CYANIDE WASTE
DISPOSAL ASSESSMENT
(FINAL REPORT)
JOHNSTON, RHODE ISLAND

PREPARED FOR:
R.I. SOLID WASTE MANAGEMENT CORPORATION
PROVIDENCE, RHODE ISLAND

PREPARED BY:
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May 26, 1987
File No. C-30021

R. I. Solid Waste Management Corp.
260 West Exchange Street
Providence, RI 02903

Attention: Mr. Ronald Delfino

Re: Cyanide Waste Disposal Assessment

Gentlemen:

In accordance with our proposal dated March 20, 1987, Goldberg-Zoino & Associates, Inc. (GZA) has conducted an investigation associated with the disposal of waste cyanide bearing materials at the Central Landfill in Johnston, Rhode Island. The investigation was conducted in accordance with the Study Plan, Cyanide Waste Disposal Assessment, Central Landfill, prepared by GZA in February, 1987. The services completed as part of this assessment were altered to reflect comments presented to Rhode Island Solid Waste Management Corporation (RISWMC) by Rhode Island Department of Environmental Management (RIDEM) following their review of the February 1987 Study Plan. Only Task 1 (Area Delineation), Task 2 (Literature/Information Search), Task 3 Waste Characterization, Task 4 (Geophysical Studies) and Task 7 (Fate Analysis) therefore are discussed in this report. GZA understands that the decision to undertake the remaining tasks associated with a subsurface exploration program will be dependent on the outcome of the presence investigation.

The studies described in this report, and the conclusions and recommendations developed therefrom, are subject to the limitations contained in Appendix A.

PURPOSE OF STUDY

On February 12, 1987, representatives of Stanley Bostitch notified RISWMC that a waste load of material from their facility in East Greenwich, Rhode Island may have inadvertently contained some cyanide-bearing waste materials. The waste material was generated from the decommissioning of a failed heat treating furnace at their plant. It is estimated that the material was delivered to the Central Landfill for disposal on January 29, 1987.

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RISWMC after notifying RIDEM and EPA requested that GZA assist in developing a study plan to assess the location, significance and probable fate of the cyanide-bearing waste material at the site.

This report has been prepared in accordance with that study plan and summarizes selected tests which have been completed to date and includes efforts by GZA and RI Analytical Laboratories, Inc., GZA's analytical subcontractor.

BACKGROUND

In late October or early November of 1986, an employee of Stanley Bostitch Co. of East Greenwich, Rhode Island determined that a case hardening furnace had failed. This determination was based on the fact that 1) the case hardening operation was requiring an excessive amount of sodium cyanide and 2) the furnace was emitting white smoke. Based on conversations with both second and third shift personnel, Stanley Bostitch has estimated that the failure likely first occurred on the night shift and that on the order to 150 pounds of material was added to the pot during that shift. Consequently it appears conservative to estimate that the mass of the material that escaped into the furnace over that few hour period was less than 150 pounds.

The operation was subsequently stopped and the bulk of the molten cyanide bath was removed to another furnace. The pot was removed from the furnace and subsequently cleaned at Stanley Bostitch's on-site waste treatment facility.

On or about January 9, 1987 Stanley Bostitch contracted with MacDonald-Watson Waste Oil Company of Scituate, Rhode Island to decontaminate and decommission all affected portions of the operation. That work commenced on January 14, 1986 and was completed by January 15, 1987.

The resulting waste was placed in thirteen 30-gallon, black metal drums, and ten yellow plastic bags (three of the yellow bags were placed in three 55-gallon drums). The waste contained spill residue, bricks, and scrapings from the pot.

It was intended that the debris deposited in the 30-gallon drums and the yellow bags placed in 55-gallon drums would be removed to the on-site treatment facility to effectuate cyanide destruction. Any remaining debris, which was not contaminated, would be disposed of with other industrial trash. Sometime between January 15, 1987 and February 11, 1987 four or five 30-gallon drums were transferred to the on-site treatment facility and their contents were decontaminated. On February 11, 1987 it was discovered that the remaining waste was no longer in the storage area. Subsequently it was determined that the material had been disposed of in a 30 cubic yard open roll-off waste container owned by Truk-A-Way of Warwick, Rhode Island on January 24, 1987.

The incident was reported by Stanley Bostitch to RIDEM and RISWMC on February 12, 1987. Air monitoring conducted by RI Analytical Laboratories Inc. (RIAL) of Warwick, Rhode Island commenced at the site on February 12, 1987. Records of Truk-A-Way, Stanley Bostitch and RISWMC indicated that the roll-off was emptied at the Central Landfill On January 29, 1987. The approximate location of disposal at the landfill was tentatively established by the driver and RISWMC personnel on February 12, 1987 (see Figure 1). Since that time no solid waste has been disposed of over the portion of the landfill where the cyanide waste is suspected to be located. Based on conversations with the landfill operator, it appears that the waste is most likely less than 20 feet below ground surface and in all probability is less than 30 feet below ground surface.

In summary, eight or nine, black, metal 30-gallon drums, and ten, yellow plastic bags of waste were disposed of at the landfill on January 29, 1987. The subject waste has a total volume of approximately 3 cubic yards and total weight of approximately two tons. Of that mass, no more than 150 pounds is residue from the case hardening bath. It appears that probably less than 50 pounds of that waste is sodium cyanide.

TASK 1. AREA DELINEATION

The disposal incident was reported by Stanley Bostitch to RISWMC officials on February 12, 1987. Based on conversations with the Truk-A-Way driver who reportedly delivered the waste material to the landfill, landfill personnel identified and cordoned off an area approximately 400 feet long by 100 feet wide which in their opinion most likely represented the active portion of the landfill on that date. Since then landfilling of this area has been prohibited. The primary objective of this task is to confirm these findings and to more accurately delineate the area of concern. The following narrative is based on review of existing landfill records and discussions with both the landfill operator and inspectors from MacDonald-Watson Oil Company.

GZA believed initially that a driver interview survey conducted by landfill personnel would be a useful method, whereby the active disposal area on the day of disposal could be more accurately defined thereby assessing the relative accuracy of the Truk-A-Way drivers' recollections of the location of the active face. It was envisioned that the program would involve interviewing selected drivers as to their memory of the location of the active face on January 29, 1987. Because of significant project delays resulting from the preparation of the consent agreement, and work plan and contract approval, it was felt that this approach no longer represented a viable method in delineating the suspect disposal area. Accordingly, GZA concentrated on identifying activities taking place at the landfill on or about January 29, 1987. This was accomplished by interviewing landfill and contract personnel. Additionally, GZA reviewed available landfill documents to evaluate the general characteristics of the refuse being dumped on or about that date.

From this effort it was established that during the latter part of January active landfilling was taking place along a north-south trending plateau near the approximate center of the landfill. The landfill operator, Mr. James Doorly, indicated that the plateau was divided in half axially, and filling took place in cells that alternated from side to side each day. A review of the operator's logs indicated that Mr. Thomas Hobbs of Caron Compactor Co. was a visitor to the site on January 28, 1987. This individual was contacted by GZA. According to Mr. Hobbs' recollection, the active cell on that day was along the western half of that plateau. Assuming that operation of the landfill continued in routine fashion, landfilling on the target date, likely took place along the eastern half of the ridge. The operator's logs show no unusual activity or diversion from routine on January 29, 1987.

More significantly the record review also indicates that on January 30, 1987 Louis Federici & Associates of Providence, Rhode Island conducted a survey between Well "C" and Well "E" (See Figure 1) across the central ridge of the landfill. This survey was performed at the request of the landfill operator in order to determine the maximum elevation of the landfill. To cross the highest portion of the area, the active survey line was run across the eastern half of the disposal area. Mr Doorley indicated that three stakes were placed during the traverse, labeled A, B, and C (See Appendix B). Stake A was placed at the northern edge of the plateau, stake B was placed at the approximate apex and stake C was placed at the southern foot of the landfill above Well "C". Based on available evidence, the location of Stake B represents the approximate center of the active cell on January 29, 1987.

During the time between this survey and the reporting of the hazardous waste disposal by Stanley Bostitch on February 12, 1987, activity on the site destroyed Stakes A and B. Realizing the coincidence between the timing of the survey and the waste disposal, the landfill operator requested that Louis Federici and Associates re-create the traverse and relocate Stake B based on their records relative existing Stake C. The second survey was conducted on February 24, 1987. The figure presented in Appendix

B is a result of that survey. Upon relocating Stake B the operator made a conservative approximation of the size of cell and this area was subsequently marked off. This area is presently clearly marked and has remained undisturbed since then.

Based upon this survey information, GZA has refined the estimate to encompass an area approximately 250 feet by 100 feet, typically 15 feet and most likely not exceeding 30 feet in depth (see Figure 1). This area represents a best estimate of the location of the portion of the landfill that was active on January 29, 1987.

On a daily basis the MacDonald-Watson Waste Oil Company, working for RISWMC, routinely inspects a portion of the waste loads entering the landfill for the presence of potentially hazardous materials and out-of-state wastes. RISWMC officials estimate that inspection is completed on approximately 10% of the refuse disposed of at the Central Landfill. Inspectors record the hauler's name and license number along with a brief classification of the type of waste. Inspection records indicate that on January 29, 1987 the majority of the trucks inspected by MacDonald Watson contained primarily wood, paper, garbage and sludge. GZA retrieved a copy of the inspection log associated with suspect cyanide containing waste load. Review of this information indicates the inspector noted only paper and wood. No evidence of drums and/or yellow plastic bags were noted. A copy of the truck slip associated with that load and a compilation of the inspector's daily log is presented as Appendix C.

Waste that could be clearly identified as from construction or demolition debris was less than 10% of the loads inspected. Because the large majority of truck loads go uninspected, and classification of inspected waste is restricted to the most general terms, a more detailed evaluation was not possible.

Records indicated that a delivery was made from the American Hoechst Co. on that date. Mr. Doorley noted that their waste has contained storage drums in the past. At GZA's request, a representative of the company reviewed their records and determined that the waste leaving their facility on January 29, 1987 contained mostly paper and trash with the possibility of a small number of metal containers. The contents of the containers were not provided.

TASK 2. LITERATURE/INFORMATION SEARCH

GZA initiated a computerized literature search through the Charles Hayden Memorial Library at the Massachusetts Institute of Technology in Cambridge, Massachusetts. This on-line retrieval method provides a rapid search of most major indices and abstracts of published literature in associated fields i.e., science and technology.

Based on key phrases and words provided by GZA and RIAL the data search provided a listing of 18 potentially related references and/or abstracts. From this listing GZA selected 12 references for retrieval. This information was primarily used in support of the Fate Analysis (Task 7).

TASK 3. WASTE CHARACTERIZATION

The purpose of this task was to attempt to characterize the composition of the waste material with regard to the make-up of cyanide, cyanate, carbonate, chloride and ammonia and, to evaluate the nature of the waste material after disposal.

All laboratory testing was conducted by RIAL. The analytical approach taken in recreating the waste material generated at the Stanley Bostitch facility was based on GZA's and RIAL's understanding of the heat treating process. As previously described in GZA's February 1987 Study Plan, the heat treating process at the Bostitch facility involves the heating of steel immersed in molten cyanide salt. Generally, a sodium cyanide bath mixture contains 30% sodium cyanide, 40% sodium carbonate and 30% sodium chloride. The surface of the steel absorbs both carbon and nitrogen from the cyanide bath. This process is referred to as "case hardening". The degree of hardening is influenced by the operating bath temperature and cyanide concentration. The normal operating temperature of the bath is 1400o-1600oF.

The active hardening agents of cyaniding baths, carbon monoxide and nitrogen are not produced directly from sodium cyanide. Molten cyanide decomposes in the presence of air at the surface of the bath to produce sodium cyanate, which in turn decomposes in accordance with the following chemical reactions:

Sodium Cyanide + Oxygen => Sodium Cyanate

Sodium Cyanate => Sodium Carbonate + Sodium Cyanide + Carbon Monoxide + Nitrogen

Carbon Monoxide => Carbon Dioxide + Carbon

Sodium Cyanide => Sodium Cyanate + Carbon Monoxide

It is known that the spill resulted in the loss of the bath from the pot to fire brick portion of the furnace (See Figure 2). The surface temperature of the fire brick is estimated to be greater than 2100oF. It was unknown what effects the increased temperature and changes in oxygen levels had on the material. Therefore, tests were performed to evaluate the relative effects these factors had on the resultant waste material.

The rate at which cyanate is formed and decomposes, liberating carbon and nitrogen at the surface of the steel, determines the case hardening activity of the bath. At operating temperatures, the higher the concentration of cyanate, the faster the rate of decomposition. Because the rate of cyanate decomposition increases also with temperature, bath activity is greater at higher operating temperatures.

WASTE SIMULATION

The laboratory experimental program was designed to simulate conditions present in Bostitch's heat treating furnace during the leak episode which resulting in the generation of the subject waste material. As described above, there are a number of influencing factors which effect the ultimate characteristics of the waste. These decisive variables are (1) temperature; (2) oxygen levels: (3) furnace exposure time; (4) sample surface area to depth ratio and; (5) initial cyanide source strength.

In order to evaluate these influences RIAL conducted a series of laboratory experiments. Test materials where collected from on-line heat treating baths at the Bostitch facility which are similar to the one that experienced the leak.

To establish the source strength of the initial test material (prior to the leak), RIAL tested these samples for sodium cyanide, sodium cyanate, sodium carbonate and sodium chloride. Testing procedures are described in Appendix D. Test results are presented in Table 1 and indicate that the raw bath material generally was composed of 26.5% sodium cyanide, 1.6% sodium cyanate, 66% sodium carbonate and 15.5% sodium chloride. It is important to note that the sodium cyanide values are in relative agreement with the theoretical heat treating bath make-up values described previously.

To evaluate the influences that oxygen levels, temperature and exposure time may have on the waste generating process, heat treating bath samples were subjected to treatment under two laboratory controlled conditions.

One set of samples were prepared for testing by placing approximately 40 grams of bath material in alumina crucibles and placed in an electric muffle furnace with an inside diameter of 4.5 inches by 4 inches by 3-3/4 inches. This furnace, while capable of exposing samples to high temperature, i.e. greater than 2100oF over time, provides little exchange of air and therefore reflects an atmosphere deficient in oxygen. Samples were exposed to temperatures of 1550oF (the normal bath temperature), 1750oF, 1900oF and 2100oF (the estimated temperature at the base of the furnace). All samples were held in the test furnace for a period of 30 minutes.

A second set of samples were prepared for testing by placing approximately 75 grams of bath material containing 35% sodium cyanide by weight in alumina crucibles. The crucibles were placed in a kerosene-fired muffle furnace owned and operated by Harrop Industries, Inc. of Columbis, Ohio. This furnace is capable of providing oxygen level adjustments. Oxygen levels of 12% were measured from within the fire box of a heat treating furnace at the Bostitch facility by the manufacturer. The same oxygen level (12%) was maintained within the kerosene-fired muffle furnace throughout the sample exposure period. Samples were exposed to temperature of 1550oF and 2100oF for periods of 15 minutes and one hour.

The resultant samples exposed to a range of temperature, for varying periods of time, under both oxygen deficient and oxygen sufficient atmospheres, were tested for sodium cyanide, sodium cyanate, sodium carbonate and sodium chloride. Test data compiled from these experimentally prepared samples are presented in Tables 2 and 3. The data findings indicate that samples exposed to higher temperatures for greater periods of time, in oxygen sufficient atmospheres result in a dramatic decrease in sodium cyanide and sodium cyanate levels with a concurrent increase in sodium carbonate concentrations. Studies conducted by RIAL indicate the test material composed of approximately 25% sodium cyanide result in an average concentration of 0.4% sodium cyanide after exposure to 2100oF for a period of one hour. Conversely, as provided in Table 2, it is apparent that the influence of temperature alone in an atmosphere deficient in oxygen has negligible effects in the resultant composition of waste materials.

Similar laboratory testing was conducted on reagent grade sodium-cyanide to better understand the rate of thermo destruction/ conversion of sodium cyanide under these conditions. Samples were prepared and handled using the same techniques as described above. Reagent grade sodium cyanide was exposed to temperatures of 1550OF and 1950oF for one hour in an oxygen sufficient atmoshere.

The results of this testing, presented as Table 4 reveals the conversion of sodium cyanide to sodium carbonate at elevated temperatures. The data indicates that 100% sodium cyanide is converted to 3.0% sodium cyanide, 0.5% sodium cyanate and 98.8%

sodium carbonate after exposure to a temperature of 1950oF for one hour.

STABILITY AND REACTIVITY TESTING

A series of laboratory tests were performed by RIAL on laboratory produced and raw bath samples to evaluate the relative chemical stability and reactivity of the cyanide waste material. Resultant data will be utilized in assessing the ultimate fate of material in the landfill environment.

Solubility Testing

Solubility tests were performed on samples selected to represent a complete range of influencing factors. That is, samples generated through exposure to oxygen sufficient atmospheres, oxygen deficient atmospheres, reagent grade sodium cyanide and a sample from an oxygen sufficient atmosphere prepared in the presence of pieces of firebrick were tested. All samples were exposed to temperatures of 1550oF and 2100oF for one hour. Solubility tests were performed to determine the ability of the material to blend uniformly with water and, therefore evaluate leachability characteristics of the material in the environment.

Samples were tested by placing five grams of sample in 100 milliliters (ml) of distilled water and stirred for fifteen minutes. Weight measurements of the undissolved samples were then recorded. Samples were allowed to set without stirring for 24 hours at which time weight measurements of the undissolved portion of the samples were recorded again.

The results of the solubility tests are presented in Table 5 and indicate that most of the laboratory prepared samples were 100% soluble in distilled water after only fifteen minutes. This suggests that solubility is influenced by sample preparation temperature, oxygen level and initial cyanide concentration. The data does indicate that contact with firebrick material during preparation influences the samples by decreasing the solubility. Although not determined under this present scope of study, the data suggest that firebrick material may act as a catalyst to reduce cyanide solubility.

Reactivity Testing

Reactivity tests were performed on subject samples to evaluate the potential for hydrogen cyanide gas (HCN) generation. This was performed in the laboratory by subjecting a series of samples of cyanide-containing materials to various pH levels over a number of time frames.

Initially, to evaluate potential chemical interference posed by test acids, titration curves for 6 normal (N) hydrochloric acid (HCL) and 6N sulfuric acid (H_2SO_4) were generated. These curves presented as Figures 3 and 4 indicate the relative consistency of titrating characteristic of the test acids.

HCN generation at various pH levels was determined by adding to 5 grams of raw bath material containing 25% sodium cyanide to 100 mls of landfill groundwater. Groundwater collected for testing was recovered from the closest downgradient monitoring wells proximate to the suspect disposal area, i.e. wells B, B-1, C and C-1. The pH of the collected composite water sample was 7.2 standard units (SU).

The pH of the prepared samples were adjusted using HCL to provide the resultant range of pH values of 10.2, 9.5., 8.5 and 7.2 SU. The samples were allowed to sit undisturbed for 18 hours, 48 hours, and 5 days. The aqueous portion of each sample was tested for total cyanide concentration at the end of each time frame. Measured total cyanide concentrations in the aqueous portion of the sample reflects the difference between starting cyanide concentration and that amount of cyanide lost via the gaseous route as HCN.

The results of this experiment are presented in Table 6 and reveal that HCN generation is a function of both pH level and time, with off-gasing increasing at lower pH levels.

TASK 4. GEOPHYSICAL STUDIES

As described in GZA's February 1987 Work Plan, various geophysical options were reviewed as possible means of determining the location of the waste material. Although it was recognized that the conditions are unfavorable for direct determination of the location of the subject waste by geophysical methods, it was recommended that it may be possible to use these methods to delineate general areas in which concentrations of metallic objects are present and, thereby eliminate other areas from the investigation.

GZA's work plan recommended two geophysical methods be employed at the site, magnetometry and electromagnetics. Because inclement weather (extended periods of rain), prohibited the use of electromagnetic equipment in the field during the scheduled study period, this report presents only the preliminary results of the magnetometer survey.

Magnetic measurements are commonly used to map regional geologic structure and to explore for minerals. They have also been used to locate buried ferric materials such as pipes, tanks, and drums. A magnetometer measures the intensity of the earth's magnetic field. The presence of ferrous metals creates local variations in the strength of the earth's field permitting detection of the metal. A magnetometer's response is proportional to the mass of the ferrous target and inversely proportional to the cube of the distance to the target. Typically, a single 55 gallon drum can be detected at depths of up to 20 feet (6 meters (m)), while massive piles of drums could be detected at depths up to 65 feet (20 m) or more.

The effectiveness of some magnetometers can be reduced or totally inhibited by noise or interference from time-variable changes in the earth's field and spatial variations caused by magnetic minerals in the soil, or iron and steel debris, ferrous pipes, fences, buildings and vehicles. Complex site conditions may require the use of highly skilled operators, special equipment, and the recording and processing of data, along with skilled interpretation.

A one day magnetometer survey was conducted within the redefined suspect disposal area at the Central Landfill on April 14, 1987. The purpose of the study was to identify areas of anomalously high magnetic field strength which may indicate the presence of buried metal objects. Areas exhibiting positive anomalies may serve as focal points in the initial subsurface search for the subject hazardous waste.

The magnetometer survey was conducted using a Geometrics Model G 816 Proton Precision Magnetometer (See Figure 5). GZA personnel Norbert Schulz and Hilary Fortune performed the survey in cooperation with representatives of the landfill. This equipment is capable of measuring the vertical component of the earth's magnetic field at discrete stations along profiles requiring typically two to four seconds at each point.

Based on the suspect area defined in Task 1, an area approximately 140 feet by 240 feet, running axially north-south was staked off. A constant 10 foot grid spacing was used. Data points were plotted on a field map to indicate the presence of unusually steep gradients between neighboring stations. When large changes were observed, intermediate locations were measured. In all, nearly 300 data points were recorded.

The magnetic field data was plotted and contoured with an interval of 100nT (gammas). The contour map is displayed as Figure 6. High magnetic field values are interpreted as possible locations of buried materials with high magnetic susceptibility such as iron and some other metals. Conversely, low readings are suspected to be representative of areas that may be underlain by materials with low magnetic susceptibility such as wood, plastic, or paper.

Five areas within the study area exhibited high values compared to other locations within the survey. These areas are indicated by an H on Figure 6. Based on the results of the magnetometer survey, it is suggested that these areas most likely contain metallic materials.

TASK 7. FATE ANALYSIS

Drawing from referenced information and data generated through laboratory testing phase of this investigation (Waste Characterization), the objective of this task is evaluate the ultimate fate of the toxic constituents of the waste material in the landfill environment.

Potentially the most mobile form of cyanide in the environment would be cyanide present as a simple salt, such as the sodium cyanide. The fate of cyanide (CN-) in a landfill environment is dependent primarily on relative moisture content of the surrounding refuse fill.

If dissolved by relatively pure water CN- may eventually dissipate as hydrogen cyanide (HCN) gas; if the salt is dissolved by landfill leachate containing a high concentration of iron, much of the CN- could end up as insoluble precipitate. These possible fates of CN- were evaluated by estimating the concentrations of soluble CN- constituents and other constituents in water that could contact the heat treating bath wastes. Estimates of aqueous concentrations of aquatic species were made with TITRATOR, a computer model for equilibrium calculations1. These estimates of CN- behavior are compared with literature pertinent to the fate of CN- in the environment.

Chemical Composition of Cyaniding Bath Salt

Chemical analyses by RIAL of salt from the heat treating bath yield this composition (weight percent):

	Sodium	Cyanide	Carbonate	Chloride	Cyanate
Grams/100 grams	43.00	14.86	22.64	18.20	1.30

Fate of Cyanide in Pure Water

When salt of this composition was mixed with 100 ml of distilled water, the resulting solution had a pH of 10.2. The molar composition (gram-moles per liter) of the solution based on the five components cited above was estimated to have been:

	Sodium	Cyanide	Carbonate	Chloride	Cyanate
Moles/Liter	.935	.286	.187	.257	.015

The composition of the solution with respect to components and species important in determining the fate of CN- was estimated with TITRATOR using chemical data derived from thermodynamic data from Woods and Garrels2 and from Wagan, et al.3:

pH	HCN	HCN(dissolved)	CN^-(dissolved)
10.2	0.8 mmHg	0.008 moles	0.277 moles

The high pH is caused by the hydrolysis of carbonate which results in high concentrations of bicarbonate. Although hydrogen cyanide gas (HCN) has a small vapor pressure, 0.8 mmHg, there is no HCN in air so there is the vapor pressure gradient that would cause the slow release of gas. More rapid release of HCN would require addition of a strong acid to neutralize the alkalinity of the carbonate and bicarbonate (the alkalinity determined by RIAL was approximately 0.8 equivalents H/liter), causing the solution pH to decrease and vapor pressure of HCN to increase. Absorption of carbon dioxide (CO2) gas from air or soil gas in contact with the salt solution would be enhanced by its elevated pH and would, in turn, enhance the evolution of HCN.

Unabated exchange of HCN and CO2 would probabely result in the release to the air, or soil gas, of most of the cyanide. Gas exchange to a gas with the CO2 composition of atmospheric air was evaluated with TITRATOR which showed that almost all of the HCN would be evolved, given enough time. pH of the solution would remain high, approximately 10.6, unless strong acids were added to the solution.

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1 Carbaniss, S.E. 1987. Titrator: an interactive program for aquatic equilibrium calculations, Environ. Sci. Technol., 21, p. 209-210.

2 Woods, T.L. and R.M. Garrels. 1987. Thermodyamic Values at Low Temperature for Natural Inorganic Materials: An Uncritical Summary, Oxford University Press, New York, p. 242.

3 Wagman, D.D., W.H. Evans, V.B. Parker, R.H. Schumm, I. Halow, L.M. Bailey, K.L. Churney and R.L. Nutall. 1982. The NBS tables of chemical thermodynamic properties: Selected values for inorganic and C1 and C2 organic substances in SI units, Journal of Physical and Chemical Reference Data, 11, Supplement No. 2, p. 392.

Fate of Cyanide in Leachate

The quality of landfill leachate may greatly inhibit the subsurface mobility of CN-. Among the transition metals found in leachate at high concentration, iron and manganese form very strong complexes with CN-4, 5, 6. The most extensively studied and most important are those of iron:

Ferricyanide - Fe(CN)63+
Ferrouscyanide - FE(CN)64+

The thermodyamics of the formation of these complexes is so favorable that the complexes should be formed, to the exclusion of other iron compounds. A titration of CN- and ferrous iron, iron (II), performed with TITRATOR indicated that all of the iron (II) was complexed totally to CN- and not to other complexes such as FeOH+.

The salts formed by iron-cyanide complexes and transition metals are generally insoluble and this knowledge has been used as the basis of treatment for cyanide wastes.7 Although the ferricyanide will dissociate readily and hence are more easily mobilized, it will be shown below that ferricyanide most likely is not important in this evaluation of the fate of CN- in Central Landfill.

Reducing (anaerobic) conditions are present in the interior of most landfills, and also in Central Landfill. Although there are no indirect observations of oxidation-reduction potentials in Central Landfill, the water quality data obtained by RIAL

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[4] Ford-Smith, M.H. 1964. The Chemistry of Complex Cyanides: A Literature Survey, Department of Scientific and Industrial Research, National Chemical Laboratory, Her Majesty's Stationery Office, London p. 93.

[5] Sharpe, A.G. 1976. The Chemistry of Cyano Complexes of the Transition Metals, Academic Press, New York p. 302.

[6] Cotton, F.A. and Wilkinson. 1980. Advanced Inorganic Chemistry: A Comprehensive Text, Fourth Edition, Wiley-Interscience Publication, John Wiley & Sons, New York, p. 1396.

[7] Gierzatowica, R., L. Pawlowski and E. Smulkowska. 1985. Neutralization of wastewaters containing cyanides, Effluent and Water Treatment Journal, 25 (12), p. 426-427.

indicate these conditions are present throughout most of its interior. For example, the high concentrations of iron, ranging between, 21.8 and 54.2 mg/l, indicate the presence of highly soluble ferrous (reduced) iron, and reducing conditions. Reaction of CN- with landfill leachate, then can be anticipated to result in the formation of the ferrocyanide complex.

Since transition metal salts formed from iron ferrocyanide complexes generally are insoluble, the reaction between leachate and CN- should act to impede the rate of CN- migration in soil. This was observed in a study of CN- migration in soil columns.8 Potassium cyanide and leachate formed what the author claimed was Prussian Blue, a percipitate that accumulated at the top of the soil column. Not all of the CN- was precipitated. The author did not explain whether the incomplete precipitation resulted from total use of the available iron in the leachate or to a linetic hindrance arising from the low concentration of CN- in the environment.

Although CN- does occur naturally in the environment, those occurrences find CN- at low levels that generally are not detectable. There are soil microorganisms that can tolerate low concentration of CN- to the extent that NaCN has been investigated as a nitrogen source for farming. Concentrations of NaCN up to 200 ppm have been used to provide nitrogen for crops9. Microbial action on the CN- converts it to nitrates which are fixed to ammonia, which is eventually converted to nitrate. 10, 11. However, this microbial degradation of CN- in the landfill could only be expected to be biologically degraded if it were in an anaerobic environment.

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8 Attenuation by Soils, U.S. EPA, Solid and Hazardous Waste Research Division, Municipal Environmental Research Laboratory, Cincinnati, Ohio, EPA-600/2-78-158, p. 218.

9 McCool, M. M. 1945b. Fertilizer value of sodium cyanide, Contribution of the Boyce Thompson Institute, 13 p. 479-485.

10 Strobel, G. A. 1967. Cyanide utilization in soil. Soil Science 103(4) p. 1637-1639.

11 Calahan, M. A., M. W. Slimak, N. W. Gabel, et al. 1979. Water-Related Environmental Ate of 129 Priority Pollutants, Vol. 1, U.S.EPA, Office of Water Planning and Standards, Office of Water and Waste Management, Washington, D. C. EPA 440/4-79-029a.

In one review of CN- concentrations in groundwater at fifty industrial waste disposal sites, high concentrations of that compound were found only where seepage lagoons were recharging cyanide-bearing wastes water to the aquifer.[12] Among the many samples analyzed CN- was detected in approximately twenty samples at concentrations ranging between 5 and 14,000 parts per billion (ppb). The maximum value and two other higher concentrations were taken from a well known to be high in cyanide. The other concentrations between 40 and 60 ppm were from groundwaters near seepage lagoon.

The available information from groundwater near industrial landfills where the presence of cyanide-bearing wastes is known or suspected indicates that only where there is strong source, such as cyanide-bearing liquid wastes recharging groundwater, will CN- levels reach unacceptable levels. In other instances, where the sources of CN- are weaker, dilution, transition metal complexing, volatilization and microbial degradation may all play a role in reducing CN- concentrations to negligible levels.

TASK 7 (SUMMARY)

1) Under certain conditions, cyanide is not mobile in the environment and may not persist; it can be readily degraded to harmless constituents of carbon and nitrogen.

2) Dissolving the cyaniding bath salt in distilled water yields a solution with a hydrogen cyanide vapor pressure of approximately 0.8 mmHg, sufficiently elevated to cause evaluation of the gas.

3) Rapid evolution of hydrogen cyanide from the bath salt, that could pose a health risk, would require addition of strong acid to neutralize the alkalinity of the solution.

4) Contact of the aqueous salt solution with air containing the atmospheric composition of carbon dioxide and concurrent loss of hydrogen cyanide gas would eventually result in loss of substantially all of the cyanide initially present in the cyaniding bath salt. This release would be slow, the rate determined by the degree of confinement of the waste salt.

---

[12] Geraghty and Miller, Inc. 1977. The Prevalence of Subsurface Migration of Hazardous Chemical Substances at Selected Industrial Waste Disposal Sites, U. S. EPA, Office of Solid Waste, Washington, D. C. PB-275103, p. 166 and appendices.

5) In an anaerobic environment, such as that found in most landfills, cyanide should form ferrocyanide complexes which may form highly insoluble precipitates with iron, manganese and other transition metals. This immobilizing reaction has been observed in soil column tests.

6) Cyanide does occur naturally in the environment, but not in measurable concentrations in soils and groundwater. However, soil microorganisms can aerobically degrade cyanide converting it eventually to nitrate. Sodium cyanide has been used as a nitrogen fertilizer at concentrations as high as 200 parts per million. Anaerobic microbial degradation has not been verified.

7) The degradation and immobilization of cyanide wastes is borne out by a study of groundwaters affected by industrial waste landfills and lagoons. Elevated cyanide concentrations were associated only with seepage lagoons which were know to contain cyanide wastes, although all waste facilities investigated were suspected of containing cyanides.

SUMMARY AND CONCLUSIONS

As part of the present investigation GZA interviewed landfill and contract personnel and reviewed available landfill documents to more accurately delineate the suspect disposal area. From this effort it was established that during the latter part of January, 1987, active landfilling was taking place along a north-south trending plateau near the approximate center of the landfill. It was also learned that a survey had been performed at the landfill one day after the reported disposal incident. Based on this information GZA, has refined the area estimate to encompass an area approximately 250 feet x 100 feet, typically 15 feet and most likely not exceeding 30 feet in depth.

GZA conducted a one day magnetometer survey at the Central Landfill. Recognizing the inherent limitations of this approach, GZA that felt areas exhibiting positive anomalies may serve as focal points in the initial subsurface exploration for the subject waste, if warranted. Five areas within the study area exhibited high values compared to other location within the survey. The data suggest that these areas most likely contain metallic material.

Based on information collected as part of this study it appears that heat treating bath material which leaked into the fire box portion of the furnace was exposed to temperature of greater than

2100oF in an atmosphere containing levels of oxygen of 12%. The leak episode resulted in a loss of bath material over an eight-hour period. The bath material which contained approximately 25% sodium cyanide underwent rapid chemical changes resulting in the conversion of sodium cyanide to sodium cyanate and ultimately sodium carbonate. The waste material's physical composition changed to become much harder and porous with a green-dark green appearance.

It is estimated that at a minimum 70% of the material lost to the fire box was converted to a gaseous product (HCN) and released through the stack. Based on laboratory simulation experiments, the remaining material most likely contained less than 0.5% sodium cyanide after one hour exposure to high temperatures and oxygen sufficient conditions.

The ultimate source strength of the waste material suspected to be disposed of at the Central Landfill is approximately using the following assumption:

1) 150 pounds of bath material over and above the normal operating amount was used to "sweeten" the bath over an 8 hour sluft.

2) the material leaking from the bath contained approximately 25% sodium cyanide.

3) the leak was continuous and distributed evenly over an 8 hour period.

4) the temperature in the fire box was greater than 2100oF.

5) the oxygen level in the fire box was 12%.

6) Sodium cyanide levels in the released materials are reduced to 0.40% after one hour exposure time.

Based on calculations presented in Appendix E and under the assumption described above it is estimated that the material suspected to be disposed of at the Central Landfill contained less than 0.4 pounds of sodium cyanide and less than 0.2 pounds of cyanide. The remaining portion of the material was made up of sodium cyanate, sodium carbonate, fragments of castable material and fire brick.

It is GZA's opinion that this estimated amount of cyanide-bearing waste does not pose a significant incremental risk to current environmental conditions at the Central Landfill. This opinion is based on referenced literature which suggest that cyanide salts when present in a landfill environment can readily degrade to harmless constituents, form metal complexes which may form highly insoluble precipitates, and/or is released slowly as hydrogen cyanide gas. A rapid evolution of hydrogen cyanide gas, that could pose a health risk, however would require addition of strong acid, and given other factors does not appear as a significant incremental health risk. Accordingly, based soley on these findings, it is GZA's opinion that costs associates with addition site studies are not justified.

We trust this report presented herein satisfies your current requirements. Should you have any questions or comments, please do not hesitate to contact the undersigned. We have appreciated the opportunity to work with you on this project.

Very truly yours,

GOLDBERG-ZOINO & ASSOCIATES, INC.

John P Hartley

John P. Hartley
Project Manager

Frank W Clark

for Gregory W. Gardner
Project Reviewer

Frank W. Clark
Associate

JPH/FWC:lam

TABLES

TABLE 1

WASTE SIMULATION EXPERIMENT
(Raw Heat Treating Bath Material)

	Concentration	Range
Sodium Cyanide	26.5	(25-28)
Sodium Cyanate	1.6	(1.5-1.7)
Sodium Carbonate	66.0	(58-71.9)
Sodium Chloride	15.5	(15.2-15.8)

Notes:

(1) Cyanide bath material collected from on-line heat treating baths at the Bostitch Facility in East Greenwich, R. I.

(2) Results for sodium cyanide represents average concentrations from samples collected from four separate heat treating baths. Concentration range presented in (____).

(3) Results for sodium cyanate, sodium carbonate, sodium chloride represents average concentration from samples collected from two separate heat treating baths.

(4) All results reported as percent (%) by weight.

(5) Analytical testing methods described in Appendix D.

TABLE 2

WASTE SIMULATION EXPERIMENT
(Oxygen Deficient Atmosphere)

	Sample #1 (1550°F)	Sample #2 (1750°F)	Sample #3 (1900°F)	Sample #4 (2100°F)
Sodium Cyanide	17.1	6.1	17.6	14.7
Sodium Cyanate	6.9	NT	NT	2.4
Sodium Carbonate	69	NT	NT	65
Sodium Chloride	5.3	NT	NT	9.2

Notes:

(1) All results reported as percent (%) by weight.

(2) Reported values represent average of triplicate sample analysis; results may not total 100%.

(3) Sample #2 tested in porcelin crucible resulting in loss of portion of sample from crucible to furnace.

(4) NT denotes not tested.

(5) All samples held in furnace at temperature for 30 minutes.

(6) Analytical testing method described in D.

TABLE 3

WASTE SIMULATION EXPERIMENT
(Oxygen Sufficient Atmosphere)

	Sample #1 (1550° F) 15 min.	 1 hr.	Sample #2 (2100° F) 15 min.	 1 hr.
Sodium Cyanide	20.0	2.0	0.5	0.4
Sodium Cyanate	5.5	14.9	NT	0.1
Sodium Carbonate	73.1	79.0	NT	100.0
Sodium Chloride	15.2	15.8	NT	3.0

Notes:

(1) All results reported as percent (%) by weight.

(2) Reported sodium cyanide values represent average of triplicate sample analysis;results may not total 100%.

(3) Analytical testing methods described in Appendix D.

TABLE 4

WASTE SIMULATION EXPERIMENT
(Reagent Grade Sodium Cyanide/Oxygen Sufficient Atmosphere)

	Sample #1 (1550° F)	Sample #2 (1950° F)
Sodium Cyanide	58.0	3.0
Sodium Cyanate	19.8	0.5
Sodium Carbonate	24.4	98.8

Notes:

(1) All results reported as percent (%) by weight.

(2) Reported sodium cyanide values represent average of duplicate sample analysis; results may not total 100%.

(3) All samples held in furnace at temperature for one hour.

(4) Analytical testing methods described in Appendix D.

TABLE 5

REACTIVITY/STABILITY EXPERIMENTS
SOLUBILITY TEST

	1550° F		2100° F	
	15 min.	24 hrs.	15 min.	24 hrs.
Reagent Grade Sodium Cyanide	100	100	100	100
Sample from O_2 Sufficient Atmosphere	100	100	100	100
Sample from O_2 Deficient Atmosphere	100	100	100	100
Sample from O_2 Sufficient Atmosphere prepared in the presence of firebrick	100	100	5	15

Notes:

(1) All results reported as % solubility.

TABLE 6

REACTIVITY/STABILITY EXPERIMENT
REACTIVITY TEST

pH	18 hrs.	48 hrs.	5 days
10.2	20	13	< 1
9.5	12	3.5	NT
8.5	8.5	2.	NT
7.2	8.0	< 1	NT

Notes:

(1) Material used for testing contained 27% sodium cyanide.

(2) All results reported as percent (%) cyanide by weight.

(3) Samples prepared by adding 5 grams of material in 100 ml of pH adjusted distilled water.

(4) NT denotes not tested.

FIGURES

TARGET SHEET

**THE MATERIAL DESCRIBED BELOW
WAS NOT SCANNED BECAUSE:**

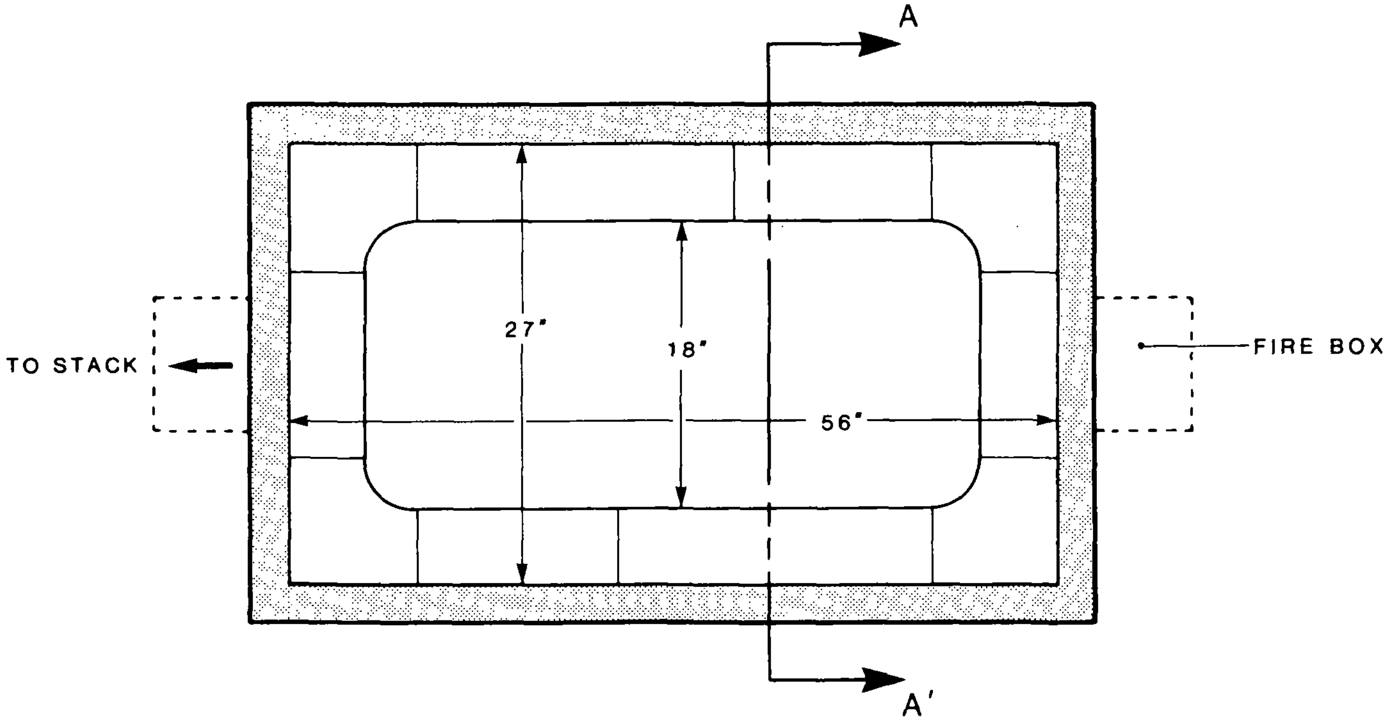
(x) OVERSIZE

() NON-PAPER MEDIA

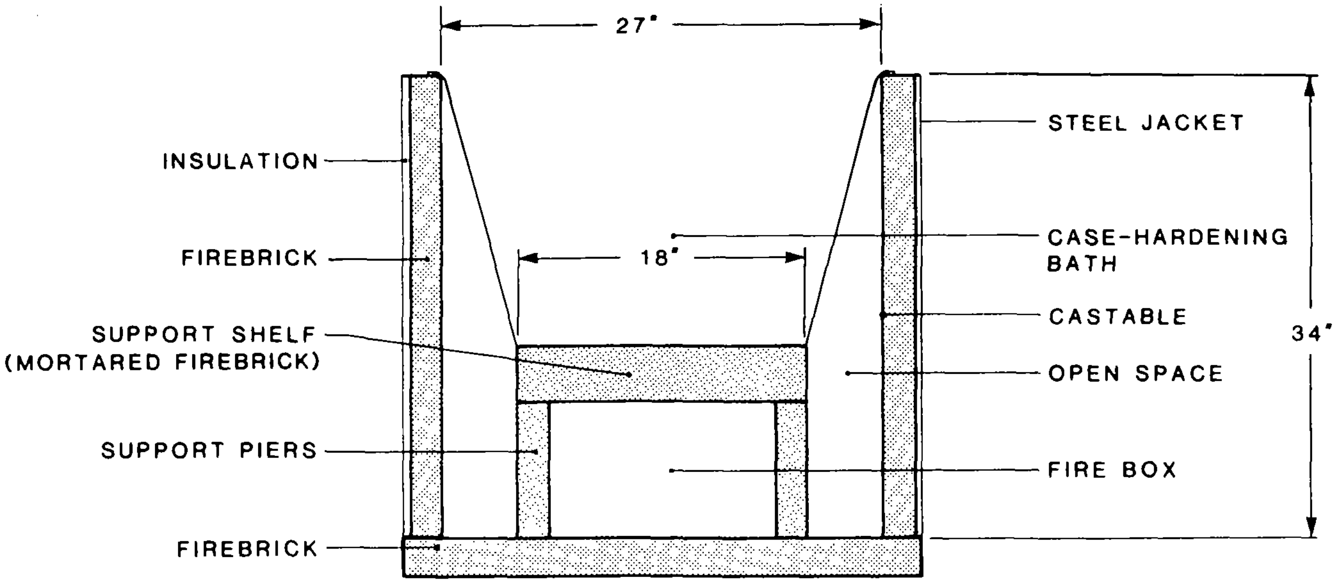
() OTHER

Site: Central Landfill
Description: Cyanide Waste Disposal Study Area
Doc ID: 465778

THE OMITTED MATERIAL IS AN OVERSIZE MAPAND IS AVAILABLE IN THE OSRR RECORDS AND INFORMATION CENTER, TO VIEW PLEASE CALL (617) 918 - 1440



TOP VIEW



CROSS-SECTION A - A'

NOT TO SCALE

FILE No. C-30021

GZA

CENTRAL LANDFILL
CYANIDE ASSESSMENT
JOHNSTON, RHODE ISLAND

TYPICAL
CASE-HARDENING
FURNACE

APRIL 1987

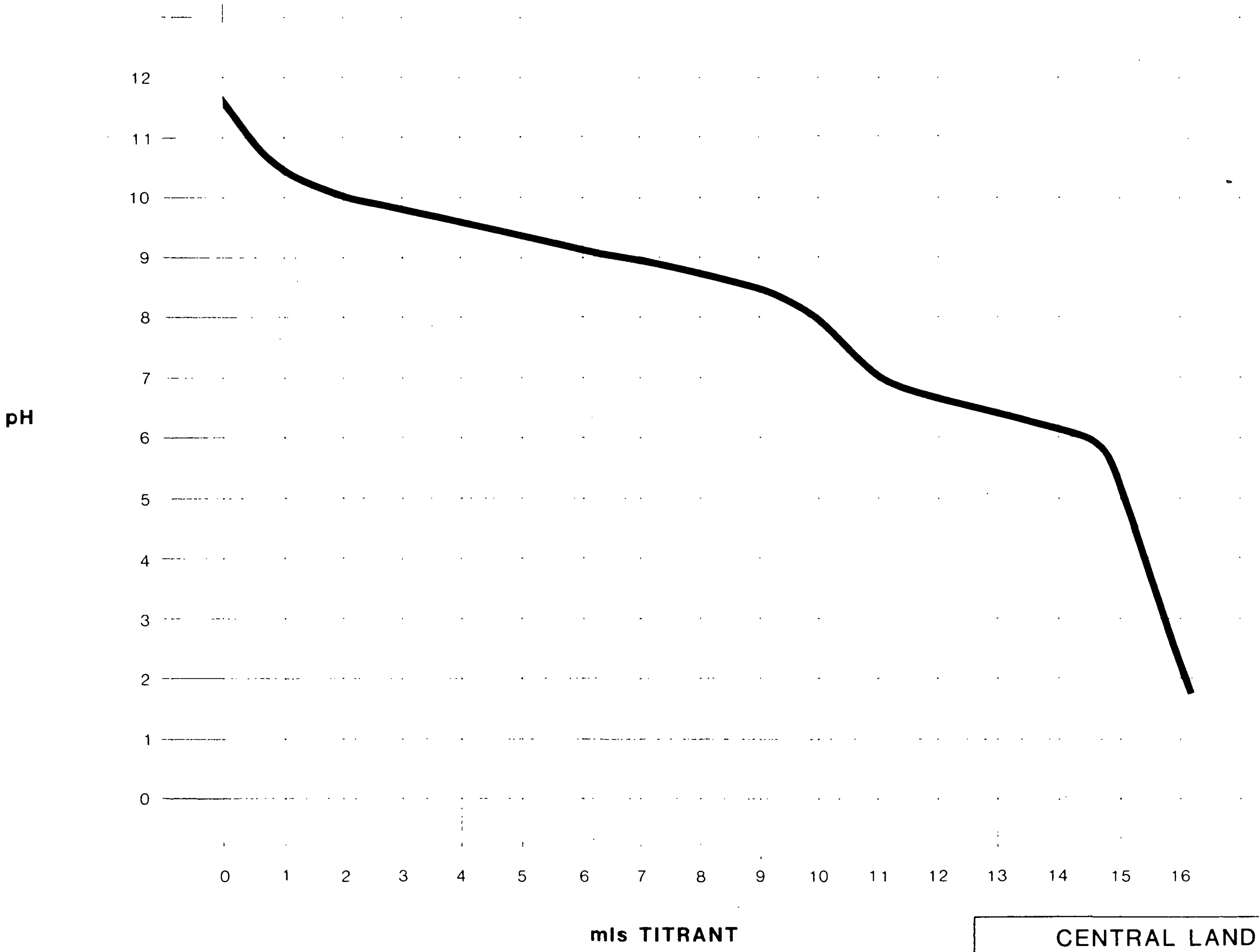
FIGURE NO.2

MAKEPEACE

CYANIDE TITRATION CURVE

6N HCl TITRANT

5 gms OF BATH MATERIAL



FILE No. C-30021

GZA

CENTRAL LANDFILL
CYANIDE ASSESSMENT

JOHNSTON, RHODE ISLAND

CYANIDE TITRATION CURVE

APRIL 1987

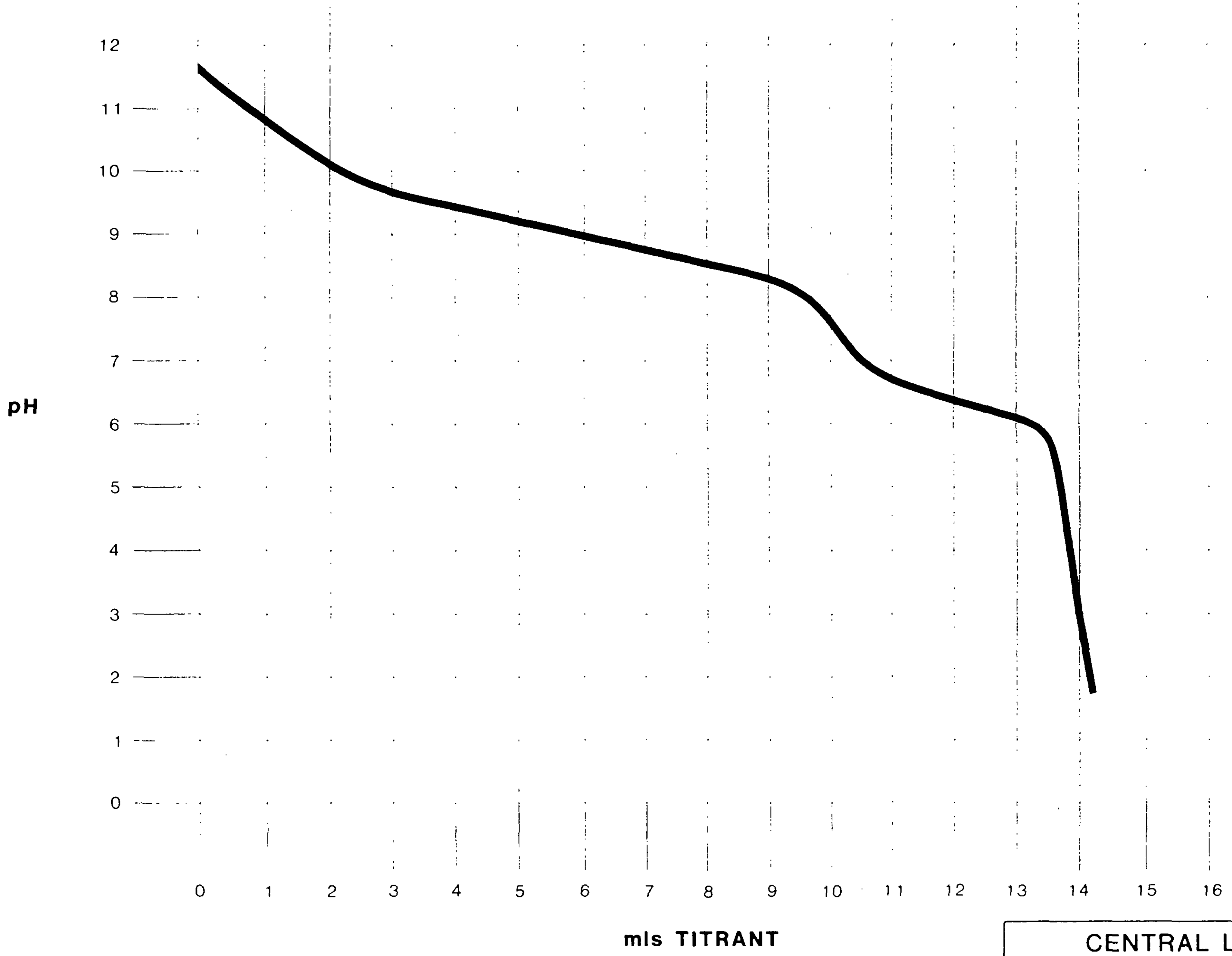
FIGURE NO.3

MAKEPEACE

CYANIDE TITRATION CURVE

6N H_2SO_4 TITRANT

5 gms OF BATH MATERIAL



CENTRAL LANDFILL
CYANIDE ASSESSMENT

JOHNSTON, RHODE ISLAND

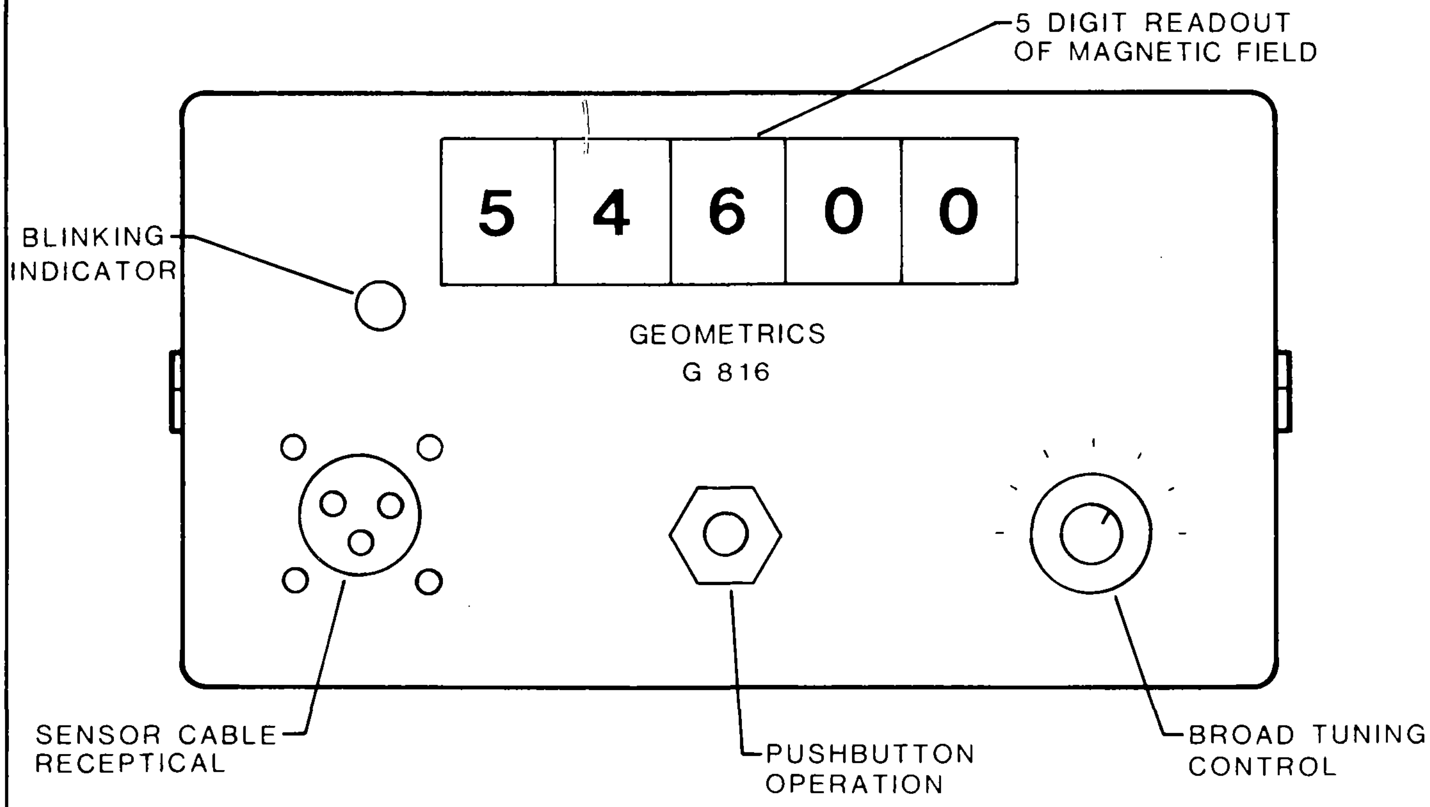
CYANIDE TITRATION CURVE

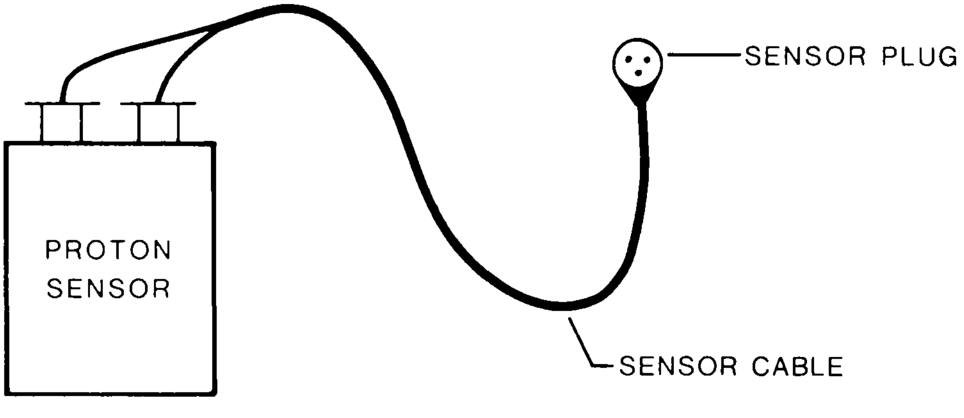
APRIL 1987

FIGURE NO.4

MAKEPEACE

GEOMETRIC MAGNETOMETER MODEL G 816





FILE No. C-30021

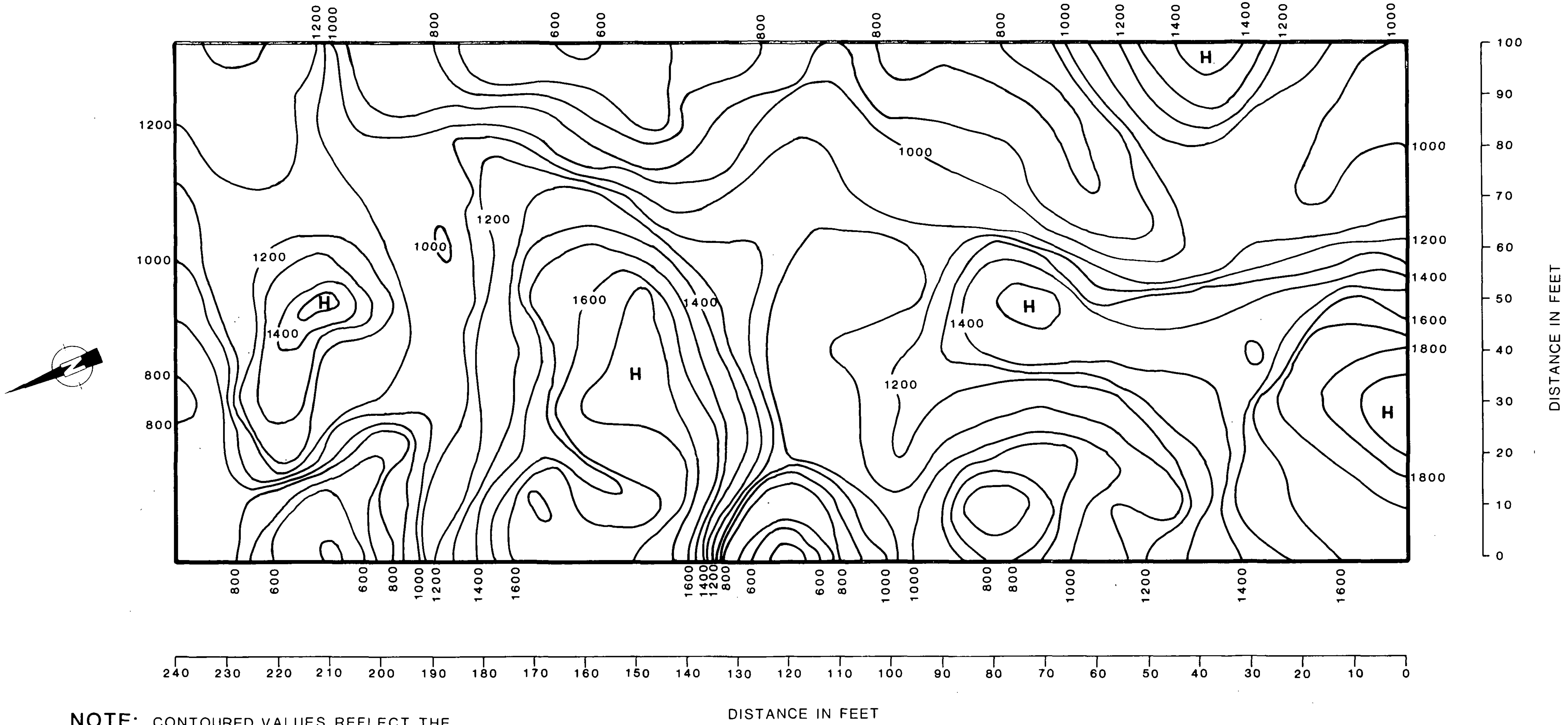
GZA

CENTRAL LANDFILL
CYANIDE ASSESSMENT
JOHNSTON, RHODE ISLAND

GEOMETRIC MAGNETOMETER
MODEL G 816
APRIL 1987
FIGURE NO. 5

MAKEPEACE

129417



NOTE: CONTOURED VALUES REFLECT THE REMOVAL OF A REGIONAL FIELD OF 55,000 nT.

H = AREAS OF HIGHER MAGNETIC FIELD

-APPROXIMATE SCALE-

0' 20' 40' 80'

GZA

CENTRAL LANDFILL
CYANIDE ASSESSMENT
JOHNSTON, RHODE ISLAND

TOTAL MAGNETIC FIELD CONTOUR MAP
IN nT (GAMMAS)

APRIL 1987

FIGURE NO. 6

MAKEPEACE

APPENDIX A

LIMITATIONS

APPENDIX A

LIMITATIONS

1. The observations described in this Report were made under the conditions stated therein. The conclusions presented in the Report were based solely upon the services described therein, and not on scientific tasks or procedures beyond the scope of described services or the time and budgetary constraints imposed by Client. The work described in this Report was carried out in accordance with the attached Statement of Terms and Conditions.

2. In preparing this Report, GZA has relied on certain information provided by state and local officials and other parties referenced therein, and on information contained in the files of state and/or local agencies available to GZA at the time of the site assessment. Although there may have been some degree of overlap in the information provided by these various sources, GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this site assessment.

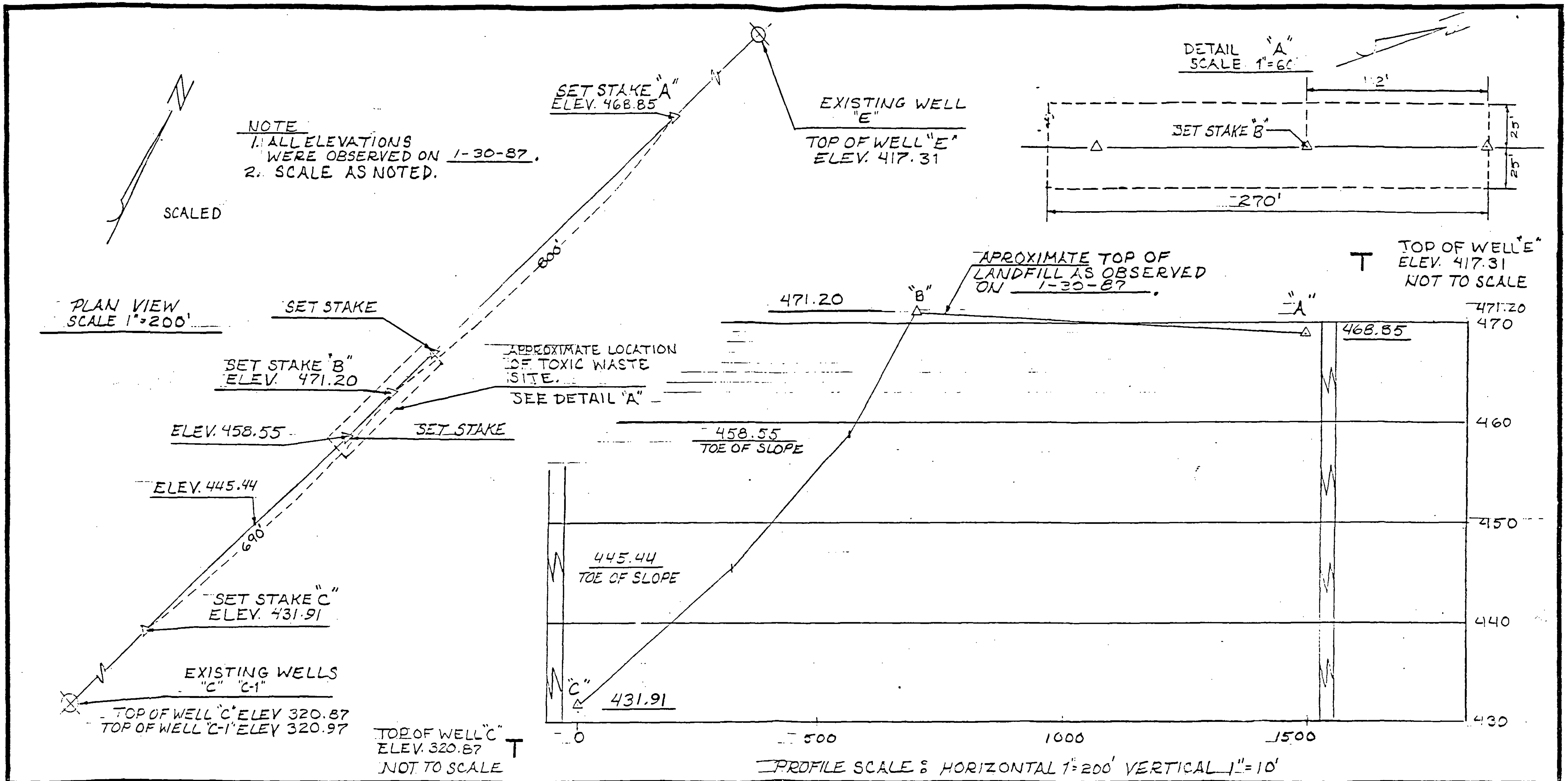
3. The conclusions and recommendations contained in this Report are based in part analysis conducted by an outside laboratory. GZA has relied upon the data provided, and has not conducted an independent evaluation of the reliability of these data.

4. Chemical analyses have been performed for specific parameters during the course of this site assessment, as described in the text. However, it should be noted that additional chemical constituents not searched for during the current study may be present in soil and/or groundwater at the site.

5. It is recommended that GZA be retained to provide further engineering services during construction and/or implementation of any remedial measures recommended in this Report. This is to allow GZA to observe compliance with the concepts and recommendations contained herein, and to allow the development of design changes in the event that subsurface conditions differ from those anticipated.

APPENDIX B

LOUIS FEDERICI & ASSOCIATES SITE SURVEY



NOTE
1. ALL ELEVATIONS WERE OBSERVED ON 1-30-87.
2. SCALE AS NOTED.

THIS SURVEY AND PLAN CONFORM TO A CLASS D STANDARD AS ADOPTED BY THE RHODE ISLAND SOCIETY OF PROFESSIONAL LAND SURVEYORS:

LOUIS FEDERICI
No. 1646
REGISTERED LAND SURVEYOR

LEGEND

△	STAKE
☐	STONE/CONC BND
○	IRON PIPE
●	IRON ROD or NAIL
⊙	DRILL HOLE
	STONE WALL
	FENCE
	HEAP OF STONES
	EDGE OF PAVEMENT
-O-	UTILITY LINE
N-F	NOW OR FORMERLY OF
T	WELL POINT

LOUIS FEDERICI & ASSOCIATES
SURVEYORS — ENGINEERS — PLANNERS
235 PROMANADE STREET, ROOM 150, PROVIDENCE, RHODE ISLAND

FOR PROPERTY OWNED BY: RI SOLID WASTE MANAGEMENT CORP

LOCATED IN JOHNSTON RI

ASSESSOR PLAT NO. AP 43/1 LOT NO. PORTION OF: 402

REVISIONS	DATE	BY	NO
Drawn By	F.W.L		
Checked By			
Approved By			
Date	3/26/87		
Scale	SEE NOTE 2		
Sheet	1 of 1		
Drg. No.	84209-03		

APPENDIX C

MACDONALD-WATSON INSPECTION LOG
& TRUCK SLIP FOR SUSPECT WASTE LOAD

RHODE ISLAND
SOLID WASTE MANAGEMENT CORPORATION

CENTRAL LANDFILL

SHUN PIKE
JOHNSTON, RHODE ISLAND 02919
TELEPHONE 401-942-1430
831-4440

06:52 AM JA 29 87

GROSS 50940LB

DATE

32000LB TR

№ 390714

18940LB NET

TARE

NET

CUSTOMER Truk Away

TYPE OF SALE: LANDFILL ☑ SLUDGE ☐ OTHER ☐

TRUCK TYPE: 30 yd op

TRUCK NO: H 15791-92

CHARGE ☑ CASH ☐

WEIGHER

DRIVER'S SIGNATURE X J Smith

APPENDIX C

CONTAINER INSPECTION RECORDS
JANUARY 29, 1987

Truck No.	Hauler	Material Description
40035	Goditt & Boyer	Paper
102370	Sweeney's	Garbage
82672	Truk-Away	Hosp. Garbage
279076	A. Metonis	Garbage
24561	Macera	Paper
423925	Goditt & Boyer	Paper
86736	Truk-away	Soap
118946	United's Rubbish	Rubber
112574	Macera	Paper & Wood
116819	D & K	Paper
423923	Goditt & Boyer	Paper
44675	Capuano's	Rubber
175	R.W. Selwyn	Paper
112575	Macera	Garbage
AC29440	Goditt & Boyer	Paper
111766	A. Macera	Yard-Garbage
14589	Macera	Paper & Wood
15791	Truk-away	Paper & Wood
88220	Truk-away	Demo
122626	Macera	Paper
112574	Macera	Paper
102370	Sweeney's	Garbage
103070	Rambone	O.J. 195 - Garbage
24561	Macera	Garbage
118946	United's Rubbish	Sludge
9508	Macera	Paper & Wood
279076	D. Matonis	Garbage
175	R.W. Selwyn	Paper
423925	Goditt & Boyer	Garbage
116819	D & K	Paper
116153	Robinson	Fur, Wood
122626	Macera	Paper & Rags
423923	Goditt & Boyer	Paper
112575	Macera	Garbage
64107	A. Macera	Yard Garbage
8581	Macera	Sludge
86736	Truk-Away	Paper
40035	Goditt & Boyer	Garbage
102370	Sweeney's	Paper
118946	United's Rubbish	Paper
AC29440	Goditt & Boyer's	Paper
24561	Macera	Garbage
112574	Macera	Wood
14589	Macera	Garbage
297076	A. Matonis	Garbage
15753	Truk-Away	Paper

APPENDIX C (continued)

1151	Vinagro	Paper
122626	Macera	Paper & Flooring
116819	D & K	Paper & Wire
175	R. W. Selwyn	Paper
71507	Bilray	Demo
112575	Macera	Garbage
88220	Truk-Away	Paper
107618	United's Rubbish	Paper
279076	A. Matonis	Garbage
15753	Truk-Away	Plastic
102370	Sweeney's	Garbage
AC29440	Goditt & Boyer	Form
423923	Goditt & Boyer	Paper & Rags
116153	Robinson	Wood
48270	United's Rubbish	Sludge
112574	Macera	Demo
40035	Goditt & Boyer	Fur, Wood
24561	Macera	Garbage
122626	Macera	Paper
279077	A. Matonis	Paper
103070	Rambone	O.J. 195 Garbage
92767	McCaughey	Wood
124556	Martin	Demo & Rugs
423925	Goditt & Boyer	Paper
101638	Macera	Garbage
27360	Macera	Garbage
37896	Liberty	Paper & Rubber
116819	D & K	Garbage
279076	A. Matonis	Garbage
48310	Macera	Paper
41887	T & J	Demo
9508	Macera	Paper & Rubber
76777	Macera	Demo
103499	Liberty	Paper & Rubber
102370	Sweeney's	Garbage
107618	United's Rubbish	Sludge
112575	Macera	Sludge
48270	United's Rubbish	Sludge
122626	Macera	Garbage
423923	Goditt & Boyer	Paper
116819	D & K	Paper & Form
279076	A. Matonis	Garbage
112574	Macera	Wood
118946	United's Rubbish	Sludge
9508	Macera	Paper & Rubber
423925	Goditt & Boyer	Paper
48310	Macera	Paper
121469	T & J	Demo
101638	Macera	Garbage
36621	United's Rubbish	Sludge

APPENDIX D

ANALYTICAL PROCEDURES

APPENDIX D

Analytical Procedures

RIAL evaluated the EPA standard methods associated with analysis for the contaminants of concern for water, Waste water and solid wastes. Because of the dilutions required in sample preparation, the necessary sample cross-section, and sample interferences associated with detecting parts per million levels of constituents normally associated with these methods, it was determined that these techniques were inappropriate. Accordingly, RIAL employed analytical methods normal followed in the characterization of similar bath samples. Standards and duplicate samples were run to evaluate procedural accuracy and repeatability. These methods are described below:

Sodium Cyanide Determination

*5 grams of sample into 100 mls of water
*Add mls of ammonium hydroxide
*Titrate with a 74 grams/1 liter water-copper sulfate solution
*End point is blue and each ml of copper sulfate is equal to 1 percent cyanide.

Standard: known 19.6%
observed 19.5%

Estimated Repeatability: ± 0.2%

Sodium Cyanate Determination

*1 gram of sample into 100 mls of distilled water.
*Add 5 mls concentrated H_2SO_4 and digest to 1/4 volume to drive off HCN and convert to CNO.
*Bring to 200 mls using distilled water.
*Add 50 mls of 50% NaOH
*Distill and collect 150 mls of distillate into 45 mls of 2% boric acid with methyl red indicator added

Calculations: $\% \text{ sodium cyanate} = \dfrac{\text{mls of } 0.02N\ H_2SO_4 \times 0.13}{\text{weight of sample}}$

Titrate to a red end point using 0.02N H_2SO_4

Standard: known 98% pure
observed 97.2%

Estimated Repeatability: ± 0.2%

Sodium Carbonate Determination

*0.5 grams into 100 mls of distilled water
*Add 25 mls of 10% BaCl solution

*Allow to stand at least 2 hours
*Filter out barium carbonate using a 1% BaCl rinse
*Add filter paper and cake to 100 mls of distilled water
*Add methyl red indicator and an excess of 0.1N HCl
*Boil for 5 minutes and backtitrate with 0.1N NaOH

Calculations: % sodium carbonate =

$$\frac{\text{mls of 0.1N HCl - ml 0.1N NaOH x 0.530}}{\text{weight of sample}}$$

Standard: known 57%
observed 58.8%

Estimated Repeatability: ± 1%

Sodium Chloride Determination

*0.5 grams into 50 mls of distilled water
*Add 5 mls of 30% formaldehyde and set 15 minutes
*Dilute to 150 mls with distilled water
*Add 5 mls of 1-1 HNO3 acid, add an excess of silver nitrate (measured), add 5 mls of ferric ammonia alum indicator
*Titrate with ferric thiocyanate to a reddisd-brown end point.

Calculations: % sodium chloride:

$$\frac{\text{mlso.in silver nitrate-mls 0.1N ammonium thiocyanate x .5845}}{\text{weight of sample}}$$

Standard: known 52%
observed 50.5%

Estimated Repeatability: ± 1%

APPENDIX E

APPENDIX E

Using the assumptions outlined in the report, the following calculations were made to evaluate the amount of cyanide bearing material that was suspected to be disposed of in the landfill.

Material converted to gaseous form:

$$150 \text{ pounds} \times 70\% = 105 \text{ pounds}$$

Material present in firebox:

$$150 \text{ pounds} - 105 \text{ pounds} = 45 \text{ pounds}$$

Material exposed to firebox conditions for greater than one hour:

$$45 \text{ pounds} \times \frac{7 \text{ hours}}{8 \text{ hours}} \times .4\% \text{ sodium cyanide level} = 0.158 \text{ pounds}$$

Material exposed to firebox conditions for more than fifteen minutes but less than one hour:

$$45 \text{ pounds} \times \frac{1\text{hr}}{8\text{hr}} \times \frac{45\text{min}}{60\text{min}} \times \frac{.5\%+.4\%}{2} \text{ sodium cyanide level} = 0.019 \text{ lbs.}$$

Material exposed to firebox conditions for less than fifteen minutes:

$$45 \text{ lbs} \times \frac{1 \text{ hr}}{8 \text{ hr}} \times \frac{15\text{min}}{60\text{min}} \times \frac{.5\%+25\%}{2} = 0.18 \text{ lbs.}$$

Total pounds as sodium cyanide, 0.356

Total pounds as cyanide, 0.21