpha activity per liter exceeded the drinking water standard.[2]

The operators of the landfill, West Lake Landfill, Inc., have an ongoing hydrogeologic investigation of the site, which also involves analyses of monitoring well samples for radioactivity and for priority pollutants.[4]

4 ESTIMATION OF RADIOACTIVITY INVENTORY

Soil sample analyses have shown that the radioactive material in Areas 1 and 2 of the landfill consists almost entirely of natural uranium and its radioactive decay products.

The analyses of soil samples indicate that the naturally occurring U-238 to Th-230 to Ra-226 equilibrium has been altered and that the ratio of Ra-226 to U-238 is on the order of 2:1 to 10:1; the ratio of Th-230 to Ra-226 generally ranges from 4:1 to about 40:1. These ratios are in accord with the history of the radionuclide deposits in the West Lake Landfill, i.e., that they came from the processing of uranium ores. The indicator radionuclides for assessment of the radiological impacts of the material are therefore U-238, Th-230, and Ra-226.

Using the RMC data and averaging the auger hole measurements over the volumes of radioactive material found in Areas 1 and 2, a mean concentration of 90 pCi per gram was calculated for Ra-226.[2] For the ratio of Th-230 to Ra-226, the RMC data[3] range from 4:1 to 40:1; data from samples taken in 1984 along the berm range up to almost 70:1.[5] A further consideration is that the material came from Cotter Corporation's Latty Avenue site (later sold to Futura Coatings, Inc.). Measurements at the Latty Avenue site are variously reported as up to 180:1[6] and about 300:1.[7] Some material of that nature might have been transferred along with the barium sulfate residues. To ensure conservatism in estimating the long-term in-growth of Ra-226, the NRC staff used a ratio of 100:1 to estimate the Th-230 activity. Similarly, the Ra-226:U-238 ratio ranges from 2:1 to 10:1. This ratio is less critical to the radiological aspect of the site and has been estimated to be 5:1 for purposes of calculation.

Using the Th-230:Ra-226 ratio of 100:1, the Th-230 activity is 9000 pCi per gram. If the U-238 concentration (as well as U-234 which would be similarly separated from the ore) is a factor of 5 less than Ra-226, this implies about 18 pCi U-238 per gram. The total mass of radioactive material in the landfill was estimated by visually integrating the volume of radioactive material from graphs and multiplying by an average soil density, resulting in 1.5×10^{11} grams (150,000 metric tons) of contaminated soil.

These numbers indicate that there are about 14 Ci of Ra-226 contained with its decay products in the radioactive material in the landfill. The material also contains about 3 Ci each of U-238 and U-234, and about 1400 Ci of Th-230. These estimates indicate the order of magnitude of the quantities to be dealt with, although the estimate for Th-230 is regarded as conservatively large.

5 APPLICABILITY OF THE BRANCH TECHNICAL POSITION

The NRC has established a Branch Technical Position (BTP) which identifies five acceptable options for disposal or onsite storage of wastes containing low levels of uranium and thorium (46 FR 52061, October 23, 1981).[8]

The concentrations permitted under each disposal option are shown in Table 1.

Table 1 Summary of maximum soil concentrations permitted under disposal options

Source: 46 Federal Register 52061

Kind of material	Disposal options 1[a]	2[b]	3[c]	4[d]
Natural thorium (Th-232 + Th-228) with daughters present and in equilibrium. (pCi/g)	10	50	-	500
Natural uranium (U-238 + U-234) with daughters present and in equilibrium. (pCi/g)	10	-	40	200

[a]Based on EPA uranium mill tailings cleanup standards.

[b]Concentrations based on limiting individual doses to 170 mrem per year.

[c]Concentration based on limiting equivalent exposure to 0.02 WL or less.

[d]Concentrations based on limiting individual intruder doses to 500 mrem per year and, in cases of natural uranium, limiting exposure to Rn-222 and other airborne alpha emitters to 0.02 WL or less.

Options 1-4 provide methods under 10 CFR 20.302, for onsite disposal of slightly contaminated materials, e.g., soil, if the concentrations of radioactivity are small enough and other circumstances are satisfactory. The fifth option consists of onsite storage pending availability of an appropriate disposal method.

The material present in the West Lake Landfill is a form of natural uranium with daughters, although the daughters are not now in equilibrium. As mentioned in

Section 4, the average concentration of Ra-226 in the West Lake Landfill wastes is about 90 pCi per gram, which (considered by itself) falls into Option 4 of the BTP since Option 4 criteria are controlled by the Ra-226 content in the wastes (i.e., 200 pCi of U-238 plus U-234 per gram would be accompanied by 100 pCi of Ra-226 per gram). However, because of the large ratio of Th-230 radioactivity to that of Ra-226, the radioactive decay of the Th-230 will increase the concentration of its decay product Ra-226 until these two radionuclides are again in equilibrium. Assuming the ratio of activities of 100:1 used above, the Ra-226 activity will increase by a factor of five over the next 100 years, by a factor of nine 200 years from now, and by a factor of thirty-five 1000 years from now. All radionuclides in the decay chain after Ra-226 (and thus the Rn-222 gas flux) will also be increased by similar multiples. Therefore, the long-term Ra-226 concentration will exceed the Option 4 criteria. Under these conditions, onsite disposal, if possible, will likely require moving the material to a carefully designed and constructed "disposal cell."

6 REMEDIAL ACTION ALTERNATIVES EXAMINED

The evaluation performed by staff of the University of Missouri at Columbia addresses six potential remedial action alternatives, including that of leaving the radioactive material as it is, designated Option A.[2] Option D is the option of excavating the material and shipping it to another site for disposal. Options B, C, E, and F address different approaches to stabilizing the material on the West Lake Landfill site, primarily as temporary remedial actions. Options B, C, and F leave most of the radioactive material where it is but include a variety of measures to contain it and its radon releases and gamma emissions. Option E addresses the approach of constructing an onsite earthen cell, similar to a disposal cell, and moving the radioactive material into it. Under Option F, the radioactive material would be left in place and separate slurry walls would be built downgradient of Areas 1 and 2 to constrain groundwater motion. The estimated costs of Options B through F range from about \$370,000 (Option B) to about \$5,500,000 (Option F) in 1984 dollars. The estimate for Option D is about \$2,500,000, but this does not include the cost of transporting the material to another site and disposing of it there; in the staff's judgment, this could increase the cost by as much as a factor of ten.

Further studies are necessary to determine the most practical approach to disposal of this material.

7 FACTORS CONTRIBUTING UNCERTAINTY

The presence in the landfill of other substances listed as hazardous by the U.S. Environmental Protection Agency raises issues of whether the waste is mixed waste (i.e., both radioactive and chemically hazardous), and whether the landfill must also be disturbed to provide for proper containment of the chemical wastes.

The manner of placing the 43,000 tons of contaminated soil in the landfill caused it to be mixed with additional soil and other material, so that now an appreciably larger amount is involved. If it must be moved, it is not certain whether the amount requiring disposal elsewhere is as little as 60,000 tons or even more than 150,000 tons.

Because the controlling radionuclide (Th-230) has no characteristics that make it easy to measure quantitatively in place, as can be done for the Ra-226 with its decay products, the large but variable ratio of Th-230 to Ra-226 and its decay products makes the delineation of cleanup more difficult. When the ratio is so large (20:1 or more), even a small concentration of Ra-226 in 1988 implies such a large concentration later that it will be necessary to employ more difficult measurement techniques to confirm that the cleanup has been satisfactory.

Any possibility of disposal on site will depend on adequate isolation of the waste from the environment, especially for protection of the groundwater. It is unclear whether the area's groundwater can be protected from onsite disposal at a reasonable cost. This matter will require additional investigation.

8 SUMMARY

In 1973, radioactively contaminated soil amounting to approximately 43,000 tons was deposited in the West Lake Landfill near St. Louis, Missouri. The material originated with decontamination efforts at the Cotter Corporation's Latty Avenue plant. Disposal in the West Lake Landfill was not authorized by the NRC. State officials were not notified of this disposal in 1973 because the landfill was not regulated by the State at the time.

In the period 1980-1981, Radiation Management Corporation (RMC) of Chicago, Illinois, under contract to the NRC, performed a detailed radiological survey of the West Lake Landfill. This survey showed that the radioactive contaminants are in two areas. The northern area (Area 2) covers about 13 acres. The radioactive debris forms a layer 2 to 15 feet thick, exposed in only a small area on the landfill surface and along the berm on the northwest face of the landfill. The southern area (Area 1) contains a relatively minor fraction of the debris covering approximately 3 acres with most of the contaminated soil buried with about 3 feet of clean soil and sanitary fill.

The RMC survey showed that the radioactivity is from the naturally occurring U-238 and U-235 series with Th-230 and Ra-226 as the radionuclides that dominate radiological impact. The survey data indicate that the average Ra-226 concentration in the radioactive wastes is about 90 pCi per gram; the staff estimates the average Th-230 concentration to be about 9000 pCi per gram. Since Ra-226 has been depleted with respect to its parent Th-230, Ra-226 activity will increase in time (for example, over the next 200 years, Ra-226 activity will increase ninefold over the present level). This increase in Ra-226 must be considered in evaluating the long-term hazard posed by this radioactive material.

In addition to RMC's radiological survey, soil and water samples were collected and analyzed by others, including ORAU, UMC, and MDNR. Occasionally a sample of water from a monitoring well exceeds slightly the EPA drinking water standard of 15 pCi gross alpha per liter. Sample analyses for priority pollutants (nonradioactive hazardous substances) show a number of listed pollutants are present. The landfill operators are also conducting a hydrogeological investigation.

From the RMC, UMC, and ORAU surveys conducted at the West Lake Landfill site the staff has made the following findings:

(1) There is a large quantity (on the order of 150,000 tons) of soil contaminated with long-lived radioactive material in the West Lake Landfill. Almost all the radioactivity consists of natural uranium and its radioactive decay products.[3]

(2) Based on the radiological surveys, the radioactive wastes as presently stored at the West Lake Landfill do not satisfy the conditions for Options 1-4 of the NRC's Branch Technical Position (BTP) regarding the disposal of radioactive wastes containing uranium or thorium residues.[8]

(3) A dominant factor for the future is that the average activity concentration of Th-230 is much larger than that of its decay product Ra-226, indicating a significant increase in the radiological hazards in the years and centuries to come.

(4) Some of the radioactive material on the northwestern face of the berm has no protective cover of soil to prevent the spread of contamination and attenuate radiation.

(5) Slightly more than 8 acres of the site exceed 20 μR per hour; the highest reading of 1600 μR per hour occurs near the Butler-type building.

(6) Radon and daughters were measured at 0.031 WL in and around the Butler-type building. This exceeds the BTP value of 0.02 WL.

(7) Based on monitoring-well sample analyses, some low-level contamination of the groundwater is occurring, indicating that the groundwater in the vicinity is not adequately protected by the present disposition of the wastes.

(8) Although these radiological conditions indicate that remedial action is needed, it is unlikely that anyone has received significant radiation exposures from the existing situation.

(9) Sampling results show that chemically hazardous materials have been disposed of adjacent to or possibly mixed with the radioactive material.[3] It is possible that part of the radioactive material has become "mixed" waste.

From these findings and the information developed to date, the NRC staff concludes: (1) measures must be taken to establish adequate permanent control of the radioactive waste and to mitigate the potential long-term adverse impacts from its existing temporary storage conditions and (2) the information developed to date is inadequate for a technological determination of several important issues, i.e., whether mixed wastes are involved, and whether onsite disposal is practical technologically, and, if so, under what alternative methods.

As indicated by the estimates developed by UMC, remedial action will be costly. Further, the investigations to develop the necessary information to resolve major questions and to provide a sound basis for evaluation of the feasibility of disposal alternatives may also be costly. Therefore, it is necessary to determine the way to accomplish the further studies and remedial actions that are needed.

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13. ABSTRACT (200 words or less)

The West Lake Landfill is located near the city of St. Louis in Bridgeton, St. Louis County, Missouri. The site has been used since 1962 for disposing of municipal refuse, industrial solid and liquid wastes, and construction demolition debris. This report summarizes the circumstances of the radioactive material in the West Lake Landfill. The radioactive material resulted from the processing of uranium ores and the subsequent sale by the Atomic Energy Commission of the processing residues. Primary emphasis is on the radiological environmental aspects as they relate to potential disposition of the material. It is concluded that remedial action is called for.

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