U.S. Nuclear Regulatory
Commission

BRECKENRIDGE, MICHIGAN
Low-Level Radioactive Waste

SITE PROFILE

June 19, 2002

DISCLAIMER: The information presented in this summary document is largely extracted from technical reports prepared by other organizations and submitted to the Nuclear Regulatory Commission (NRC). Staff of the NRC's Region III Office inspected some of the investigative activities upon which the technical reports are based, and NRC staff performed detailed reviews of the reports. In addition, NRC staff performed independent dose calculations which confirmed the principal conclusions in this profile.

THE BRECKENRIDGE SITE

I. SITE LOCATION

The Breckenridge Site is located on Madison Road about 4 miles east of downtown St. Louis, Bethany Township, Michigan. The Breckenridge property is a narrow triangular-shaped 2.2 acre parcel of land that is mostly flat and grassy with scattered large trees. The property is bounded by Madison Road on the north, by Bush Creek on the east, and by farmland on the west. A six-foot high chain-link fence controls access to the Site.

II. SITE HISTORY

Between 1967 and 1970, the Breckenridge Site was used for the disposal of process wastes from an yttrium recovery operation managed by Michigan Chemical Corporation (MCC). These disposal activities were authorized under U.S. Atomic Energy Commission (AEC) License Number SMB-0833 and were performed in accordance with 10 CFR 20.304, "Disposal by Burial in the Soil."

The buried waste material is a solid waste byproduct known as filtercake. Disposal records reported that the filtercake was typically a dense, clay-like material containing elevated levels of naturally occurring uranium and thorium. After site operations ceased, AEC License number SMB-0833 was terminated. In 1975, the Atomic Energy Commission was dismantled, and the Nuclear Regulatory Commission was created to assume some of its former responsibilities, including issues relating to formerly-licensed sites.

Several radiological evaluations have been performed at the Site in recent years. The most recent of these evaluations took place in November 2001 and led to completion of a characterization report which was submitted to the NRC in March, 2002. The characterization report provided an estimate for the radioactive waste source term in area, volume, and the average thorium-232 and uranium-238 concentrations in the buried waste material. These average concentrations were determined to be 267 picocuries per gram (pCi/g) thorium-232+D and 170 pCi/g uranium-238+D. The "+D" indicates that the parent isotope is in equilibrium with its decay daughters. Further details regarding the site characterization are provided in the following sections.

III. SITE CHARACTERIZATION

A. Above-Ground Studies

The site characterization involved a variety of scientific techniques to locate and quantify the nature and amount of buried filtercake material at the Breckenridge Site. Above-ground search techniques included radiation measurements, as well as measurements for the presence of buried metal or other indications that the soil had been disturbed. Figures 1 and 2 show the results of two different types of above-ground search techniques.

A gamma scintillation detector was used to perform localized surface scans for radiation "hot spots": areas of elevated radioactivity detectable from the surface. These scans were primarily performed in areas where buried waste was suspected. A representative of the U.S. Nuclear Regulatory Commission was present and independently performed some surface scans and identified several "hot spots" for investigation.

In general, surface "hot spots" were detected near confirmed waste areas. At one surface "hot spot" located in grid B6, some pieces of dispersed filtercake material were observed visually and identified by the detectors. This suggests that in some scattered areas about the site, small amounts of waste material were deposited on the surface and mixed into the soil, potentially as a result of spills during burial activities.

At several of the "hot spots" with the highest surface-activity measurements, the top layer of soil was removed to a depth of several inches. At each location, the removed soil continued to show elevated activity and the activity of the remaining soil (in the hole) either decreased or stayed at about the same level. Core borings were taken in the vicinity of two of the "hot spots," including the location with the highest measured surface activity. These did not show the presence of buried waste materials. These findings suggest that surface "hot spots" do not necessarily indicate the presence of buried waste. One boring from a location near a confirmed waste area showed elevated radiation levels in the soil in the 0 to 4-foot range.

B. Underground Studies

Based on the results of the geophysical survey data, six preliminary sampling locations were selected in grids A-7, A-10, A-12, A-16, and A-18 with the objective of obtaining 6 to 8 waste samples. Other sampling locations were added later. To evaluate a sample, a core boring was made at the preliminary sampling location. Then the boring spoils were examined visually and scanned with a radiation detector to determine if they contained radioactive waste material. If the boring spoils consisted of only non-radioactive soil, the drill rig was moved several feet in various directions around the original boring until waste material was located. About 80 borings were made during this underground investigation.

Once filtercake was identified, a sample of the material was collected directly from the auger into a 0.5-liter glass jar. The appearance of the waste and the depths at which it was found were recorded. Next, the drill rig was moved around the location of the initial boring to identify the extent of the disposal area in each direction (north, south, east, and west) and to collect one or two additional samples of the waste material in each area.

Tables 1 and 2 show some examples of direct radiation readings and radioactivity concentration measurements for a number of samples.

TABLE I
COMPOSITE SAMPLES

Composite Sample ID Number	Contributing Samples	Waste Area	Wet Sample Weight (g)	Wet Sample Density (g/cm^3)	Gamma Activity (Times Background)
BR-Comp-1	A-7-A,A-7-B,A-7-C	CWA-1	521	1.35	8.7
BR-Comp-2	B-10-A,B-10-B,B-10-C	CWA-2	478	1.24	2.6
BR-Comp-3	A-11,A-12	CWA-3	585	1.52	4.1
BR-Comp-4	A-13-A,A-13-B	CWA-4	611	1.59	3.0
BR-Comp-5	A-16-A,A-16-B,A-17-A	CWA-5	437	1.14	1.7
BR-Comp-6	A-16-C,A-16-D,A-16-E	CWA-6	458	1.20	4.3
BR-Comp-7	A-17-B,A-17-C,A-18-A	CWA-7	299	0.78	1.6
AVERAGE			**484**	**1.26**	**3.7**

TABLE 2
URANIUM AND THORIUM ACTIVITIES

Waste Area Designation	Composite Sample ID Number	Uranium-238 Activity (pCi/g)	Thorium-232 Activity (pCi/g)
CWA-1	BR-Comp-1	288	666
CWA-2	BR-Comp-2	62.2	129
CWA-3[a]	BR-Comp-3	485	575
CWA-4	BR-Comp-4	95.2	110
CWA-5	BR-Comp-5	39.9	23.3
CWA-6	BR-Comp-6	166	234
CWA-7	BR-Comp-7	49.3	130
AVERAGE		**170**	**267**

Notes:

[a] The average activity for CWA-3 includes the composite sample CWA-3 (257 pCi/g) thorium activity of 1,210 pCi/g and a uranium activity of 1,218 pCi/g (Reference 2.) [Activity = *((CWA-3 x 2) + A-12-4) / 3)* where the CWA-3 activity is weighted as two samples because it was a composite of two waste samples from the area.]

C. Waste Inventory Estimates

Waste inventory estimates were derived using two different methods. Each of these methods is described below.

The first waste inventory estimate was derived based on confirmed waste areas and potential waste areas identified during the 2001 site characterization activities. Confirmed waste areas were identified by the geophysical surveys and confirmed using core boring. Potential waste areas were identified as potential disposal areas by the geophysical surveys but were not confirmed by core boring. The locations of the confirmed waste areas (CWA) and potential waste areas (PWA) are provided in Figure 3. The total estimated waste volume is 113 cubic meters (m^3), based on the assumption of one 55-gallon waste drum per square meter of disposal area.

The second waste inventory estimate used a filtercake volume estimate based on the average densities of the 19 waste-material samples collected and the historical estimate of 151 wet tons of total waste deposited at the Breckenridge Site, as provided in the 1998 Historical Site Assessment. The average wet density was determined to be 1.33 grams per cubic centimeter (1,330 kilogram per cubic meter). Based on this average density, the estimated waste inventory volume is approximately 103 cubic meters.

The two waste inventory volume estimates are consistent within about 10% and are considered reasonably sound approximations of the filtercake volume.

Table 3 shows the estimated waste inventory by volume and by quantity of radioactive material. The thorium-232 inventory is consistent within 34% of the historical estimate (it is assumed that the historical thorium value included only thorium-232 and its decay daughters). The uranium-238 inventory is significantly greater than the historical estimate, indicating that the method used to determine the historical disposal activity for uranium was flawed. This difference, however, was not unexpected because data from a 1999 site characterization effort indicated that the uranium-238 and the thorium-232 concentrations in the waste material were on the same order of magnitude.

TABLE 3
WASTE INVENTORY

Waste Area	Approximate Size (m^3)	Estimated Volume (m^3)	Uranium-238 Inventory (µCi)[b]	Thorium-232 Inventory (µCi)[b]
CWA-1	60	13	4,980	11,515
CWA-2	25	6	496	1,029
CWA-3	60	13	8,386	9,942
CWA-4	50	11	1,393	1,609
CWA-5	75	16	849	496
CWA-6	75	16	3,532	4,980
CWA-7	75	16	1,049	2,766
PWA-1[c]	75	16	3,618	5,677
PWA-2[c]	25	6	1,357	2,129
TOTALS	**410**	**113**	**25,661**	**40,143**
ERROR[d]			+/-3,850	+/-6,020

Notes:

[a] It is assumed that waste was buried at a rate of one 55-gallon drum per square meter (rounded up to the nearest integer)(55 gallons = 0.21 m^3 per drum).

[b] Based on composite sample results presented in Section 4.1.

[c] Radionuclide inventories in the "potential" disposal area is based on the average values presented in Table 2.

[d] Based on the average error of +-15% for the reported activity.

The information obtained from this site characterization supports the conceptual site model that approximately 151 wet cubic tons (approximately 100 to 125 cubic yards) of waste materials with varying concentrations of thorium and uranium were buried at the Site. It is also evident that waste was buried in a non-uniform manner. Additionally, it is apparent that burial practices were unrefined and resulted in surface and near surface contamination.

IV. DOSE ASSESSMENT

The following paragraphs describe the assessment of the dose to a hypothetical future site resident, and the dual simulation method that was used to establish the exposure parameters for the dose assessment. For the purpose of the dose assessment, the hypothetical future site occupant is a resident farmer. This is considered the most conservative approach available.

A. Analysis Method

The RESRAD computer code (Version 6.0) developed by Argonne National Laboratory for the U.S. Department of Energy (DOE) was used to calculate a site-specific radiological dose to the future hypothetical resident farmer. Site-specific input parameters were obtained from site and waste characterization data and local well drilling records. Because the site contains a buried waste material with cover material that has only localized areas of surface or near surface contamination and the site is surrounded by farmland, a dual-simulation model with a resident farmer scenario was chosen as representative of the site conditions. The dual simulation method assesses the dose impact from two separate sources: subsurface contamination that is brought to the surface and subsurface contamination that remains undisturbed.

B. Analytical Results

B.1 Surface Contamination

The first simulation assessed the dose from buried radioactive waste material that is brought to the surface during the excavation of a basement for a hypothetical residence built on top of the buried waste. The NRC guidance is that the dose model examine the impact of a volume of contaminated materials that is brought to the surface and spread over an area of 700 square meters (m^2) with a thickness of 0.9 meters (m).

Calculations based on the NRC guidance would result in approximately 600 cubic meters (m^3) of excavated material being brought to the surface. However, since the waste inventory at the Breckenridge site is estimated to be only 113 m^3 and it is sporadically located about the site, it would be more realistic and limiting in this case to assume that a small 93 m^2 (1,000-square-feet) basement is excavated through the entire thickness of the waste material.

This scenario assumes that the waste material rests in a contamination layer 1.3 meters below the surface and 1.3 meters thick. This would result in the excavation of 121 m^3 of material from the contaminated zone and an equal volume (121 m^3) of cover material. Although there is a possibility of some contaminated material in the cover layer, the thorium and uranium concentrations in the cover are negligible when compared to the concentrations in the waste material. Assuming that the excavated material is spread over an area of 700 m^2 area, as recommended in the NRC guidance, the mixture of cover and waste material would be 0.35 m thick.

The 1.3 m-thick subsurface contamination layer is assumed to contain 0.21 m^3 of waste per square meter of disposal area (one 55-gallon drum of waster per 1 square meter of disposal area). When this material is mixed with the "clean" cover material, the soil-to-waste ratio will be about 11 to 1. Assuming that all of the excavated material is evenly distributed, the mean activity of the excavated material will be about 8% of the mean activity of the undiluted waste material. This source term is 21.6 pCi/g thorium-232+D and 13.7 pCi/g uranium-238+D. The standard simulation includes exposure to direct gamma radiation, and exposure through inhalation, soil ingestion, and plant ingestion (excluding irrigation with contaminated water). This simulation did not include measurements for plant ingestion. The probable existence of a driveway and other paved areas and landscaping near the house would make it highly unlikely that crops would be grown in the contaminated materials. Therefore, only exposure to external gamma, inhalation, and soil ingestion pathways were included in the first simulation.

The annual dose from the dual-simulation model is approximately 214 mrem/yr, with over 98% of the dose coming from external gamma exposure to surface activity that was brought to the surface. This is the maximum dose modeled. Due to the surface erosion rate of 0.001 meters per year, the dose from the excavated materials brought to the surface disappears over about 350 years while dose from sub-surface contamination remains approximately 80 mrem/yr.

B.2 Subsurface Contamination

The second simulation examined the dose contribution to the future resident farmer from a 1.3-meter-thick subsurface contaminated zone that includes the buried waste material mixed with clean soil. In this simulation, sources of exposure included contaminated groundwater and other aquatic sources used for drinking and irrigation and food sources such as plants, milk, meat, and fish (NRC 1999). Therefore, the sources of external gamma, inhalation and soil ingestion were not included in the second simulation.

The subsurface contaminated zone used in the dose assessment model was assumed to be equal to 410 m^2, the size of the combined confirmed and potential waste disposal areas identified in the 2001 site assessment.

The waste materials within the contaminated zone have average concentrations of 267 pCi/g thorium-232+D and 170 pCi/g uranium-238+D. However, the average thorium-232+D and uranium-238+D concentrations in the contaminated zone was assumed to be 43.1 and 27.5 pCi/g, respectively, based on the assumption that there is only 0.21 m^3 of waste per square meter of disposal area and that there is a 1.3 m-thick clean cover over the contaminated zone.

The dose from the subsurface contamination increases from 2.4 mrem/yr at time t=0 to more than 82 mrem/year after about 370 years (the maximum dose in the 0-to-1,000-year time frame). At 600 years, the dose falls to about 55 mrem/yr but begins to increase again to a dose of about 62 mrem/yr at 1,000 years. Over 92% of the dose from the subsurface contamination results from plant ingestion (water dependent pathway). It should be noted that the total percentage of contaminated plant, meat, and milk consumption is less than 1% due to the small size of the contaminated zone.

V. CONCLUSION

The modeled total dose to the future hypothetical resident farmer clearly exceeds the NRC's 25-mrem/yr dose limit established by 10 CFR 20 Subpart E for the free-release or radiologically contaminated areas. This dose assessment does not include the surface and near-surface contamination because it was assumed to have a minimal impact on the overall dose.

Figure 1

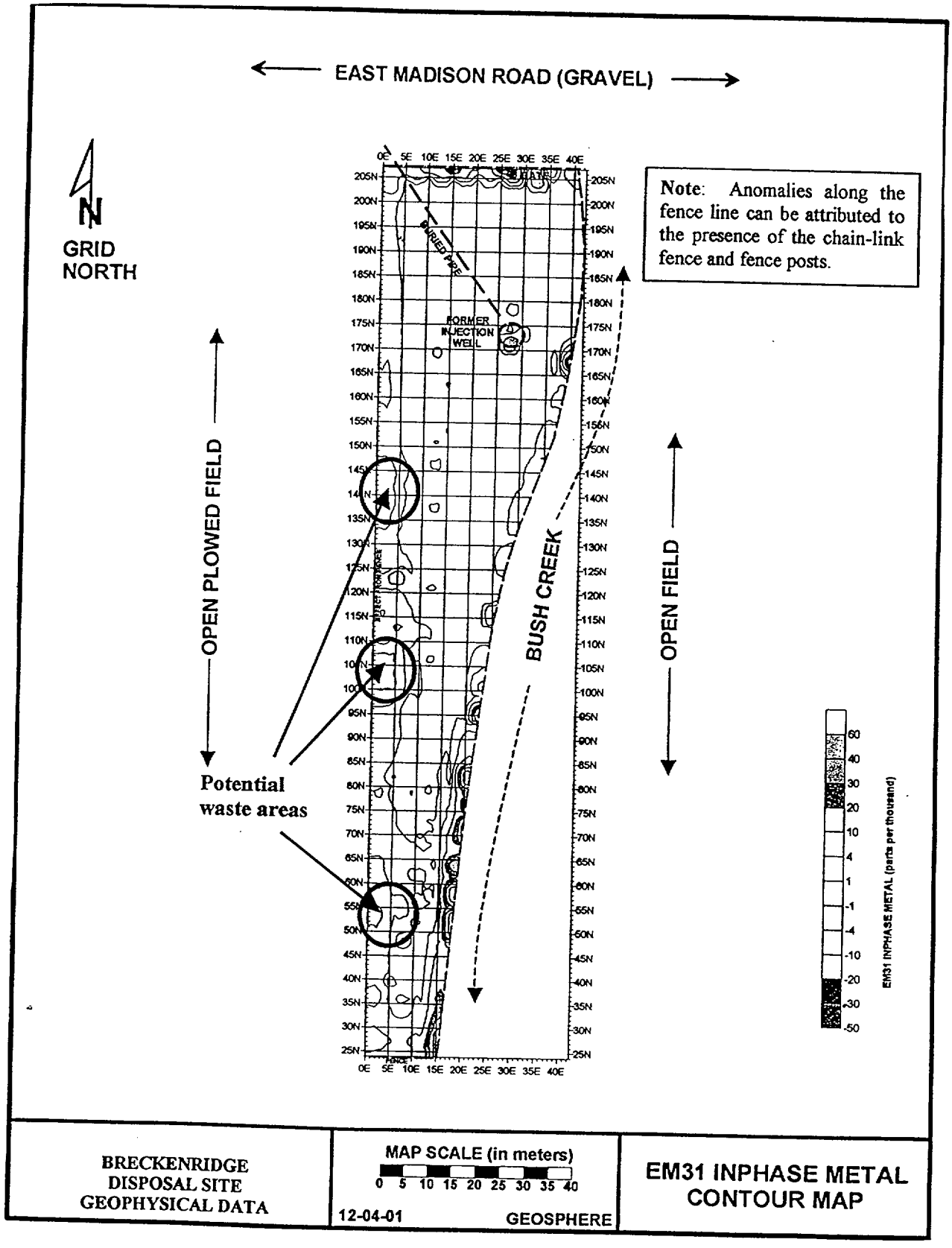

EAST MADISON ROAD (GRAVEL)
N
GRID NORTH
Note: Anomalies along the fence line can be attributed to the presence of the chain-link fence and fence posts.
OPEN PLOWED FIELD
OPEN FIELD
BUSH CREEK
BURIED PIPE
FORMER INJECTION WELL
Potential waste areas
EM31 INPHASE METAL (parts per thousand)
60
40
30
20
10
4
1
-1
-4
-10
-20
-30
-50
BRECKENRIDGE DISPOSAL SITE GEOPHYSICAL DATA
MAP SCALE (in meters)
0 5 10 15 20 25 30 35 40
12-04-01
GEOSPHERE
EM31 INPHASE METAL CONTOUR MAP

Figure 2

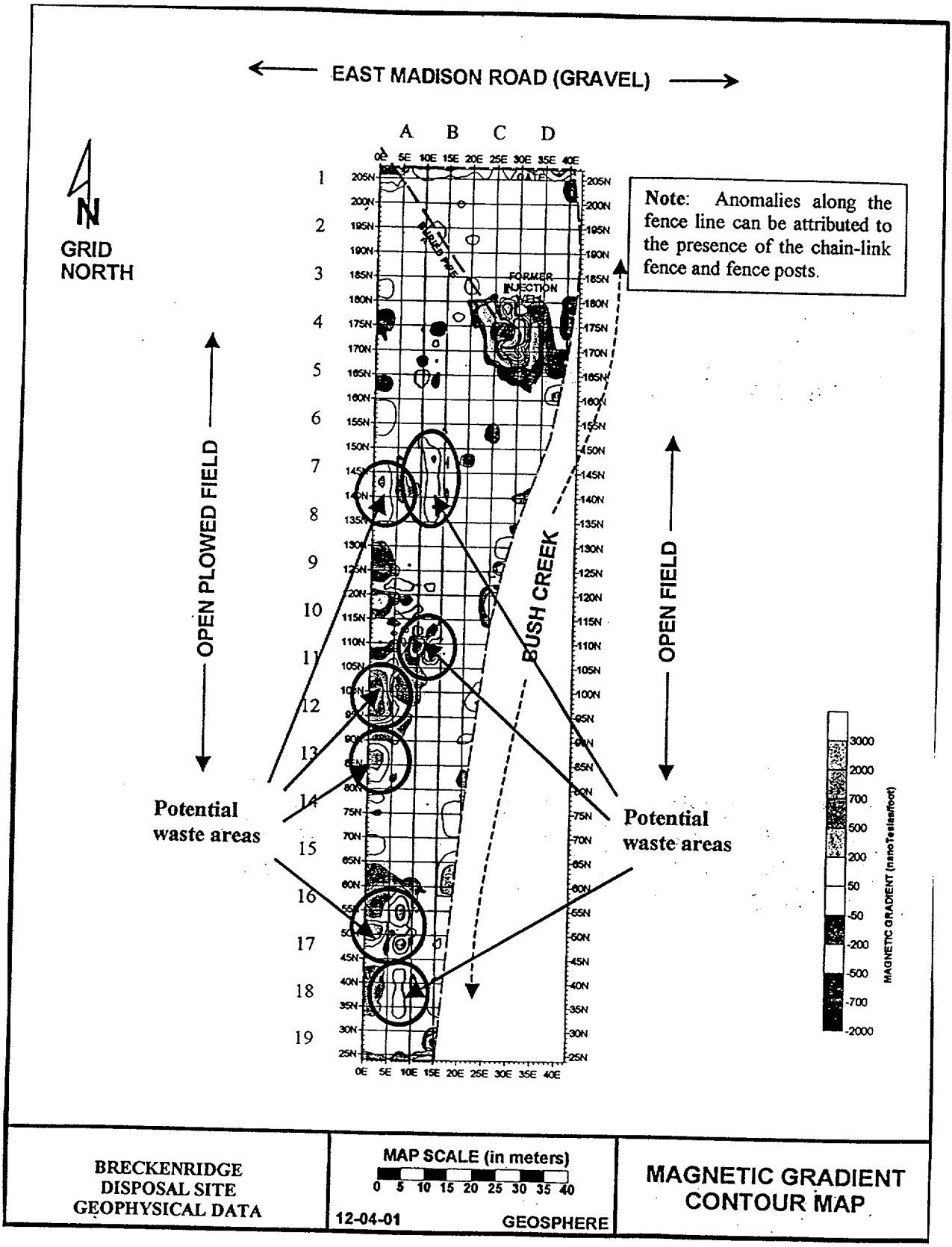
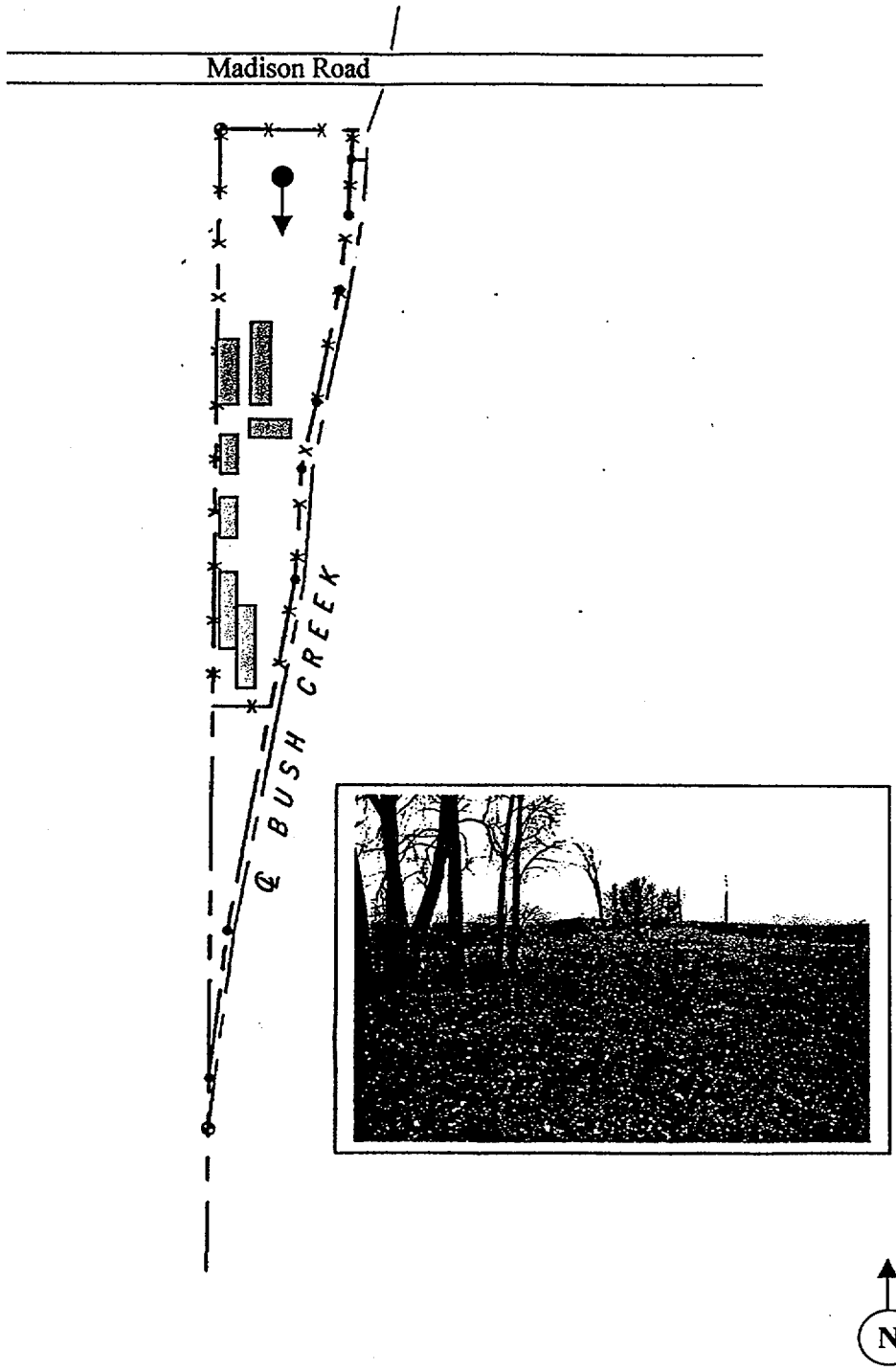

EAST MADISON ROAD (GRAVEL)
GRID NORTH
A B C D
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Note: Anomalies along the fence line can be attributed to the presence of the chain-link fence and fence posts.
FORMER INJECTION WELL
BUSH CREEK
OPEN PLOWED FIELD
OPEN FIELD
Potential waste areas
Potential waste areas
MAGNETIC GRADIENT (nanoTeslas/foot)
3000
2000
700
500
200
50
-50
-200
-500
-700
-2000
BRECKENRIDGE DISPOSAL SITE GEOPHYSICAL DATA
MAP SCALE (in meters)
0 5 10 15 20 25 30 35 40
12-04-01
GEOSPHERE
MAGNETIC GRADIENT CONTOUR MAP

Figure 3



BRECKENRIDGE PROPERTY SITE LAYOUT MAP

Location and direction of site photograph

Confirmed or potential buried waste areas

Source: Reference 2