SCS ENGINEERS

Fire Suppression Plan

Countywide Recycling and Disposal Facility

Submitted To:

Republic Services of Ohio II, LLC

REPUBLIC SERVICES, INC.℠
Adding value at every stop!™

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May 25, 2007
File No. 05206012.01

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Table of Contents

Section	Page
Executive Summary	ES-1
1.0 Introduction	1-1
2.0 Site and Project Background	2-1
2.1 Site Setting and History	2-1
2.2 Relevant History	2-1
2.3 Remedial Actions Taken to Date	2-2
2.4 Overview of Aluminum Industry Processes	2-3
2.5 Project Team	2-7
3.0 Field Investigations and Data Evaluation	3-1
3.1 Work Performed Prior to the March 28, 2007 Findings and Orders	3-1
3.2 Work Performed After the March 28, 2007 Findings and Orders	3-2
3.2.1 Daily Incident/Smoke/Steam Logs	3-2
3.2.2 Weekly Elevation Surveys	3-2
3.2.3 Weekly Residue Inspection	3-2
3.2.4 Weekly Gas Well Field Parameters	3-3
3.2.5 Vertical Temperature Profiles and Carbon Monoxide Testing	3-3
3.2.6 Monthly Aerial Infrared Photography	3-3
3.2.7 Aluminum Waste Sample Collection	3-4
3.3 Limitation of Oxygen	3-4
3.4 Odor Monitoring	3-4
3.5 Data Evaluation	3-6
3.5.1 Extent of Reaction	3-6
3.5.2 Surface Expression of the Reaction	3-7
3.5.3 Evaluation of Reaction Over Time	3-7
3.5.4 Stability	3-8
4.0 Reaction Evaluations	4-1
4.1 Aluminum Waste Reactions	4-1
4.2 Reactions in Waste	4-2
4.3 Duration of the Reaction	4-3
5.0 Remedial Alternative Evaluation	5-1
5.1 Alternative 1 - Excavation Of Waste	5-1
5.1.1 Alternative 1 Conceptual Design	5-2
5.1.2 Alternative 1 Implementation Schedule	5-2
5.1.3 Alternative 1 Evaluation	5-2
5.1.3.1 Alternative 1 Technical and Logistical Feasibility	5-2
5.1.3.2 Alternative 1 Cost Effectiveness	5-3
5.1.3.3 Alternative 1 Stability Impacts	5-3
5.1.3.4 Alternative 1 Potential Impact on Human Health, Safety, and the Environment	5-3
5.1.3.5 Alternative 1 Effectiveness/Performance	5-4

Table of Contents, Cont.

5.1.4 Alternative 1 Operation And Maintenance 5-5
5.1.5 Summary of Alternative 1 Excavation 5-5
5.2 Alternative 2 – Injection Technologies....5-6
5.2.1 Alternative 2 Conceptual Design 5-7
5.2.2 Alternative 2 Implementation Schedule 5-9
5.2.3 Alternative 2 Evaluation 5-9
5.2.3.1 Alternative 2 Technical and Logistical Feasibility 5-10
5.2.3.2 Alternative 2 Cost Effectiveness 5-11
5.2.3.3 Alternative 2 Stability Impacts 5-11
5.2.3.4 Alternative 2 Potential Impact on Human Health, Safety, and the Environment 5-13
5.2.3.5 Alternative 2 Effectiveness/Performance 5-13
5.2.3.6 Landfill Gas Temperature....5-14
5.2.4 Alternative 2 Operation And Maintenance 5-14
5.2.5 Alternative 2 Injection Technologies Summary 5-14
5.3 Alternative 3 - Additional Capping 5-15
5.3.1 Alternative 3 Conceptual Design 5-16
5.3.2 Alternative 3 Implementation Schedule 5-16
5.3.3 Alternative 3 Evaluation 5-17
5.3.3.1 Alternative 3 Technical and Logistical Feasibility 5-17
5.3.3.2 Alternative 3 Cost Effectiveness 5-17
5.3.3.3 Alternative 3 Stability Impacts 5-18
5.3.3.4 Alternative 3 Potential Impact on Human Health, Safety, and the Environment 5-18
5.3.3.5 Alternative 3 Effectiveness/Performance 5-19
5.3.4 Alternative 3 Operation And Maintenance 5-20
5.3.5 Alternative 3 Additional Capping Summary 5-20
5.4 Alternative 4 – Enhanced Best Management Practices 5-20
5.4.1 Alternative 4 Conceptual Design 5-21
5.4.2 Alternative 4 Implementation Schedule 5-21
5.4.3 Alternative 4 Evaluation 5-21
5.4.3.1 Alternative 4 Technical and Logistical Feasibility 5-22
5.4.3.2 Alternative 4 Cost Effectiveness 5-22
5.4.3.3 Alternative 4 Stability Impacts 5-22
5.4.3.4 Alternative 4 Potential Impact on Human Health, Safety, and the Environment 5-22
5.4.3.5 Alternative 4 Effectiveness/Performance 5-22
5.4.4 Alternative 4 Operation And Maintenance 5-23
5.4.5 Alternative 4 Enhanced Best Management Practices Alternative Summary5-23
6.0 Recommendations 6-1
6.1 Waste Excavation....6-1
6.2 Injection Technologies....6-1
6.3 Additonal Capping....6-2
6.4 Enhanced Best Management Practices....6-2
6.5 Summary....6-3

Table of Contents, Cont.

List of Figures

No.

1	Site Plan
2	Materials Flow Diagram
3	Cumulative Settlement April 16 to May 14, 2007
4	Landfill Gas Temperature Contour Map April 2007
5	Carbon Monoxide Concentration Contour Map April 2007
6	Aerial Infrared Photo, Overview
7	Aerial Infrared Photo, Detail
8	Temperatures at Base of the Landfill
9	Hydrogen Concentration Contour Map April 2007
10	Cumulative Settlement September 2005 to December 2006
11	Cross Section Locations
12	Cross Section A-A'
13	Cross Section B-B'
14	Landfill Gas Temperatures July 2006
15	Landfill Gas Temperatures December 2006
16	Stability Analysis Section Locations
17	Stability Analysis Cross Sections Sheet C-2
18	Stability Analysis Cross Sections Sheet C-3
19	Stability Analysis Cross Sections Sheet C-4
20	Stability Analysis Cross Sections Sheet C-5
21	Stability Analysis 1
22	Stability Analysis 2
23	Additional Capping Areas

Appendices

A	Boring Log
C	Treatability Testing Proposal

EXECUTIVE SUMMARY

Fire Suppression Plan Purpose and Contents

On March 28, 2007, the Ohio Environmental Protection Agency (OEPA) issued Director's Final Findings and Orders (F&Os) which require Countywide Recycling and Disposal Facility (Countywide) to perform tasks aimed at reducing odors and suppressing a reaction in the landfill. The reaction generates gas, with odors and temperatures above those typically seen in landfills.

Order 8 of the F&Os requires that Countywide prepare a Fire Suppression Plan (FSP). As delineated by Order 8, the FSP is to include : (1) information on the nature and extent of the reaction; (2) identification, discussion, an evaluation of various methods to control or suppress the fire or reaction and its gas emissions and odors; (3) the remedial alternatives are to include at minimum excavation, application of magnesium chloride, specialty foams, and additional capping; (4) an evaluation of each remedial alternative for its ability to suppress or control the reaction or fire relative to returning the landfill's settlement, methane, hydrogen, carbon monoxide, and temperature to typical levels; and (5) for each remedial alternative, an evaluation of the slope stability, cost, schedule for implementation, and an operations and maintenance (O&M) summary.

Background

We believe that the actions taken in the fall of 2006 under the original September 2006 F&Os were the right actions for that time, and continue to believe those actions were appropriate. Under current landfill conditions and under these new March 2007 F&Os, many of the efforts implemented under the previous F&Os will continue to be used. Those efforts were primarily to greatly expand and enhance the landfill gas collection and control system (GCCS) and to apply a geomembrane cap over 30 acres of the landfill surface where the reaction was most concentrated. Those efforts were designed to reduce significant odors by expanding the coverage and collection volume of the GCCS, by enhancing GCCS system efficiency with the cap, and by containing and collecting more gas. Those improvements offered relatively immediate benefits when completed in December 2006. The immediate benefits were improved with continued adjustment to the system that was completed in early 2007, resulting in additional improvement being achieved. The odor monitoring program data discussed in this report confirms the benefits of those actions. Odor detections off-site and the magnitude of those detections have decreased dramatically.

Landfill Reactions

This report (FSP) contains a section that discusses the general nature and history of aluminum processing and the wastes that may be generated by aluminum processing. Through our research, we believe we have characterized the above-normal conditions in this landfill as deriving primarily from a specific aluminum reaction. This reaction involves aluminum waste in the landfill that reacts with water to generate aluminum oxide, hydrogen, ammonia, and heat among other by-products. We believe the aluminum waste is undergoing a chemical reaction, and that it is not on fire. We are confident that there is no metal fire. We further believe that the municipal solid waste is not burning or undergoing a smoldering fire, but is undergoing pyrolysis. Our experience indicates that elevated carbon monoxide levels sometimes found in landfill fires are traceable to methane oxidation and other reactions related to the aluminum reaction and to the refuse pyrolysis that is occurring at Countywide. We believe that this aluminum reaction has a limited life, and is already over its peak in areas of the fill. We have estimated that the majority of the current aluminum reaction will end in approximately 2 years.

Remedial Alternatives

The FSP has identified and addressed four general remedial alternative categories including; (1) waste excavation, (2) injection technologies, (3) additional capping, and (4) continued interim actions.

Waste excavation would entail the excavation of at least the reaction volume, and possibly a larger volume of aluminum waste which is located in Cells 1 through 6. The total area at issue here is 88 acres, and the total waste quantity is approximately13 million tons. Aluminum waste is a significantly smaller amount, estimated at only about 600,000 tons. The aluminum waste is, however, interspersed and can not be excavated or handled separately. Waste excavation at an optimistic rate of 2,000 tons per day would take more than 10 years to complete, and would be prohibitively expensive. The excavation process would create significant health and safety concerns for site workers, and would create significant air emissions resulting in over-whelming odor impacts on the community. Waste excavation is not feasible.

Several injection technologies are addressed by this Plan, including magnesium chloride, sodium phosphate, sodium silicate, commercial fire-fighting foam, a surfactant known as FlameOut®, and inert gas. The injection technologies listed here are all intended to have chemical impacts, except for inert gas which would be intended to cool the reaction with no chemical impact. This report includes a preliminary evaluation of the particular technology's ability to provide chemical benefits by suppressing or controlling the reaction. Potential success of these technologies cannot be determined, however, until the completion of treatability studies which are now underway. Until the results of these studies are in, we must caution the reader that there is a very real possibility that these agents may have no benefit at all, and could even be detrimental to reaction suppression by fostering an expansion and/or acceleration of the reaction. The various chemical agents may also impact the integrity of the engineered components. Thus, the injection technologies will require additional study and evaluation.

Regardless of any particular injection technology's theoretical benefit, there is a question as to whether any particular chemical can be delivered in such a way that it could positively impact the situation at Countywide. Uniform delivery of any chemical agent (including inert gases) will be difficult, if not impossible to accomplish in the precise amount and concentration of the chemical needed to suppress the reaction. Past experience suggests that it is difficult if not impossible to deliver a product in a uniform, comprehensive distribution such that the agent reaches all parts of the waste mass. This is because the landfill's waste mass is heterogeneous and will likely contain large, tightly-packed waste masses that will not be able to be reached by such applications.

In addition, once the agent is no longer being applied, we have found that areas that were untouched and remain reacting will merely re-start reactions in those areas that had been suppressed. If any injection technology is considered (for the record, it is not recommended here), it cannot be implemented unless preceded by a small, pilot scale project to test for the likelihood of physical or chemical success in the field, and determine the ability to deliver the agent in a uniform and comprehensive manner. We therefore believe that this approach is not feasible on a large scale, but is deserving of further consideration for localized applications.

The next remedial alternative is additional capping. The F&Os prohibit additional waste disposal in most of the 88 acres (Cells 1 through 6) except for such waste necessary to bring the facility up to grade for closure. The F&Os potentially allow for additional waste fill only in the recently settled “bowl” depression area atop this area. This bowl area and additional flat areas atop the 88 acres in Cells 1 through 6 are the heart of the concentrated reaction area.

As a result, we conclude that final capping could proceed immediately on portions of the east or west sideslope areas of the 88 acres. The reaction is not affecting these areas and no additional waste deposits will be necessary. Countywide is prepared to start permanent capping of the east or west end as early as 2007. Given the predicted duration of the reaction and the practical area limits that can be capped in one construction season, we estimate that it may take 3-6 years to complete final capping in the entire 88 acre area.

In the meantime, we believe the remaining flat, settling, and depressed areas atop the fill should be left as they are for the time being, with perhaps some additional temporary cap applied in the next near future. Areas that could receive additional temporary cap will be evaluated to determine whether any benefit will be provided.

Enhanced Best Management Practices (BMPs) are the final category of remedial alternatives addressed in this Plan. Under this alternative, Countywide would implement a proactive, aggressive program including:

1. Installation of additional condensate pumps in certain gas wells;
2. Installation of additional gas wells where beneficial;
3. Enhancement of existing LFG header system;
4. Replacement of compromised existing LFG wells;
5. Maintenance of the intermediate cover soil;
6. Maintenance of the LFG, cover, and other systems;
7. Evaluation of, and refinement, the odor neutralizing system; and
8. Modifications to and addition to the temporary synthetic cap.

In addition, Countywide would implement a monthly inspection program of the landfill gas system and cap system. This inspection would be accompanied by an evaluation of the performance of these items and recommendations for continued best management practices.

Recommendation

It is recommended that we proceed with Enhanced Best Management Practices and permanent capping on portions of the 88 acres. We believe that some areas may benefit from temporary capping; those areas will be identified as an ongoing effort.

We believe that injection technologies have too many chemical unknowns and risks at this time, and cannot be delivered in a successful manner over a large area. If any injection technology is proven to have potential, based on the treatability studies in process, then it could be applied only on an initial, pilot scale, to determine if subsurface injection in a uniform and complete manner can be performed as local applications.

1.0 INTRODUCTION

This submittal is intended to satisfy the requirements of Order 8. of the March 28, 2007 Ohio EPA Director's Final Findings and Orders (F&Os) for the Countywide Recycling and Disposal Facility (Countywide).

A brief description of the Countywide facility and the project history is presented in Section 2.0 below. Section 3.0 presents the investigatory program and the evaluation of data procured in the investigations. The data collected during investigations were used to characterize the horizontal and vertical extent of the subsurface thermal reaction and the stability of the impacted area as required by Order 8.A.

Section 4.0 describes the reactions that are understood to be occurring in both the aluminum waste and the municipal solid waste.

Section 5.0 evaluates nine potential remedial alternatives according to the criteria described in Order 8.B. and Order 8.C. The remedial alternatives evaluated include the four minimum alternatives prescribed in Order 8.D. An evaluation of the potential impact on the stability of the impacted area by the implementation of each remedial alternative and an Operations and Maintenance discussion are presented for each remedial alternative, per Order 8E., Order 8F., and Order 8.G.

Section 6.0 presents the remedial alternative(s) recommended by Countywide based on the anticipated effectiveness in meeting the performance criteria stated in Order 8.B. and Order 8.C., technical feasibility, cost, and impact on human health and the environment.

2.0 SITE AND PROJECT BACKGROUND

2.1 SITE SETTING AND HISTORY

Countywide is a fully lined Subtitle D municipal solid waste landfill located in Stark County, Ohio. Countywide is owned and operated by Republic Services of Ohio II, LLC (Republic). Countywide is permitted and licensed to accept solid waste as defined in the Ohio Revised Code. Countywide has been in operation since 1991. Countywide was owned and operated by Waste Management, Inc. until February 1999, when it was purchased by Republic. The facility has engineered systems to protect the environment, including bottom liner, leachate collection system, and landfill gas collection and control system (GCCS). The site is depicted in Figure 1, Site Plan.

2.2 RELEVANT HISTORY

Solid waste landfills in Ohio are permitted to accept household waste, commercial waste, and non-hazardous industrial waste. Countywide estimates that it accepted, as one of its waste streams, approximately 600,000 tons of aluminum process waste between 1993 and 2006. The majority of this material was described as “dross” or “salt cake”, which are by-products of the melting of aluminum with a salt flux. Other related aluminum-containing wastes accepted by Countywide (at much smaller quantities) included cyclone and bag house dusts from various processes from both pre-processing and the melting of recycled aluminum. An overview of the relevant aluminum industry processes is presented in Section 2.4, below.

Historically, Countywide’s landfill gas (LFG) collection system operated as expected. Prior to late December 2005, the LFG well data were typically within expected ranges for normal waste decomposition and LFG production. By December 2005, Countywide had identified LFG wells with higher than expected temperatures. Around that same time, an increase in odor complaints was observed.

In light of the odors attributed to Countywide, the Ohio Environmental Protection Agency (OEPA) issued Directors Findings and Orders on September 6, 2006. By December 16, 2006, Countywide had complied with all the orders. This included installing enhancements to the LFG collection system in the area where high temperatures had been identified. In addition, Countywide voluntarily constructed approximately 30 acres of HDPE geomembrane cap over the impacted area. These improvements have been successful in reducing fugitive emissions and virtually eliminating the associated odors.

In addition to the temperatures and odors, substantial rapid settlement was observed in a specific portion of the landfill. This has resulted in settlement in the landfill surface and compromises to the intermediate cover and the HDPE geomembrane cap that was subsequently installed. These breaches to cover and cap have been repaired. Countywide also discovered changes in the landfill gas composition, including a decrease in methane, an increase in carbon monoxide, and an increase in hydrogen concentrations.

Based on these conditions, the OEPA felt that a fire was occurring in the landfill, involving both the aluminum waste and the MSW. The OEPA required Countywide to enter into a second set of F&Os which became effective on March 28, 2007. The F&Os require Countywide to prepare and submit a Fire Suppression Plan (FSP) no later than 60 days from March 28, 2007. The F&Os specify that four remedial alternatives be evaluated in the FSP, including application of a magnesium chloride solution, application of specialty foams, excavation of the aluminum wastes, and additional capping. Countywide has the option to determine what, if any, other remedial alternatives will be evaluated in the FSP.

It is Countywide's position that the process that is occurring in the landfill does not involve a metal fire in the aluminum waste or a smoldering fire in the MSW as was suggested to be occurring by the OEPA. While high concentrations of carbon monoxide (CO) can be an indicator of a landfill fire, other typical indicators are not present. No smoke has been observed at the landfill and no open flames have been observed in the settlement cracks that have occurred. In 2006, over 80 new gas wells were drilled at Countywide. Temperature measurements of cuttings (waste brought to the surface by the drilling process) from those borings were no higher than 200 deg. F, and no evidence of fire was noted during the inspection of the cuttings. No LFG wells have melted or otherwise been compromised by the presence of high temperatures. Thus, although temperatures observed in the landfill and in the LFG at the extraction well heads are higher than typical for a landfill, they are not as high as typically seen during actual landfill fires

Countywide believes that a reaction is occurring in the aluminum waste. The primary reaction is believed to be:

$$2\ Al + 6\ H_2O \Rightarrow 2\ Al(OH)_3 + 3\ H_2 + Heat$$

A more detailed explanation of the reactions identified above is presented in Section 4.0. The heat generated is high enough to disrupt the methanogenic bacteria in the MSW, resulting in a decrease in methane production. The heat generated by the aluminum waste reaction is also causing pyrolysis to occur in the adjacent MSW. Pyrolysis is a chemical decomposition brought about by heat. This heat driven decomposition of the waste and of the by-products of the normal waste decomposition process is resulting in the production of carbon monoxide. The reaction byproducts (i.e. gas) overwhelmed the LFG collection system in 2006, resulting in the increased fugitive emissions of gas and the associated odors.

2.3 REMEDIAL ACTIONS TAKEN TO DATE

Countywide implemented extensive measures in an effort to respond to the odor issues. Since late December 2005, consultants, contractors, and experts have designed, installed, and operated an expanded LFG collection/control system, along with other ancillary systems, to reduce the odors and LFG emissions.

In light of the odors attributed to Countywide, the OEPA issued an initial set of Directors Final Findings and Orders on September 6, 2006. By December 16, 2006, Countywide had completed all the work required by the orders. This work included installing enhancements to the LFG collection system in the area where settlement and high temperatures had been identified. The enhancements included the installation of additional extraction wells and increased flaring capacity. The capacity of the LFG collection and treatment system prior to the enhancements was approximately 3,000 scfm. The system's flaring capacity is now just under 10,000 scfm. Countywide also voluntarily constructed approximately 30 acres of HDPE geomembrane cap over the impacted area. These improvements have been successful in significantly reducing fugitive emissions and virtually eliminating off-site odors.

2.4 OVERVIEW OF ALUMINUM INDUSTRY PROCESSES

This general description of the Aluminum Industry is intended to provide background information on processes, equipment, input materials, products and wastes which are typical of many of the US aluminum production facilities in the 1970s through the 1990s. The observations about the generators are based on general knowledge of the Aluminum Industry plus published information and personal files. The descriptions are meant to show examples of the processes, equipment, materials, etc., and are by no means a complete list in any case. The information was collected from a review of public data and discussions with individuals with experience in the aluminum industry. The intent is to characterize the secondary industry and provide a platform for further investigations to determine what additional actions, if any, may be helpful from a remediation perspective.

Broad Description of Aluminum Industry

Primary Facilities

Primary aluminum is produced by reducing alumina (Al_2O_3) using large amounts of electrical energy and carbon. Fume control is sophisticated because of the materials involved in a reduction cell. A company can operate both Primary and Secondary facilities. Approximately 65% of the metal produced comes from primary plants.

Secondary Facilities

Secondary aluminum is produced by melting scrap aluminum or dross and converting the metal into an alloy to produce such things as castings, aluminum cans, building sheet, extrusions, and steel deoxidizers. The molten or solid aluminum could be used in-house for further manufacture or shipped to a customer.

With the proper scrap selection and operating practices, secondary plants can produce alloys to tight chemical limits. Metal from secondary plants can be cast directly into an automobile engine part or a sheet ingot to be rolled into can body stock. Secondary aluminum requires only 5% of the energy needed to produce primary aluminum.

Typical customers for these companies could be automobile manufacturers, major aluminum companies, steel producers, small engine, or siding products makers.

Secondary Aluminum Facilities

Typical Equipment used

Reverberatory Side-bay Furnaces (Often called Side Well Furnaces)

This is a stationary rectangular enclosed furnace with a hearth, heated by a gas or oil fired burner, using air or oxygen for combustion. This hearth is connected with arches to an adjacent bay where the scrap and salt flux are added for melting. The operating temperature is approximately 1350°F. Molten metal pumps are often used to increase metal circulation between the hearth and the side-bay. Metal is tapped from the hearth and black dross is skimmed from the surface of the side-bay. There is a hood over the side-bay, which draws fumes to a baghouse.

Rotary Furnaces
This is a drum shaped furnace with a refractory lining and a burner on one end. The gas burner fires toward the furnace wall and the furnace rotates bringing the hot refractory wall under and into contact with the scrap, dross, or salt flux. The operating temperature is approximately 1350°F. The furnace is tapped or tilts to remove metal and tilts further to dump out the salt cake. The charging end of the rotary furnace has a hood connected to a baghouse.

Crushers & Shredders
Many plants have crushers for pulverizing drosses to help separate metal from non-metals. Shredders are often used to break down large pieces of scrap into more manageable sizes. This also helps expose moisture and non-metallics in the scrap. Crushers and shredders are hooded and connected to a baghouse or cyclone to collect particulate. Magnetic separators are used for iron removal.

Delacquering Kilns
Delacquering is a process whereby scrap (usually used beverage cans) is heated to burn off the paints, lacquers, and oils. Fumes from this process are collected by a fume control system.

Baghouses & Cyclones
These are dust and fume collection units which capture particulate material from melting, delacquering, or shredding type operations. Furnace bags are usually coated with an injected powder to aid in particulate capture and tie up trace of materials that could be a problem, such as hydrochloric acid. Some equipment could use cyclones or afterburners for fume control.

Input Raw Materials

Scrap Types
Every type of industrial and post-consumer aluminum scrap that can be collected has a value and is shipped to a facility to be remelted and made into a new product. Scrap types include used beverage cans, old castings, siding, extrusions, and defective items, trim materials from manufacturing plants, etc. Metal recovery will be higher for new or heavy gauge scrap compared with light gauge scrap or old scrap, which usually has more contamination.

Salt Flux

Salt flux is used in almost all aluminum melting operations involving light gauge scrap. The molten salt has three purposes. It will:

- prevent oxidation of the molten aluminum surface,
- trap the non-metallics and contamination from the scrap, and
- coat the scrap pieces before they are melted to prevent oxidation.

The objective of the salt flux is to enhance the recovery percentage of molten metal from each pound of scrap or dross. As the salt flux absorbs the contamination from the scrap, it becomes more viscous and turns black. At this point, it is called dross. It also can entrain some aluminum from the molten metal surface.

Many plants look for ways to reduce their salt usage rates, but this often increases the likelihood of thermites in the dross and will affect metal recovery. "Thermite" is the industry term used to describe the rapid oxidation of aluminum (and specific contaminants, including iron) and release of extreme heat that sometimes takes place in hot dross from a furnace.

Chemistry
The majority of fluxing salts are made from sodium chloride (NaCl), potassium chloride (KCl) and a source of fluoride. They form a eutectic with a lower melting temperature (±1200°F. vs. 1450°F.). Approximately 5% cryolite (or another fluoride source) is usually added to the eutectic salt mixture. The fluoride increases the fluidity of the dross and is believed to strip the oxide film from molten metal droplets trapped in the molten flux and allow the droplets to coalesce. They will form larger drops and usually fall through the molten flux into the metal bath. The objective is to minimize the metal in the flux when it is removed from the furnace.

Waste Products from Secondary Plants

Waste products from secondary plants are process dependent, but can typically include the following.

- Side-bay Furnace Baghouse Dust – Contains primarily a bag coating material such as $Ca(OH)_2$ and particulate material from dirty scrap.

- Shredder/Dross Mill (Crusher) Baghouse Dust – Contains primarily dirt, contaminants, and some fine aluminum from the scrap or particulate from crushing dross. This particulate would contain oxides, metallic aluminum, and salt. A material called "fluff" is sometimes generated from shredding automobiles or other items with fibrous or plastic components.

- White Dross – Comes from the hearth of a melting furnace. It consists primarily of aluminum oxides, metallic aluminum with a particle size of 15mm and smaller. White dross usually contains no salt. The metal content can be from 30-60%. It is generally reprocessed, rather than disposed of by landfilling, to recover the metal content present.

- Black Dross – Contains salt flux, oxides, metallic aluminum, contaminants, and carbon from melting scrap. This material comes from the surface of the side-bay of a reverberatory furnace. It is usually scraped off into a container and cooled. The metal content is typically from 10 to 20%. Unmelted scrap such as foil or screen wire may be present in black dross due to poor operating practices. Depending on the market price for aluminum and the metal content of the dross, the black dross could be disposed of, including by landfilling, or reprocessed to recover more aluminum.

- Salt Cake – Contains salt flux, oxides, metallic aluminum, and contaminants from the charged material. This material comes from a rotary furnace. These furnaces usually require a higher ratio of salt flux since the charge material generally has more non-metallics than the material charged into a side-bay furnace. The metal content is typically from 5 to 10%. Depending on the market price for aluminum and the metal content, salt cake could be disposed of by landfilling or it could be reprocessed to recover more metal.

Excluding the bag house and cyclone dusts, the generators generically referred to all the dross type material disposed of at Countywide as "salt cake" and in our estimation, a majority of the aluminum waste disposed of at Countywide is likely "salt cake".

Material Flow Diagram for Generating Drosses

The Materials Flow Diagram presented as Figure 2 is taken from The Aluminum Association's Guidelines & Definitions, By-Products of Aluminum Melting Processes. Salt flux is used in side-bay and in the rotary furnaces. The main hearth of a side-bay melter generates white dross. The side-bays would have had a hood and baghouse connected to them to collect the fumes and particulate from melting the dirty scrap. Salt flux was added to the side-bay and therefore produced black dross. If this black dross was high in metallics, it may have been run through a crushing and screening system to separate it into higher and lower metal fractions. The higher metal fraction is put into a furnace to recover the metal. The lower metal fraction could be sent to landfill or to a salt recovery operation.

A rotary furnace is often used to melt material that contains a lower percentage of recoverable aluminum, typically 35% or less. Salt flux is added to the rotary furnace. Salt cake is the dross from the rotary furnace and is more fluid than typical black dross.

Several companies have tried to address the issue of salt consumption by developing a process for recovering the salt for reuse. This is a straightforward process, but the economics of the recovery may be marginal.

The salt recovery process involves:

- Crushing & screening black dross and salt cake to separate the metallics for remelting and crush the non-metallics into fine particles.

- Leaching the salt from the oxides and putting the mixture in a thickener system to separate the remaining solids and develop a brine solution.
- Sending the brine solution to an evaporator/crystallizer to recover the salt granules.
- Sending the underflow from the thickener to landfill. This material is mostly aluminum oxide and water, with traces of aluminum and other oxides.

Efforts are ongoing to find a use for this material, called Non-Metallic Product (NMP). This material is saturated with water or may be dried.

A salt recovery system was used for a period at certain companies to reclaim salt. In addition to reusing the salt in a furnace for melting scrap/dross, some companies pelletized this salt and sold it as a water treatment chemical. The high oxide product from the salt recovery process (called NMP, for Non-Metallic Product) is usually disposed of by landfilling, although efforts continue to find a use for this material.

Based on the information provided on the waste acceptance forms, general industry information, information specific to the generators, and samples collected during drilling through waste on-site, the following types of waste have been disposed of at Countywide:

- Salt cake
- Black dross
- Delacquering baghouse dusts
- Shredder baghouse dusts
- Furnace baghouse dusts

Secondary Industry Dross Disposal History

In the early days of the industry, waste material was often landfilled on site if acreage was available. The dross materials were considered to be non-hazardous and this was a low cost option. In later years, most waste dross materials were usually placed in non- or pre-Subtitle D landfills. With increased concerns over what future regulations could require, generators of aluminum waste began to move to Subtitle D landfills for dross disposal.

We have consulted with secondary aluminum industry experts who acknowledge that there is no precedent in the industry for the type of reaction that is occurring at Countywide, nor is there any way that Countywide could have anticipated that the reaction would occur.

2.5 PROJECT TEAM

Countywide and Republic have assembled an experienced team of experts to address the remediation of the reaction occurring at Countywide RDF. The team incorporates many years of experience and expertise in landfill design and construction, landfill gas systems, chemical characterization, treatability, landfill fires, and landfill stability. Many members of the team also have specific significant experience in the design and construction of Countywide RDF throughout the development of the facility. The following individuals are prominent contributors to the Fire Suppression Plan (FSP).

- James Walsh, P.E., BCEE, SCS Engineers – 33 years experience
- Randall Mills, P.G., SCS Engineers – 25 years experience
- Gary Saylor, P.E., SCS Engineers – 25 years experience
- Rick Moore, CIH, American Analytical Laboratory – 29 years experience
- Peter Carey, P.E., P.J. Carey and Associates – 30 years experience
- James Walker, P.E., Cornerstone Environmental Group, LLC – 25 years experience
- Michael Michaels, Cornerstone Environmental Group, LLC – 26 years experience
- Christopher Bower, Diversified Engineering, Inc., 15 years experience
- Michael Beaudoin, P.E., Earth Tech, Inc. – 23 years experience
- Thomas Bianca, P.E., Earth Tech, Inc. – 20 years experience
- Donald Pierce, Donald C. Pierce, LLC – 30 years experience
- Charles Schaefer, PhD, Shaw Environmental and Infrastructure, 10 years experience
- Stewart Abrams, Shaw Environmental and Infrastructure, 25 years experience

3.0 FIELD INVESTIGATIONS AND DATA EVALUATION

3.1 WORK PERFORMED PRIOR TO THE MARCH 28, 2007 FINDINGS AND ORDERS

Early in 2006, Countywide observed an unusual increase in temperatures, leachate outbreaks, accelerated settlement, and an increase in odors. Countywide undertook aggressive measures to evaluate and control the changes that were observed in the landfill. Specialty consultants were hired for this process, and, through their efforts, the nature of the issues were addressed. In August 2006, Cornerstone Environmental Group issued a comprehensive evaluation titled "Gas System Operating Review at the Countywide Landfill" which first described the suspected aluminum waste reaction and recommended additional measures to enhance collection of the additional gas being resulting from the reaction.

Then, on September 6, 2006, the OEPA issued Countywide Findings and Orders. The September 6, 2006 Findings and Orders memorialized Countywide's commitment to complete various actions it had begun implementing. These activities included:

- Weekly monitoring and tuning of all gas wells and fields as required by 40 CFR, Part 60, Subpart WWW.
- Monthly survey intermediate cover condition, and as needed scarify and recompacted the intermediate cover.
- Conduct a vacuum survey of the headers and lateral piping system.
- Identify and seal locations allowing either the venting of landfill gas or the intrusion of air.
- Weekly monitoring of the strength, location, and time of any odor identified by plant personnel at the facility boundary and identification the possible causes of that odor.
- Investigate all odor complaints to identify possible causes.
- Evaluate the current slope stability conditions in the affected areas.

In addition, a significant amount of work, including the installation of the 30 acres of temporary geomembrane cap, was voluntarily completed to reduce odors.

The regular monitoring that documented conditions within the landfill as required by OAC regulations and regular operations included:

- Monitoring landfill gas extraction wells for flow, temperature, methane content, and oxygen content.
- Sampling leachate and analyzing for OEPA required parameters on an annual basis.

The data collected pursuant to regulation and the September 6, 2006 Findings and Orders have been reported as required and were included in the data evaluated during the preparation of this FSP.

3.2 WORK PERFORMED AFTER THE MARCH 28, 2007 FINDINGS AND ORDERS

Order 4.A. of the March 28, 2007 Director's Final Findings and Orders (F&Os) required the collection of additional data. All field and raw data collected to satisfy these orders are currently kept on site. When requested by the OEPA, portions of data are transmitted via email. A description of the efforts made to comply with Order 4.A, accompanied by summaries of the results is presented in the following sections. The methods used to collect this data are described in detail in a report "Data Collection Plan and Historic Data Review," submitted to the OEPA on April 27, 2007.

3.2.1 Daily Incident/Smoke/Steam Logs

Each business day, Countywide prepares one or more daily logs recording any observations of incidents, steam, smoke, or anything else that could be attributed to the reactions occurring in the landfill. A brief summary of each of these follows:

- Incidents – Occasional repairs are needed on a routine basis or as a result of challenges caused by settlement at the landfill. These issues are noted in the logs.
- Smoke – No smoke has been observed.
- Steam – Contractors are tuning and adjusting the well field on a daily basis. There have been no observations of steam emitting from the landfill.

3.2.2 Weekly Elevation Surveys

Every week, a surveyor uses a dense grid of survey shots to monitor settlement at the top and on the side slopes of the landfill where well temperatures are greater than 131 deg. F. Each week, the surveyor produces two maps: one showing the settlement that occurred during the previous week, and one showing the cumulative settlement that has occurred since the first good base map (April 16, 2007) was produced for this Order. An example of these maps is presented as Figure 3. Comparison of weekly settlement maps indicate that the rate of settlement is decreasing.

3.2.3 Weekly Residue Inspection

Each week, a specialty contractor disassembles and inspects the flame arrestor at each flare location. The flame arrestor consists of a metallic grate that is intended to prevent backflash of flame from the flare tip. All gas that is burned in the flare passes through this flame arrestor before it is burned. Its design allows for accumulation of particles, condensate, or anything else in the landfill gas. To date, there has been no indication of residue indicative of combustion on the flame arrestors.

3.2.4 Weekly Gas Well Field Parameters

Every gas well on the landfill is visited by a technician at least weekly. The technician takes measurements of typical landfill gas parameters, makes adjustments to the well flow to optimize well field performance, and inspects the gas well for maintenance purposes. During these weekly measurements, landfill gas temperature and quality readings are made at the top of the well, indicating average values for the gas collected by that particular gas well.

Wells within the reaction zone typically exhibit low methane content, and higher than typical landfill gas temperatures. A plot showing the distribution of wellhead landfill gas temperatures for mid-April, 2007 is included as Figure 4.

3.2.5 Vertical Temperature Profiles and Carbon Monoxide Testing

Gas wells that have wellhead temperatures greater than 150 deg. F are subjected to downhole temperature monitoring on a monthly basis. A thermocouple is lowered in the well and temperature is recorded at 10 foot intervals. Typically, the maximum temperature found in the downhole sounding is about 20% higher than the temperature found at the wellhead (which yields an average temperature as discussed in Section 3.2.5.

The maximum downhole temperature recorded in April 2007 was 228.2 deg. F in gas extraction well PW-115.

In addition, in April, samples were collected for laboratory analyses of carbon monoxide (CO). A contour map indicating concentrations of CO is included as Figure 5. The 1,000 ppm CO contour very closely matches the >131 deg. F. temperature contour on Figure 4.

3.2.6 Monthly Aerial Infrared Photography

The first monthly aerial infrared photo of the landfill is presented as Figure 6 (overview), and Figure 7 (detail with spot temperatures). Three of the landfill flares can be clearly seen in the image on Figure 6 as the brightest areas. Generally, it appears that the area under the temporary geomembrane cap is warmer than the surrounding ground. This may be because the cap material has a higher emissivity value or it may be that the cap essentially covers the reacting area and warm gases are conveyed to the geomembrane surface from which it is collected.

In addition, the warmer spots (white areas), which range from 80 to 140 deg. F under the geomembrane cap may occur where settlement cracks in the underlying soil cap are releasing warm gas or may occur in low areas where condensate accumulates. This may occur because moist, warm gas is drawn up to the cap for collection, and when that gas contacts the liner, it is condensed by the cooler air above; the resulting condensate then accumulates in the low areas as warm pools in contact with the membrane.

There is no indication of fire in theses images.

3.2.7 Aluminum Waste Sample Collection

On May 17, 2007, a boring was advanced in the vicinity of PW-111 in order to collect additional samples of the aluminum waste for further laboratory analysis, including treatability testing necessary to assess the feasibility of various injection technologies. The proposed treatability testing program is described Section 5.2.3.1 below. The boring was advanced to approximately 79 ft below surface. A boring log is presented in Appendix A. Materials encountered included dross, salt cake, and a “super sack” containing bag house dusts. The bag house dust was encountered at approximately 15 to 20 feet below surface and exhibited an ammonia odor. The dross material was encountered between 40 and 60 feet. Small amounts of household trash and soil were included in areas within the dross material. The dross was described as dry. Temperatures of the dross material ranged from 140 to 170 deg. F. No smoke or steam was noted during drilling. The aluminum reaction is not occurring at this location at an appreciable rate.

Samples of the black dross and salt cake and a sample of the refuse were collected for laboratory analysis. A sample of the bag house dust was collected for record purposes. As described above, the aluminum content of the dust is believed to be low enough that it does not make a significant contribution to the ongoing reactions.

The results of the treatability testing will not be available for incorporation into this report.

3.3 LIMITATION OF OXYGEN

Concurrent with the weekly gas well readings described in Section 3.2.5, oxygen readings are taken at every well head on a weekly basis. 154 wellheads are currently in operation. Order 4.B requires that oxygen levels in the gas wells be at or under 1.5%. At the beginning of the F&Os oxygen reduction program, seven wells were above 1.5%. As of this writing, only two wells are above the 1.5% level, and Countywide is working diligently to reduce air infiltration to bring those oxygen contents down as well.

3.4 ODOR MONITORING

A comprehensive odor monitoring program in the community surrounding Countywide RDF was implemented by representatives of Republic Services in accordance with the September 6, 2006 Director’s Findings and Orders. This program was an extension of the pre-existing odor control and contingency plan dated March 2004.

On September 19, 2006 Diversified Engineering Inc. (DEI) representatives were trained in the use and documentation of the Nasal Ranger Olfactometer. This training took place at Slutz Park in Sandy Township, the training was provided by St. Croix Sensory Inc., the manufacturers of the Nasal Ranger.

On September 20, 2006 DEI began odor monitoring around Countywide. Beginning on September 20, 2006 and daily thereafter, a DEI odor surveyor conducted odor monitoring twice daily at 20 fixed monitoring points surrounding the facility. This monitoring loop is completed approximately eight times a day from 6 am to midnight weekdays and 2-4 times a day on weekends. The monitoring consisted of personal observations along with the objective measurement of odors that were detected using a Nasal Ranger Olfactometer.

For purpose of odor surveying, the "facility boundary" was defined as public roads that surround the landfill. Odor monitoring was conducted at fixed monitoring points on the surrounding roads. DEI returned to the exact locations for monitoring each day.

If an odor was detected during an odor survey, DEI personnel would measure the odor by using the Nasal Ranger and record the results. Upon discovery of detectable odor, DEI odor surveyors would investigate possible sources of the odor.

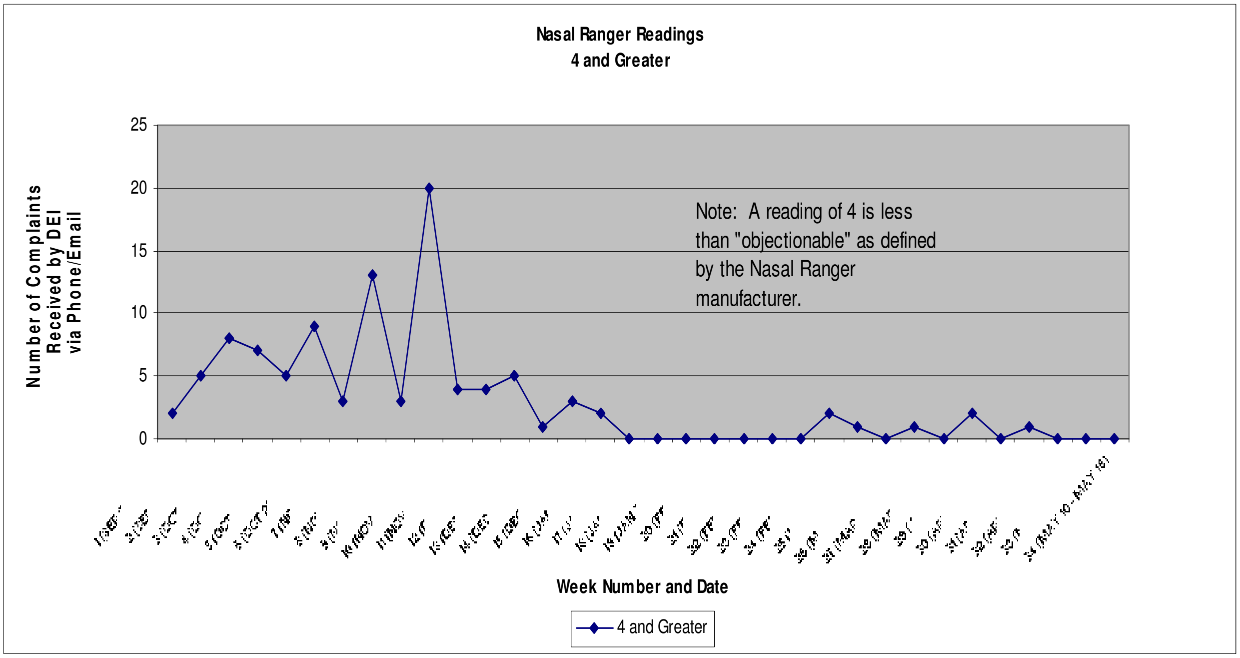
If the source of an odor was determined to be the landfill the odor monitor would report the odor to the Landfill Operations Manager, Landfill Engineer, or the Landfill Manager to determine possible causes of the odor. These potential causes of odor were recorded. In the event of an odor complaint, the odor monitor would go to the site of the complaint and follow similar procedures.

At the start of odor surveying and complaint investigations, odors were more intense and more frequent. Nasal Ranger results of 2 are classified "noticeable", results of 7 are classified "objectionable", and results of 15 are classified "nuisance". At times the odors measured a 7 or greater on the Nasal Ranger, during September, October, November and early December of 2006. This is not unexpected considering that much of the landfill work that was being conducted during that time period was intrusive and required certain acres of landfill to be "opened up" during construction.

Once 30 acres of HDPE cap and approximately 180 gas collectors were installed, measurable odors were reduced dramatically in frequency, intensity and duration. The figure below shows the decline in the number of investigated complaints with a Nasal Ranger reading of 4 or greater. In March and April, some intrusive maintenance activities were performed, resulting in a small number of complaints that were verified as "4"s. However, the record since the beginning of 2007 has shown remarkable improvement.

Clearly, the expanded and upgraded gas collection system is working as intended and has virtually eliminated landfill odors in the surrounding community. Countywide believes that it is at, or less than, the odors that are normally attributed to a landfill operation.

Nasal Ranger Readings
Countywide RDF



3.5 DATA EVALUATION

The objective of the data evaluation is to satisfy the requirements of Order 8.A. by describing the lateral and vertical extent of the subsurface reaction and evaluate the changes through time of selected indicator parameters.

It should be noted that the final results from much of the initial sampling and testing required by the F&Os are not yet available, or have not been available long enough to undergo evaluation, at the time of submittal of this document. This is due to the time needed to prepare the required work plans, the lag time between sample collection and the final data from the laboratory, and the lag time between the receipt of the final data and the release of the results following quality assurance review.

3.5.1 Extent of Reaction

The current lateral extent of the reaction has been evaluated using the following parameters: LFG wellhead temperature, carbon monoxide concentration in the LFG, hydrogen concentration in the LFG, methane concentration in the LFG, and the total settlement. The results of the evaluation of these parameters are generally consistent one another. Figure 4 presents the distribution of landfill gas wellhead temperatures above 131°F as measured in April 2007. Figure 5 present the carbon monoxide concentration in landfill gas as measured in April 2007. Figure 9 presents the hydrogen concentration in the landfill gas as measured on April, 2007. Figure 10 presents the total settlement measured from September 2005 to December 2006. Based on these drawings, the reaction is occurring primarily in the western edge of Cell 3, the southern half of Cell 4, and the northern half of Cell 6A. The elevated hydrogen concentrations, elevated temperatures, and elevated carbon monoxide concentrations extend more to the west into the southern portion of Cell 5A. The impacted area is roughly 33 acres out of the 88 total in Phases 1, 2, 3, 4A, 4B, 5A, 5B, 5C, 5D, and 6A.

There are no available records describing the placement of aluminum waste in the landfill that would allow the preparation of plan view maps or cross sections showing the location of the waste. The best information available is the total quantity of municipal solid waste and aluminum waste disposed of in each cell. The relative proportion of aluminum waste versus municipal solid waste provides a preliminary indication of the likelihood and intensity of the reaction in a specific cell. This will be affected by distribution of aluminum waste within the municipal solid waste. If the aluminum waste is dispersed, it will not provide a long term source of heat. If larger quantities of aluminum waste are present in an area the rate and severity of the reaction will depend on the density of the waste and rate at which water necessary for the reactions can infiltrate into the waste.

The vertical extent of the reaction has been evaluated using a series of cross sections through the landfill. Temperature measurements made in existing landfill gas extraction wells with temporary thermocouples and temperature measurements made within the leachate collection system at the base of the landfill are contoured on two east-west cross sections. The cross section locations are shown on Figure 11. The cross sections are shown in Figures 12 and 13. The data are insufficient to adequately delineate the vertical extent of the reaction because downhole temperature readings collected in only select wells in the reaction area. The data do show, particularly in section A-A', that the reaction is not continuous at a specific depth across the reaction area. A cooler zone at well PW-150 separates warmer zones at PW-102 and PW-104, to the west and east respectively.

3.5.2 Surface Expression of the Reaction

Per Order 4.A.1., Daily Incident History Logs have been maintained by Republic and subcontractor personnel. Per Order 4.A.2., Daily Smoke and Steam Documentation has been performed by a designated individual. As of the date of this submittal, no reports of smoke or flame have been logged. No steam has been observed emitting from the ground.

3.5.3 Evaluation of Reaction Over Time

Figure 14 presents the landfill gas temperatures from July 2006. Figure 15 presents the landfill gas temperatures from December 2006. Figure 4 shows the landfill gas temperatures from April 2007. Based on these temperature distributions, and based on inspection of Figure 3 (cumulative settlement), the reaction appears to be moving in some areas and diminishing in others.

Another method for evaluating the progress of the reaction over time is the time-rate of settlement caused by the chemical degradation of the waste resulting from the reaction. Between April 2006 and March 2007, an average of about 1,400 cubic yards of settlement occurred daily in the reaction area. Between April 16, 2007 and May 21, 2007, about 800 cubic yards per day of settlement occurred in the same area. This suggests that the intensity of the reaction may be decreasing.

3.5.4 Stability

As required by F&Os Order 8.E., a slope stability analysis of the current facility has been performed and is summarized below. The analysis shows that the landfill is stable. Potential stability concerns that should be addressed when evaluating the remedial alternatives are described within the discussion of each of the alternatives.

Beginning in the summer of 2006, a slight outward motion of a portion of the southern slope of the landfill was observed. This area was the subject of study and stabilization efforts during the fall of 2006 and has been stabilized. The study of the area identified the causes of instability as the presence of a low strength/ low permeability interface proximate to the existing waste surface and high pore pressures/parallel seepage conditions within the waste mass above the aforementioned interface. No other types of instability or indications other types of instability could develop were identified during the evaluation of the south slope “affected area”. The investigations and stabilizing activities were reported to the OEPA in October and December 2006 and in January 2007.

Stability of the east, west and north slopes of the area within Cells 1-6 were evaluated during the applications for expansion of the landfill in 2000 and 2001 and remain unchanged. The focus of this evaluation was to determine if other areas around the perimeter of the cells had conditions similar to those found in the “affected area” or other conditions that would lead to instability.

Identification of Hypothetical Weak Interfaces

An example of the filling conditions identified as being necessary in to the development of slope instability is presented on Figure 18, at Station 56+73.96. To determine if this weak area may potentially affect other areas of the landfill, an inspection of the existing and the 2002 waste grades was completed. Figures 17 through 20 present the cross sections, depicting the existing grades, 2002 waste grades, and the bottom liner throughout the landfill. This inspection showed that the only areas where some fill has been placed over the old waste interface occur directly under the haul road on the north face of the cell. This fill was not waste but road fill. No indication of the “sliver fill” similar to the “affected area” was identified elsewhere within the area encompassing Cells 1-6.

Piezometric Heads

Gas pressures were measured in 8 landfill gas wells along the north and east faces of Cells 1-6 on May 2, 2007. These wells are depicted in Figure 16. The specific gas wells were chosen to cover the zones adjacent to the region of the landfill experiencing elevated temperature. The valves connecting the wells to the collection header were closed and the pressures were allowed to stabilize. The stabilized pressures are presented below.

Well	Dead Headed Pressure (inches of water column)
B-2	40.5
W-9	.3
W-33	1.8
PW-56R-2	6.2
PW-56R-M	200.5
PW-104	1.5
PW-105	2.2
PW-123	1.7

The highest pressure (200 inches of water column) was measured in Well W-56R-M, which extends 119 feet below grade. The pressure measured in the shallower well W-56R-2, extending 100 feet below grade and not more than 55 feet away from W-56-M, was substantially lower, indicating a significant reduction in pressure within the waste mass as the landfill surface is approached. Other readings were substantially lower and typical of dead headed pressures at landfills. The stability analyses, presented in Figures 21 and 22, represent the conditions at station 14+95. The analyses utilize the pore pressure parameter, r_u, to demonstrate that 200 of water column measured at depths of greater than 40 feet below the landfill cap surface does not suggest any stability problems. This corresponds to a R_u of 0.4. The pore pressure parameter is equal to the ratio of pore pressure to vertical. The pressure heads measured at 20 feet or deeper, with the exception of PW-56R-M correspond to an r_u of 0.16 or less. As can be seen comparing Figures 21 and 22, potential failure surfaces that would involve the baseliner are less sensitive to elevated pore pressure, even when conservative values of shear strength are assigned to the baseliner system.

Site Inspection

Peter J. Carey, PE of P.J. Carey & Associates and Jim Walker, P.E. of Cornerstone Environmental Group, LLC conducted a site reconnaissance of Cells 1-7 on April 24, 2007. Performance of the reconnaissance was to make observations of any visible issues with stability. No signs of instability were observed. Inspections of the surface topographic surveys, performed by DEI, were also conducted. No indication of instability was observed in these surveys.

Conclusion

No signs of instability were observed at the site within Cells 1-6. No conditions, similar to those know to have caused the instability on the south slope were found to exist on the perimeter of the remainder of the site. Therefore, it can be concluded that the existing site is stable, as was demonstrated in the PTI submittals associated with the current site permit.

4.0 REACTION EVALUATIONS

This section is a summary of the most probable reactions occurring in the Countywide Landfill. Many different parameters were evaluated and researched before deciding on the most probable reactions, including:

- Historical data of waste disposed of in the landfill
- Chemical analyses of the gas from the wells.
- Leachate analytical results
- Temperature data from various locations within the landfill

Data was reviewed from landfills operating under normal conditions for use as a control basis.

4.1 ALUMINUM WASTE REACTIONS

Aluminum is a versatile element. It constitutes about 8 percent by weight of the earth's crust and it is exceeded in amount only by oxygen and silicon. It is found in auto parts, power transmission lines, magnets, paints, coatings, shaving cream, and toothpaste. Secondary aluminum processing produces waste called dross. This dross is typically a mixture of aluminum, metal oxides, metal halide salts, metal nitrides, chlorides, and carbides.

Elemental or metallic aluminum is very reactive and will form an oxide coating instantaneously. Aluminum powder or dust in contact with water may heat spontaneously. Moist, finely divided aluminum powder may react in air, with the formation of hydrogen gas. Bulk aluminum metal itself is not combustible.

Within the conditions of the landfill environment, an unanticipated reaction started within the aluminum waste. Based on the information from the industry that the baghouse dusts typically do not contain a significant percentage of metallic aluminum, it is assumed that the reactions are occurring primarily in the dross material. Some of the chemical reactions that are known to be possible with the carbides, nitrides, and elemental aluminum in the aluminum dross are outlined below.

Hydrogen, Water, and Heat Production

The first reaction believed to take place with the aluminum dross involves water and the metallic aluminum. This reaction produces hydrogen and heat.

$$2\ Al + 6\ H_2O \Rightarrow 2\ Al(OH)_3 + 3\ H_2 + \text{Heat}$$

Countywide is experiencing increased temperatures in the landfill due to the heat being released and large amounts of hydrogen gas are being liberated.

Ammonia from Nitrides in the Aluminum Dross

The aluminum nitrides in the dross are reacting with water to produce ammonia as expressed below.

$2\ AlN + 3\ H_2O \Rightarrow Al_2O_3 + 2\ NH_3$

Significant levels of ammonia are being measured from the landfill leachate.

Methane from Carbides in the Aluminum Dross

Aluminum carbides, also in the dross in small quantities, are reacting with water to yield methane.

$Al_4C_3 + 6\ H_2O \Rightarrow 2\ Al_2O_3 + 3\ CH_4$

Although methane is being produced from this reaction, methane production from the reaction area of the landfill is lower than normal. This is most likely due to the higher than normal temperatures in the reaction zone. Increased temperatures results in halting the anaerobic decompositional phases from fully occurring. Methane production from normal landfill decomposition becomes very limited.

4.2 REACTIONS IN WASTE

Many secondary or side reactions are likely occurring in the Countywide landfill. Many of these can be produce carbon monoxide and likely provide a legitimate explanation of the presence of carbon monoxide other than a fire. The following are examples of secondary aqueous reactions in the landfill may be producing carbon monoxide in addition to the pyrolysis.

Formic Acid + Heat

$CH_2O_2 + \text{Heat} \Rightarrow CO + H_2O$

The source of formic acid is from areas of the landfill where the anaerobic phase is still taking place. Formic acid is a strong reducing agent and therefore very reactive. Other reactions will take place with formic acid to yield carbon monoxide.

Acid Dehydration of Formic Acid

Acids such as H_2SO_4 'dehydrate' Formic acid releasing CO

Other secondary reactions producing carbon monoxide are:

- Partial Oxidation of Methane to CO

  $CH_4 + \frac{1}{2}\ O_2 \Rightarrow 2\ H_2 + CO$

- Release from Carbonates with Heat (Zinc Example)

  $Zn + CaCO_3 \Rightarrow ZnO + CaO + CO$

4.3 DURATION OF THE REACTION

Chemical Model

Based upon the aluminum dross reaction mechanism, a model was developed to predict the remaining length of time the reaction will continue. The model is based on several assumptions including the following:

1. The maximum amount of metallic aluminum in the dross is 15%.

2. Water produced from the reaction is approximately 1,000,000 gallons per month.

3. Hydrogen released without reacting with oxygen averages 750 cfm.

If conditions in the landfill remain unchanged the model provides the following results based on the current data:

- Total time needed for the reaction to significantly diminish is 40 months or about 3.5 years. Since the reaction has been going on for approximately 18 months, the total time left is predicted to be slightly less than 2 years.

- Heat generated by the dross reaction is averaging 4.5 million BTUs per day.

This model may be refined or updated based on ongoing analyses.

Physical Model

As discussed in Section 3.5.3, settlement rate and may be an indicator of the intensity of the reaction and the total volume of settlement may be a predictor of the duration of the reaction. A physical model for this purpose is being developed for consideration.

5.0 REMEDIAL ALTERNATIVE EVALUATION

Order 8.D. of the F&Os required that, at a minimum, the following remedial alternatives be evaluated:

- Magnesium chloride application
- Foam application
- Excavation of waste
- Additional capping

The following additional remedial alternatives have been identified and are also described in the sections below:

- Phosphate or silicate salt solution injection
- Injection of FlameOut® solution
- Inert gas injection
- Enhanced Best Management Practices

The alternatives are presented in four general groups:

1. Waste excavation,
2. Injection technologies (including magnesium chloride, phosphate salts, silicate salts, foam, FlameOut®, and inert gas),
3. Capping alternatives, and
4. Continued monthly interim actions.

5.1 ALTERNATIVE 1 - EXCAVATION OF WASTE

This alternative involves the excavation of a large quantity of the waste materials in Cells 1, 2, 3, 4A, 4B, 5A, 5B, 5C, 5D, and 6A for the purpose of attempting to remove a majority of the aluminum process waste buried in those cells. By removing the water reactive aluminum waste from the landfill, the "fuel source" of the reaction would be eliminated, which would likely result in a reduction of the high temperatures and excessive gas. Excavation to control combustion of materials in a landfill is generally limited to shallow areas where the excavated waste can be doused with water to extinguish a fire immediately after excavation. The conditions that generally apply when excavation is used as a method to control combustion at a landfill are not present at Countywide.

The aluminum material and resulting reaction is deep within the waste mass and cannot be suppressed by simply applying water or normal fire retardants to the surface of the landfill. This alternative is also complicated by the limited amount of information on the location of the aluminum wastes within the landfill and the lack of information about the minimum quantity of waste necessary to undergo a significant reaction.

5.1.1 Alternative 1 Conceptual Design

The outcome of this alternative would be an excavated pit in the center of the 88-acre area that comprises Cells 1, 2, 3, 4A, 4B, 5A, 5B, 5C, 5D, and 6A. It is estimated that the pit may eventually be 150 or more feet deep in some areas and cover a surface area of 50 to 60 acres. For stability of the excavated slopes, it is estimated that the cut slopes in the excavation would need to be benched or cut to a slope 3:1 or higher, resulting in the large surface area for the excavation (see 5.1.3.3 below). Excavated waste material that does not contain aluminum waste would be transferred to an active disposal cell at the landfill or moved to another area of the excavated pit. Excavated aluminum waste would have to be diverted to a temporary holding area for on-site treatment to control and/or to stop the oxidation reaction. The aluminum waste would need to be rendered inert prior to reburying the waste or shipping it off-site for reuse or disposal. Special measures, not yet identified, would need to be developed to stop the material from reacting in more violent fashion when exposed to the atmosphere.

5.1.2 Alternative 1 Implementation Schedule

The time needed to implement this alternative would be significant. Due to worker safety concerns, the excavation process would need to be a relatively slow and controlled process compared to conventional soil excavation. Assuming an excavation rate of 2,000 tons per day of in-place waste material and using conventional excavation techniques, it is estimated that the excavation process could take 10 years or more (working 6 days per week) in order to reach and remove a majority of the aluminum waste in the 88-acre area. It would then take an additional amount of time after excavation is completed to fill the excavation and permanently close the 88-acre area.

5.1.3 Alternative 1 Evaluation

In the following sections, the anticipated impact of Remedial Alternative 1 is evaluated against the performance criteria presented in Order 8.C.

5.1.3.1 Alternative 1 Technical and Logistical Feasibility

The technical and logistical feasibility of excavating the volume of waste necessary to adequately remove the aluminum waste from the 88-acre area is extremely low. From a technical standpoint, the physical excavation and handling of the waste would present many challenges that include worker safety, impacts to the gas collection system, acceleration of the aluminum waste reaction, oxygen intrusion in the waste, odor control during excavation, and increased leachate production. Handling of the excavated material would present its own unique challenges with regard to inspection of the material for aluminum waste, handling and disposal of ammonia off-gassing material, and providing a temporary storage/treatment location for the excavated aluminum waste. In addition, identification and segregation of dross from other waste would be difficult.

Once the excavation would start, the opportunity for additional oxygen and water entering the waste in the 88-acre area would greatly increase. As the excavation continued, more and more water would enter the excavated area increasing the likelihood of expanded subsurface reactions. At the same time, the existing gas collection system would need to be scaled back and vertical wells in the excavation would need to be eliminated. This would result in a large increase in fugitive air emissions during excavation and a significant increase in odors in direct contrast to the goals of this endeavor. The additional water entering the waste mass via rainfall in the open excavation would be in direct contradiction to Order 1. in the F&Os requiring the facility to cease leachate recirculation in Cells 1, 2, 3, 4A, 4B, 5A, 5B, 5C, 5D, 6A, and 7.

Opening the aluminum waste and the surrounding MSW to additional oxygen intrusion would also result in a substantially increase in subsurface reactions. Allowing more oxygen into the already warmer than normal areas of waste could cause an actual landfill fire. During the time period it would take to complete the excavation, the actions of excavating the waste would only accelerate and increase the subsurface reactions and have a negative impact on suppression potential.

5.1.3.2 Alternative 1 Cost Effectiveness

The cost of implementing such a massive excavation of waste under the current conditions would be significant. It clearly would have the highest costs of any of the alternatives. It is also the alternative with the greatest risks and the most negative impacts on the surrounding community. This is the least cost effective of all the alternatives evaluated within the FSP and is actually cost prohibitive.

5.1.3.3 Alternative 1 Stability Impacts

Excavation of the waste materials would be needed to elevations within several feet of the base liner to allow removal of the potentially reactive waste. The maximum excavation slope for waste materials is limited by the strength of the waste and shear strength of the base liner as well as the pore pressures within the waste mass. Given the type of liners at the site and reduced shear strengths associated with pyrolized waste, the safe excavation slope is approximately 3H:1V in Cells 2 through 6 where textured liner product was utilized. In Cell 1 where smooth baseliner and clay were utilized in the liner, this excavation slope would be flattened to approximately 4H:1V.

5.1.3.4 Alternative 1 Potential Impact on Human Health, Safety, and the Environment

The impacts on human health, safety, and the environment from this alternative could be substantial in light of the potential dangers associated with this alternative. This would include potential health impacts from the increased fugitive air emissions during excavation, safety for workers working within and around the waste excavation, and a potentially significant negative impact to the environment from increase air emissions and odors.

While the potential human health impacts from excavation cannot be quantified at this time, it is reasonable to assume that people living down wind of the facility would have a higher exposure to fugitive gases and odors than if the waste were to be left in place and covered. Gases that are currently being collected would escape the site and could likely include various volatile organic compounds (VOCs), carbon monoxide (CO), and particulate matter. The route of exposure would be through inhalation of the increased fugitive gases. Foul odors, though not necessarily posing an increased health risk, would certainly be a quality of life issue for those living down wind of the facility.

Worker safety during the excavation process would be a major concern. At a minimum, personal protective equipment (PPE) at a modified Level C would be required for all workers in the excavation that includes some form of respiratory protection. At certain times, full Level C or even Level B (with supplied breathing air) may be required. In any event, minimizing worker exposure to high concentrations of potentially dangerous compounds would be paramount. Other dangers to workers would include working close to heavy equipment, heat stress, and dangers associated with potentially unstable excavation slopes. A comprehensive Health and Safety Plan (HSP) would have to be developed prior to the start of excavation, including requirements for PPE, worker training, and medical monitoring.

Negative impacts to the environment would primarily be the degradation of air quality in the surrounding area resulting from the increased fugitive air emissions during excavation. Greenhouse gas emissions of methane and carbon dioxide would increase because of a less effective gas collection system during excavation. Increased emissions of carbon monoxide, particulate matter, and other air pollutants would also decrease air quality. Leachate generation rates at the landfill would increase during excavation resulting in additional wastewater to be managed that would have previously been non-contaminated runoff.

5.1.3.5 Alternative 1 Effectiveness/Performance

The following sections evaluate this alternative for each of the performance metrics indicated under Order 8. under the F&Os.

5.1.3.5.1 Prevention of Nuisance Odors and Uncontrolled LFG Emissions

As described above, the implementation of the waste excavation remedial alternative would result in a significant increase in nuisance odors and uncontrolled gas emissions during the excavation operations. The waste excavation remedial alternative would, upon completion of the excavation and the construction of final cap over the remaining waste, reduce nuisance odors and uncontrolled LFG emissions to normal levels associated with MSW landfills.

5.1.3.5.2 Carbon Monoxide Levels

The waste excavation remedial alternative would, upon completion of the excavation and the construction of final cap over the remaining waste, reduce carbon monoxide production to normal levels. At that time, all the aluminum waste would have been removed or would have fully reacted, eliminating the heat source that is driving the carbon monoxide production in the MSW. During the excavation activities, carbon monoxide production would continue. In the excavation areas, the carbon monoxide produced would be released as the landfill gas collection system is removed in the excavation area and shut down in nearby areas to prevent air from being drawn into the landfill, potentially creating an actual landfill fire.

5.1.3.5.3 Rapid Settlement

The waste excavation remedial alternative would, upon completion of the excavation and the construction of final cap over the remaining waste, eliminate the rapid settlement.

5.1.3.5.4 Hydrogen Production

The waste excavation remedial alternative would, upon completion of the excavation and the construction of final cap over the remaining waste, eliminate hydrogen production. At that time, all the aluminum waste would have been removed or will have fully reacted. During the excavation activities, the hydrogen production would continue. In the excavation areas, the hydrogen produced would be released as the landfill gas collection system is removed in the excavation area and shut down in nearby areas to prevent air from being drawn into the landfill, potentially creating an actual conventional landfill fire.

5.1.3.5.5 Methane Production

The waste excavation remedial alternative would, upon completion of the excavation and the construction of final cap over the remaining waste, allow methane production to return to normal levels. The amount of methane produced would depend on how much of the organic matter in the waste has already been consumed by the current accelerated reactions.

5.1.3.5.6 Landfill Gas Temperature

The waste excavation remedial alternative would, upon completion of the excavation and the construction of final cap over the remaining waste, allow the landfill gas temperatures to return to normal levels. At that time, all the aluminum waste would have been removed or would have fully reacted, eliminating the heat source that is contributing to the current high gas temperatures, both directly and through the secondary reactions caused in the MSW.

5.1.4 Alternative 1 Operation And Maintenance

The long-term operation and maintenance for an excavated area of waste would be the same as a closed MSW landfill once the area is backfilled and closed. In the interim, until all the excavation of the aluminum waste could be completed, a modified version of F&Os Order No. 4 (Data Collection and Immediate Precautionary Measures) would be implemented. A list of monitoring and precautionary measures required during excavation would be developed along with a detail implementation plan for this alternative, if selected.

5.1.5 Summary of Alternative 1 Excavation

Overall, the long-term effectiveness of this alternative is over-shadowed by the negative impacts to human health, safety, and the environment during the excavation. While eventually achieving the benefit of the source of the subsurface reactions being removed, the process of removing the source will only increase the current subsurface reactions and have a significant negative impact on local air quality for the period of time needed to complete the project. The expected performance of this alternative in delivering a reasonable near term solution to odor problems at the facility is nil.

5.2 ALTERNATIVE 2 – INJECTION TECHNOLOGIES

The alternatives below are being considered as a group because they share a common logistical challenges, that is, how to ensure that the active agent is introduced into the landfill in such a manner so that it is uniformly distributed throughout the impacted materials.

The overall approach for this alternative includes selecting an injectant that, when in contact with the reactive aluminum metals (and the impacted MSW), will mitigate the exothermic reactions and gas production. The selected injectant must be readily available in bulk quantities, be non-hazardous for transport and handling, and be readily dispersed in aqueous media if not in gaseous form. Based on a combination of literature review, discussions with industry experts, and preliminary laboratory testing, several compounds were identified that meet these criteria. The list of potential injectants is as follows:

- Magnesium Chloride – Magnesium chloride is sometimes used as a fire extinguishing agent for flammable metal fires. It is typically applied as a dry powder to the burning metal. Studies have suggested that magnesium chloride (or magnesium chloride hydrates) in a water solution can serve as a fire suppressant (Esmail et al., 2001; Chand and Verma, 2005). In addition, preliminary laboratory testing of aluminum dross material from the Countywide Landfill showed that magnesium chloride suppressed the rate of the aluminum hydrolysis reaction, as evidenced by reduction in the gas generation rate. The likely mechanism for this mitigation is the formation of magnesium hydroxide on the surface of the aluminum metals, which serves as a temporary passivating layer on the dross surface. Magnesium hydroxides have been shown to be effective fire suppressants (Hornsby, 2004).

- Sodium Phosphate – Studies have shown that phosphate salts can be effective fire suppressants (Fisher and Jayaweera, 2002). In addition, Krnel and Kosmac (2000) have shown that phosphates can form insoluble complexes on the surface of aluminum metal, thereby reducing the rate of hydrolysis reaction.

- Sodium Silicate – Similar to phosphates, silicates can also form complexes on the surface of reactive aluminum metals, thereby reducing the rate of hydrolysis reaction Krnel and Kosmac (2000). Sodium silicate is also used as a fire protectant.

- Commercial Foam – Fire suppressing foams as applied in typical structural firefighting work by forming a barrier between the fuel and the oxygen, and by cooling the surface. Firefighting foam typically consists of three components; water, air, and foam concentrate. Foam can be generated by entraining air into the water and foam concentrate solution at the point of application using a specialized nozzle, or by mixing compressed air with the water and foam concentrate solution. Because this remedial alternative would require injecting the foam into the landfill, compressed air foam would be required. The injection of large quantities of air would present a significant risk of converting the current situation in the impacted areas of the landfill into a full blown subsurface landfill fire.

- Flame Out® - Flame Out is a commercially available aqueous fire suppressant that contains surfactants that allow for wetting and cooling of the fuel surface. The FlameOut® compound is also purported to scavenge oxygen (i.e., tie it up chemically so it is not available for combustion) and encapsulate volatile organic compounds. These additional properties would contribute to the FlameOut® solution's ability to control the secondary reactions occurring in the MSW.

- Inert Gas – Carbon dioxide and nitrogen have been used to combat typical subsurface landfill fires. When the gas in injected under pressure, it cools the fuel and displaces any oxygen that is supporting combustion.

To test the efficacy of each of the most promising of these potential injectants, a bench-scale study may be performed to determine the impact of each compound on the rate and extent of aluminum metal reaction. The testing can be performed to determine the appropriate injectant dosage, and to verify the irreversibility of the reaction mitigation. Details of the proposed laboratory testing and evaluation procedure are provided in Appendix B.

The approach to accelerate the main dross reaction mechanism would face the same problems relating to introducing the above injectants. There may be a variety of ways to accelerate these reactions, however they would most likely be impractical or ineffective because of the uncontrolled environment the reaction mechanism is occurring in. An example of this would be adding a catalyst. Assuming there is a catalyst found to be effective in a laboratory environment; it would theoretically be a candidate to add to the landfill to speed up the reactions. The temperatures, pressures, and concentrations would vary greatly within the landfill. Variations as these could render the catalyst ineffective. Chemistry in the landfill is another unknown variable. Poisoning of the catalyst would be a real possibility. While this potential alternative could shorten the time that the landfill would have to deal with the symptoms of the reaction, it is not being considered due to the uncertainties about the effect of any accelerant and the risk of unanticipated reactions.

5.2.1 Alternative 2 Conceptual Design

Following the completion of the treatability studies and selection of an injectant, implementation of Alternative 2 could consist of in situ treatment of the reactive aluminum metals and the impacted MSW by delivering the suppressant agent within the landfill. Materials likely will be delivered using a network of injection wells or injection points. Alternately, or in conjunction to the injections, amendments could be percolated through the landfill with leachate or other waters. Depending upon the level of difficulty associated with injecting into the reactive zones (discussed in Section 5.2.3.1), injections will target the center of the reaction zone, focus on mitigating the reaction from the perimeter of the "hot spots", or simply serve to prevent the expansion of the reactive zones.

Overall treatment effectiveness will be assessed in terms of performance criteria presented in Order 8.C. in the F&Os:

1. decrease the carbon monoxide in the landfill gas,

2. end rapid settlement,

3. decrease the hydrogen in the landfill gas (presumed hydrolysis products of the dross material),

4. return of methane concentration in landfill gas to normal levels indicative of methanogenesis, and

5. decrease landfill gas temperatures.

Magnesium Chloride, Phosphate Salt, and Silicate Salt Solutions; Specialty Foam; and FlameOut®

If the bench scale testing demonstrates that one of these agents is effective in reducing or stopping the aluminum reactions under laboratory conditions, an on-site pilot scale test would be conducted. The pilot scale test could evaluate a number of approaches to introducing the agent solution, including:

- using existing gas wells,
- using the existing leachate recirculation system,
- surface application
- new wells, or
- some combination of the above.

If the pilot scale testing demonstrates that the agent solution can effectively be distributed through the waste mass, a full scale program could be implemented. The design of a full scale program could focus on treating the entire impacted area or it could focus on treating only those areas where the reaction is expanding, to prevent the spread of the reaction while it runs its course in the majority of the currently impacted area.

For the foam application, a specialty foam contractor would employ a proprietary apparatus that mixes water, mine fire fighting foam concentrate, and nitrogen to create foam. The apparatus would also inject the foam. Support equipment would include 1000 scfm air compressors, nitrogen generators, KVA electrical generators, light plants, diffusers, nitrogen chillers, and a great deal of miscellaneous equipment. Water from the storm water retention ponds would be used to prepare the foam. If insufficient volume is available from the retention pond, select leachate, with minimal on-site pretreatment, could be utilized.

For the other agents, a contractor would mix the concentrated agent with water in large batches. Again, water from the storm water retention ponds could be used to prepare the solution for injection unless chemical and/or physical properties prove to be undesirable. The use of leachate could also be evaluated if the stormwater ponds do not contain sufficient volume.

The FlameOut® supplier's application recommendations included using small diameter injections wells. Two applications were recommended. Approximately 10,000 to 15,000 liters or approximately 5 to 10 liters of solution per cubic meter of waste in the well's zone of influence would be injected at 100 to 150 psi. If necessary, 1 liter per cubic meter could be applied on a maintenance level. As an alternative to using permanently constructed injections wells, the FlameOut® could be injected by using a very high pressure, low volume pump to both advance a temporary well point and inject the solution at the same time.

Inert Gas

If the MSW reactions need to be addressed, inert gas injection could be considered. It is assumed that the inert gas would be injected using an array of small diameter injection wells because of temperature and pressure issues. As with the water solutions above, the design of a full scale program could focus on treating the entire impacted area or it could focus on treating only those areas where the reaction is expanding, to prevent the spread of the reaction while it runs its course in the majority of the currently impacted area.

The gas would be injected into one or a small group of wells on multiple occasions. At a minimum, the landfill gas collection system would be turned off in the immediate vicinity of the injection activity. Alternatively, the landfill gas collection system would be turned of in the entire impacted area during treatment. If part of the landfill gas collection system remains active, gas extraction wells near the injection area might be able to be used to "steer" the migration of the treatment gas. The downside of leaving the landfill gas collection system active near the treatment area would be the capture of a significant amount of the treatment gas. If the methane (and/or hydrogen and carbon monoxide) content is sufficiently reduced, the flare(s) could require supplemental fuel to burn.

5.2.2 Alternative 2 Implementation Schedule

On site pilot scale testing of Alternative 2 is necessary to determine the feasibility of this approach and to determine critical, site specific design parameters such as injection pressures, injection point spacing, in situ reaction kinetics, radius of influence and distribution, optimum delivery rates and concentrations, and overall treatment effectiveness. The pilot testing program will utilize from one to three injection wells. The immediate vicinity of the test would be monitored to evaluate the success of both the delivery and effect of the treatment agent. It is anticipated that the pilot testing program could be designed and implemented within 60 days of a selection of this alternative. The performance and evaluation of an appropriate pilot test would require an additional 3 to 6 months.

It is anticipated that the initial duration of the expanded remediation program following pilot testing would take another 3 to 6 months. Some reduced level of activity, as described in the Operations and Maintenance section below, could continue for one to two years, until it has been verified that the performance criteria have been achieved or it has been demonstrated that they cannot be achieved.

5.2.3 Alternative 2 Evaluation

In the following sections, the anticipated impact of Remedial Alternative 2 is evaluated against the performance criteria presented in Order 8.C.

5.2.3.1 Alternative 2 Technical and Logistical Feasibility

Implementation of Alternative 2 presents several potential challenges. First, delivery of injectants to the reactive zones within the landfill will be difficult. Elevated temperatures (> 200 degrees F) and pressures (> 5 atmospheres, if the landfill gas extraction system has to be shut down during treatment) may make any sort of injection delivery technique technically difficult to infeasible within the reactive zone. If so, an iterative injection approach may be needed that gradually delivers amendments from the perimeter or an edge of the reactive zone, or is applied across the surface of the reactive zone and infiltrates downward. If a surface distribution system has to be constructed to implement this approach, the breaching of the temporary liner and/or the intermediate cover would result in a significant increase in the releases of odor and fugitive gas emissions. The use of the existing leachate recirculation system could also be evaluated to supplement either an injection or infiltration delivery system.

Distribution of the injected materials within the landfill poses the biggest challenge. The nature of municipal solid waste landfills typically consists of a very heterogeneous subsurface, with many preferential flow pathways. Ultimately, this would result in a relatively small radius of influence around each injection point, thereby increasing the number of injection penetrations required for treatment. Given the large area of the impacted zone (approximately 33 acres), poor distribution could result in an unreasonable number of injection points that would be both time and cost prohibitive. We believe that an injection technology could only be effective in a localized area.

Injection of the suppressant amendments might also result in a decreased permeability within the landfill due to unanticipated chemical reactions. This permeability loss may become a problem if the rate of permeability reduction is greater than the rate of reaction mitigation. If so, it may become increasingly difficult to deliver injectants to the targeted zones, thereby decreasing overall treatment effectiveness.

Because of the inherent challenges described above, it is recommended that (pending successful demonstration at the bench scale) a pilot test be performed prior to any full-scale implementation. Pilot testing of Alternative 2 is not only needed to determine the feasibility of this approach, but also to determine critical, site specific design parameters such as injection pressures, injection point spacing, in situ reaction kinetics, radius of influence and distribution, optimum delivery rates and concentrations, and overall treatment effectiveness. It is anticipated that the design, implementation, and evaluation of an appropriate pilot test would require at least 3 to 6 months.

One consideration specific to the application of foam is that it is uncertain how it would remain a foam as it moves away from the injection point and out through the MSW, before it breaks down into its liquid and gas components. If the radius of influence as foam is small, the effect of foam injection would not be significantly different from the combined injection of the same relative amounts of gas and foam concentrate water solution.

5.2.3.2 Alternative 2 Cost Effectiveness

Until the bench scale testing demonstrate one of the injectants is effective and until the pilot study demonstrates that is possible to effectively distribute the injectant through the waste mass, there is insufficient information available to prepare sufficiently detailed design of a full scale implementation program and there is insufficient information to evaluate the cost effectiveness of any of the injection technologies. If a closely space array of injection wells were required for effective application, the cost of an injection technology program would become prohibitive and would not be cost effective.

5.2.3.3 Alternative 2 Stability Impacts

The injection of magnesium chloride, phosphate salts, silicate salts, specialty foam or FlameOut®, as described in Section 5.1.1, entails pumping an aqueous solution under pressure into the fill through injection points. In general, all injection processes, including this one, raise pore pressures at the injection point, which create a pressure gradient between the point of application and the surrounding areas. This pressure gradient provides the transportation mechanism of the injected liquid throughout the fill. The injection results in an increase of pore pressure within the waste mass and therefore always reduces the stability of the mass. The potential impacts of this reduction in stability of the landfill are very dependent on the method and scale of injection as well as the location of the injection relative to the sloping surfaces of the landfill. Pore pressure increases are physically limited to the minor principle stress plus the tensile strength of the media being injected. If pressures above this threshold level are generated during injection, hydro-fracturing will occur. Fracturing and associated strength reduction of the waste mass will likely be necessary to inject adequate quantities of solutions into the presumably low permeability waste mass that is anticipated at the depth of the reactions. Both of these phenomena are discussed briefly below.

Pore Pressure Increase

Classical Pore Pressure Increase

Pore pressure increases that occur at the point of injection typically associated with injection of liquid into a porous media, are very dependent on the method of injection, the rates of injection, and quantity of injection. The pore pressure increase will also depend on the temperature of the media surrounding the injection point. Increasing the injection pressure, the rate of injection, and the amount injected will all result in increased pore pressures that could be persistent for weeks or months

The rate of pore pressure dissipation depends on the permeability and deformability of the media being injected and the amount of liquid added during the injection process.

Temperature Related Pore Pressure Increase

Injection of liquids may occur within areas where the temperature is above 212ºF. As such, steam may be generated. The generation of steam would potentially cause rapid fracturing of the waste mass unless vents for the steam were constructed in advance of the injection.

Pore Pressure Increase Related to Gas Conduction Reduction

The injection of liquid into the landfill may also have an impact on the landfill gases that are being collected. Even if no additional gas volume is generated due to the injection, adding moisture to the waste mass will decrease the available pore space for gas transmission. As such, the pressure loss from the point of generation to the collection device will increase. The increase in the amount of pressure loss will be dependent on the amount of liquid added to the site, the elevation at which it is added and the size of the area injected, as well as the gas conduction properties of the waste at the depths affected by the injection.

Hydro-fracturing and Strength Loss

Fractures created within the material being injected are described as hydro-fracturing. These fractures are developed normal to the minimum principal stress and tensile strength of the material. The fractures remain open as long as the pressure creating them persists. In the case of solid waste materials, the fracture will impact the strength along the fracture, likely eliminating any true tensile strength by the rupture of the reinforcing fibers crossing the fracture. If fractures occur during injection they become the primary conduit for injected materials. Therefore, if the volume of injected material is large or if steam is created, the fracture can grow to significant dimensions. Given the minimum principal stress in the ground is typically oriented near horizontal, vertical fractures would be expected. In some cases, the subsidence created by volume reduction in the waste or dross creates a stress field where the horizontal stress within the waste if very low if not negative. This is evident in the development of tension cracking at the surface on the flanks of the depression on top of the landfill. Therefore, hydro-fracturing may occur at injection pressures far lower than the typical 0.6 or 0.7 times vertical stress computed based on total overburden less pore pressure.

Hydro-fracturing can also lead to rapid transport of grouted liquids upward through the waste mass where they could have negative impacts on the stability of the near surface wastes and possibly the stabilizing berm on the south side of the landfill.

If the material injected contains solids or will take up space in the fractures once the injection pressure is removed, the strength of the injected material in the fractures needs to be considered in the stability analyses.

Limiting Pore Pressures/Hydro-fracturing

The amount of excess pore pressure or hydro-fracturing that can be accepted without detrimental impact to stability will be determined based on the specific requirements of the injection process. At this time there are too many unknowns associated with the undefined injection process, location, etc. to allow a meaningful analysis to be performed. Measurements of the increase in pore pressure and hydro-fracturing during and following any injection can be measured during any pilot study performed. Required restrictions based on stability issues can be developed and incorporated into the injection process plan along with proposed monitoring to preclude development of stability issues. Specific restrictions on the volume of injection allowed within a given time period or on temperatures of general areas which may generate steam will also be required. These restrictions will be needed due to the difficulty in monitoring pressure or fracturing within a waste mass when injecting. In addition, specifications would need to be developed on for values of pore pressures if any are monitored. These restrictions would be typical of those contained in grouting programs.

The stability impacts for inert gas injection would be the same as for the water solution injection without the potential for steam generation.

5.2.3.4 Alternative 2 Potential Impact on Human Health, Safety, and the Environment

The treatment agents may present some risks to human health and safety of the workers implementing the program. For example, the inhalation of magnesium chloride dust during the preparation of the water solution could result in "metal fever" in affected workers (Merck Index, 1989). Magnesium chloride also generates significant heat when dissolved in water and presents the risk of scalding from the heated solution.

5.2.3.5 Alternative 2 Effectiveness/Performance

The following sections attempt to compare the potential effectiveness of the injection technology approach in general, and the specific agents if they have a unique effect.

5.2.3.5.1 Prevention of Nuisance Odors and Uncontrolled LFG Emissions

It is anticipated that the drilling of injection wells and the making and unmaking of connections to the injection wells would result in a short term increase in the release of nuisance odors and landfill gas emissions.

Any long term positive impact on odor would result from a decrease in the production of non-methane gases in the aluminum waste and the MSW, thereby reducing the pressure driving the gases to escape from the landfill. If any of the agents included in this section are successful in stopping or retarding the aluminum waste reactions, it is anticipated that the potential for the creation of the unique odor attributed to the aluminum reactions would be reduced. The interim actions have been successful in capturing and eliminating the odors currently being created without remediation.

It is anticipated that these alternatives would reduce some of the excess gas being produced in the impacted areas. The cooling effect of the agents would reduce the amount of carbon monoxide being generated from the MSW. The impact of these alternatives on the generation of hydrogen is dependent on their effectiveness in stopping or retarding the aluminum waste reactions. The results of the bench scale testing will provide some indication of which, if any, of the agents affect the aluminum reactions.

5.2.3.5.2 Carbon Monoxide Levels

The application of sufficient water or inert gas to the impacted areas of municipal solid waste would cool the MSW and thereby reduce the secondary reactions in the MSW being driven by the heat generated by the dross reaction(s). This should result in reduced carbon monoxide levels.

5.2.3.5.3 Rapid Settlement

The application of sufficient water to the impacted areas of municipal solid waste would cool the MSW and thereby reduce the secondary reactions in the MSW being driven by the heat generated by the dross reaction(s). This should reduce the rate of settlement.

5.2.3.5.4 Hydrogen Production

Unless the passivation is successful, the addition of additional water will maintain and could potentially accelerate the reactions in the aluminum waste and the resultant generation of hydrogen until all the dross has been reacted.

5.2.3.5.5 Methane Production

The application of sufficient water to the impacted areas of municipal solid waste would cool the MSW and thereby reduce the secondary reactions in the MSW being driven by the heat generated by the dross reaction(s). Once the MSW is cooled to a temperature at which the methanogenic bacteria can survive, methane generation from al parts of the MSW will resume. The amount of methane generated from the impacted areas will depend on how much of the original organic matter present in the MSW remains. Methane production in the MSW outside the impacted areas may increase with the presence of additional water.

5.2.3.6 Landfill Gas Temperature

Application of sufficient water to the impacted areas would absorb the heat generated by the dross reaction and cool the impacted MSW. The cooling of the impacted MSW would reduce the secondary reactions occurring in the MSW and would result in lower landfill gas temperatures.

5.2.4 Alternative 2 Operation And Maintenance

During and immediately following the implementation of the selected remedy, a modified version of F&Os Order 4. (Data Collection and Immediate Precautionary Measures) would be continued. A list of short-term and long-term monitoring and precautionary measures required would be developed along with a detailed implementation plan for this alternative, if selected. This may include retreating hot spots that remain or redevelop.

The long-term operation and maintenance of the engineered components of the landfill will be the same for this alternative as required for any MSW landfill, once the reactions cease and the area is closed.

5.2.5 Alternative 2 Injection Technologies Summary

The physical technologies under this Alternative 2 include inert gases. All of the other technologies are chemical agents, intended to suppress or control the reaction through chemical actions. The chemical benefits of these agents are unknown pending the completion of the laboratory treatability tests now ongoing. Until these are completed, there is no way to know if these agents will provide chemical benefit in suppressing or controlling the reaction. In fact, there is even some risk that these agents may provide more harm than benefit by possibly accelerating the reaction. Note that at minimum, all such agents will use water as a carrier media, and that water was earlier believed to have started or exacerbated the aluminum reaction conditions at Countywide.

Of greater concern however, is the challenge of applying these media in a uniform manner that gets to all of the reacting waste. Landfills are heterogeneous masses with channels of low resistance for fast passage surrounded by tightly packed waste deposits that neither low nor high pressure liquid or gaseous agents are likely to penetrate. Our experience with applying gaseous agents in a conventional landfill fire has shown that these gases do an effective job of suppressing or extinguishing the fire in areas of high gas flow. But other areas remain hot or burning when not exposed to the injected gas. And that once the application is removed, the heated or burning areas can re-ignite those areas that were suppressed at great effort and expense by the gaseous injection. In short, there is no way to apply injected agents to all parts of the subsurface waste mass, regardless of well spacing or application pressure. Thus, application of such media will prove very challenging, and makes this alternative unlikely to succeed.

If application of such agents is ordered, small pilot scale programs should be done first to see if the concerns here are valid or if they can be abated.

5.3 ALTERNATIVE 3 - ADDITIONAL CAPPING

Additional capping is an alternative that would provide the following benefits:

- Further incremental reduction of moisture into the landfill
- Further incremental improved gas collection
- Further incremental reduction of air intrusion
- Further incremental improved odor control

It is believed that the first benefit listed will reduce the duration of the existing aluminum waste reaction and the potential for the remaining reactive material to react by limiting the infiltration of additional amounts of water.

As an alternative, additional capping can consist of temporary capping, permanent final capping or a combination of temporary and permanent final capping. At this time landfill gas temperatures in the landfill are continuing to be monitored and status of the reaction is continuing to be assessed. It is probable that the reaction may still be occurring in some areas where elevated temperatures have been observed. Therefore a combination of temporary and final cap construction is recommended.

5.3.1 Alternative 3 Conceptual Design

The conceptual design approach for this alternative is to final cap the areas within the 88 acre area where:

1. no reaction is apparent or anticipated in the future
2. stable slopes can be maintained during and following cap construction
3. liner tie-in for future cell 9 would not be impacted
4. access roads would not be impacted
5. gas control system operation would not be impacted

Based on these criteria, the areas shown in green in Figure 23 have been selected for final cap construction.

Remaining areas within the 88 acre footprint are eligible for temporary capping with the following consideration:

1. existing access roads are not required to be capped due to the need for access and the low permeability of existing soil from heavy truck access
2. critical gas operational areas such as flares, valves, etc should not be disturbed if this would be detrimental to gas control

5.3.2 Alternative 3 Implementation Schedule

The implementation schedule is influenced by a number of factors such as the following:

1. time of construction initiation due to seasonal weather impacts
2. availability of construction materials, especially recompacted soil barrier material
3. construction preparation and coordination required for the gas collection system
4. review and approval of the permit modification by Ohio EPA which is required under a separate Order
5. weather impacts during actual construction

With the consideration of these items, the estimated time needed to completely apply a permanent cap would be approximately 3 to 6 years. The maximum area to be covered with a permanent cap in one construction season would be 20 to 25 acres. Permanent capping could commence in 2007 construction season, on the east or west slopes of Cells 1-6, subject to the availability of construction materials.

Temporary capping would be implemented on an expedited schedule or on an as needed basis, depending on current assessments.

5.3.3 Alternative 3 Evaluation

In the following sections, the anticipated impact of Remedial Alternative 2 is evaluated against the performance criteria presented in Order 8.C.

5.3.3.1 Alternative 3 Technical and Logistical Feasibility

The alternative of temporary and final cap construction is technically the most reliable solution to reducing the duration of the reaction. While other alternatives exist, they are less reliable. Capping on the other hand will definitely influence the reaction by reducing the amount of water available to the aluminum waste. Cap construction is also a very feasible alternative as it involves routine construction procedures which can be implemented with minimal preparation as compared to other alternatives which can involve more study and pilot testing.

Engineered caps have long been successfully used to seal buried wastes, reduce fugitive air emissions, reduce water infiltration into the waste (thereby decreasing leachate production), and enhancing landfill gas collection. Final caps can be placed with conventional construction equipment using a combination of natural and synthetic components. A drawback to placing additional cap on this facility would be a tendency to retain more of the subsurface heat in the landfill for a longer period of time. This however would likely be offset by the reduction in chemical reactions in the aluminum waste due to less water and oxygen reaching the material.

A major concern with scheduling would be placing the final cap too soon and have some of the cap components damaged by differential settlement that is occurring in the landfill. A possible approach to this potential problem may be to limit the capping areas initially to a pilot-scale project or installing a temporary cap where the performance of the cap design could be evaluated between construction seasons. If modifications to the design are needed, these could be incorporated into subsequently capped areas. It would not be feasible to install final cap in any area of the landfill still subject to rapid differential settlement.

Sealing the aluminum waste and the surrounding MSW to additional oxygen and water intrusion would result in substantially decreased subsurface reactions. Allowing less oxygen and water into these areas of waste would be an effective method in controlling any reaction by starving the affected area of oxygen.

5.3.3.2 Alternative 3 Cost Effectiveness

The cost of installing additional cap material on the landfill is substantial, but would be less than the waste excavation alternative. The additional capping alternative would provide an incremental improvement in conditions at the landfill with little negative impact on the surrounding community. This alternative has a moderate to low cost effectiveness.

5.3.3.3 Alternative 3 Stability Impacts

No negative stability impacts are anticipated from additional capping in currently stable areas, other than issues related to the cap strength itself, which can be designed based on conditions anticipated. The decision to apply a permanent rather than a temporary cap in the impacted area will be controlled by the ongoing rate of settlement in that area. Also, there is a need to maintain the buttressed slope until such time as the pore pressures within the slope area subside and the buttress can be removed, precluding final cap construction in this area.

5.3.3.4 Alternative 3 Potential Impact on Human Health, Safety, and the Environment

The impacts on human health, safety, and the environment from this alternative would be relatively low. Potential impacts on human health, safety and the environment include the following:

1. slope instability,
2. increased stormwater runoff from temporary cap areas or final cap construction areas until vegetation is established, and
3. possible short term increase in landfill temperatures as a result of increased gas available for collection once the cap is installed.

Slope stability is addressed in Section 5.3.3.3. Based on this discussion, slopes are expected to be stable. Shear strength testing will be performed to confirm the required shear strength will be provided to assure slopes will be stable.

Capping would preclude potential health impacts from increased fugitive air emissions, the potential for worker exposure would decrease, and there would be a general positive impact to the environment from decreased air emissions and decreased leachate generation. Landfill gas production and temperature trends can be monitored during cap construction to determine if the gas system needs adjustment or upgrading during or following cap construction. Stormwater runoff should be analyzed as part of the cap design and additional control measures constructed if necessary to avoid impacting the environment.

While the potential human health impacts cannot be quantified at this time, it is logical to assume that the area down wind of the facility will have a lower exposure to fugitive gases and odors than if the waste was to be excavated. There would still be gases escaping the site during implementation that would likely include various volatile organic compounds (VOCs) and carbon monoxide (CO). Odors, though may not necessarily posing an increased health risk, would be less compared to other alternatives. Increased traffic entering the facility from trucks hauling clay soil (if needed) could have a negative impact on local air quality through increased exhaust emissions and fugitive dust.

Worker safety during the capping process would be a concern, but no more than during any other landfill capping project. Workers should be able to perform their duties in Level D personal protective equipment (PPE), and not be required to have respiratory protection. Typical dangers to workers would include working close to heavy equipment. A project Health and Safety Plan (HSP) would need to be developed prior to the start of work, but would not necessarily have to include site-specific requirements medical monitoring.

Impacts to the environment would be the eventual improvement in air quality in the surrounding area resulting from the decreased fugitive air emissions from the landfill. Greenhouse gas emissions of methane and carbon dioxide would decrease because of a more effective gas collection system after capping. Decreased emissions of carbon monoxide, particulate matter, and other air pollutants would also tend to improve air quality over time. Leachate generation rates at the landfill would decrease after capping, resulting in less wastewater to be managed. Leachate head levels in the landfill would decrease over time, decreasing the potential for future ground water issues at the facility.

5.3.3.5 Alternative 3 Effectiveness/Performance

The following evaluates this alternative against each of the performance metrics contained in the F&Os Order 8, for the Fire Suppression Plan (FSP):

5.3.3.5.1 Prevention of Nuisance Odors and Uncontrolled LFG Emissions

The additional capping remedial alternative will reduce the potential for the release of odor and uncontrolled LFG emissions in those areas of the landfill which receive final capping. The control of nuisance odors and uncontrolled LFG emissions in the impacted area will continue to depend on the interim actions that have successfully been accomplishing this task to date. Improvement in the control of nuisance odors and uncontrolled LFG emissions in the impacted area will have to wait until settlement has decreased to the point where the impacted area can be brought to a final grade and a final cap constructed.

5.3.3.5.2 Carbon Monoxide Levels

The additional capping remedial alternative will not have a direct impact on the carbon monoxide generation. This alternative may have a minor, indirect impact through the reduction in water infiltration, which could help reduce the water available for the aluminum waste reactions. A decrease in the aluminum reactions would reduce the amount of heat available to drive the reactions creating carbon monoxide in the MSW.

5.3.3.5.3 Rapid Settlement

The additional capping remedial alternative will not have a direct impact on the rapid settlement. This alternative may have a minor, indirect impact through the reduction in water infiltration, which could help reduce the water available for the aluminum waste reactions. A decrease in the aluminum reactions would reduce the amount of heat available to drive the reactions that are reducing the MSW volume.

5.3.3.5.4 Hydrogen Production

The additional capping remedial alternative will not have a direct impact on the hydrogen generation. This alternative may have a minor, indirect impact through the reduction in water infiltration, which could help reduce the water available for the aluminum waste reactions and thereby reduce the hydrogen generated.

5.3.3.5.5 Methane Production

The additional capping remedial alternative will reduce oxygen infiltration and improve the quality of the landfill gas but it may not have a significant impact on the quantity of methane produced. This alternative may have a minor, indirect impact through the reduction in water infiltration, which could help reduce the water available for the aluminum waste reactions. A decrease in the aluminum reactions would reduce the amount of the heat that is helping to keep the temperatures in the MSW above the range where methanogenesis can take place.

5.3.3.5.6 Landfill Gas Temperature

The additional capping remedial alternative will not have a direct impact on the landfill gas temperature. This alternative may have a minor, indirect impact through the reduction in water infiltration, which could help reduce the water available for the aluminum waste reactions. A decrease in the aluminum reactions would reduce the amount of heat generated in the aluminum waste and by the secondary reactions in the MSW, thereby reducing landfill gas temperature.

5.3.4 Alternative 3 Operation And Maintenance

The long-term operation and maintenance for a capped area of waste will be the same as any closed MSW landfill once the area is closed. In the interim, and until all capping of the landfill areas containing aluminum waste could be completed, the requirements of F&Os Order 4. would continue. (Data Collection and Immediate Precautionary Measures) would continue to be implemented. A list of monitoring and precautionary measures required during and after capping would be developed along with a detailed implementation plan for this alternative, if selected.

5.3.5 Alternative 3 Additional Capping Summary

Overall, the long-term effectiveness of this alternative by far exceeds any short-term impacts to human health, safety, and the environment. Capping will eventually achieve the benefit of having the source of the subsurface reactions being totally encapsulated, restricting exposure of the aluminum waste to water and oxygen needed to continue the subsurface reactions. The expected performance of this alternative in delivering a reasonable near term solution to odor problems at the facility is high.

5.4 ALTERNATIVE 4 – ENHANCED BEST MANAGEMENT PRACTICES

The actions taken by Countywide by December 16, 2006 to comply with the OEPA Directors Findings and Orders issued on September 6, 2006 included constructing 30 acres of HDPE geomembrane cap and installing enhancements to the LFG collection system in the area where high temperatures had been identified. These improvements have been successful in reducing fugitive emissions and odors. Off-site odors have virtually been eliminated. Some of the recent monitoring results indicate a significant improvement in certain performance criteria.

Countywide feels that diligent and programmatic implementation of Best Management Practices (BMPs) will result in continued abatement of odors and control of the reaction. As part of this alternative, Countywide would implement a monthly inspection program of the landfill gas system and other components identified in Section 5.4. This inspection would be accompanied by an evaluation of the performance of the gas collection system. A report will be prepared concluding with recommended actions to be taken by Countywide.

Examples of items that would be identified and implemented as part of a BMP program include:

- Installation of additional condensate pumps in more LFG wells.
- Installation of additional LFG wells in areas that could use enhanced coverage
- Enhancement of the existing LFG header system
- Replacement of compromised existing LFG wells
- Maintenance of the existing intermediate cover
- Evaluation and refinement of the odor neutralizing system
- Modifications to the existing temporary synthetic cap
- Installation of additional temporary cap (previously discussed as part of Alternative 3)

This alternative calls for the conduct of all the actions identified above on an expanded, long-term basis.

5.4.1 Alternative 4 Conceptual Design

The conceptual design of this alternative is to operate and maintain the interim corrective actions. Interims actions taken in 2006 have already been designed and installed. Details of the proposed additional interim actions are described in the IAEP. If approved by OEPA, the recommended additional measures will be implemented and maintained as described in the IAEP.

5.4.2 Alternative 4 Implementation Schedule

This alternative requires no further testing or evaluation and can be immediately implemented. Most of the recommended additional interim actions can be completed during the 2007 construction season, if approved soon by OEPA. Monitoring of the interim actions would be performed until the subsurface reactions subside and closure of the affected areas could be implemented.

5.4.3 Alternative 4 Evaluation

In the following sections, the anticipated impact of Remedial Alternative 6 is evaluated against the performance criteria presented in Order 8.C.

5.4.3.1 Alternative 4 Technical and Logistical Feasibility

This alternative is both technically and logistically feasible. The performance of the improvements made to date has demonstrated their capability to control the off-site impacts of the ongoing reactions, specifically the odor and fugitive gas emissions. This alternative can be implemented quickly and has the potential to be successful in further controlling future odors and fugitive gas emissions.

5.4.3.2 Alternative 4 Cost Effectiveness

This alternative has been demonstrated to be effective. With continued operation and planned improvements, it will, at a minimum, remain effective and will likely become more effective in preventing negative impacts on the surrounding community. This is the lowest cost alternative. This is also the most cost effective alternative.

5.4.3.3 Alternative 4 Stability Impacts

No negative stability impacts are anticipated for this alternative.

5.4.3.4 Alternative 4 Potential Impact on Human Health, Safety, and the Environment

This alternative has no potential for negative impact on human health, safety, and the environment beyond the normal operation of a municipal solid waste landfill. There would need to be routine precautions taken for worker safety during implementation of this alternative, but potential impacts to human health and the environment would be improved.

5.4.3.5 Alternative 4 Effectiveness/Performance

In the following sections, the anticipated impact of Remedial Alternative 4 is evaluated against the performance criteria presented in Order 8.C.

5.4.3.5.1 Prevention of Nuisance Odors and Uncontrolled LFG Emissions

The ongoing monitoring has demonstrated that the improvements made to date have been able to control the nuisance odors and uncontrolled LFG emissions. Enhancement of current procedures through implementation of these BMPs will assure continued abatement of odors, thereby providing the largest benefit to the community of all of the options considered.

5.4.3.5.2 Carbon Monoxide Levels

This alternative will not have a direct, immediate impact on the generation of carbon monoxide. The heat generated by the aluminum reactions will decline as the metallic aluminum content of the waste is consumed. The decrease in the heat generated by the aluminum reactions will reduce the secondary reactions in the MSW that are generating the majority of the carbon monoxide.

5.4.3.5.3 Rapid Settlement

This alternative will not have a direct impact on the rate of settlement. The rate of settlement will decrease as the heat generated by the aluminum reactions declines as the metallic aluminum content of the waste is consumed. The decrease in the heat generated by the aluminum reactions will reduce the secondary reactions that are causing the reduction of volume in the MSW.

5.4.3.5.4 Hydrogen Production

This alternative will not have a direct impact on the generation of hydrogen. The generation of hydrogen will decrease as the metallic aluminum content of the waste is consumed.

5.4.3.5.5 Methane Production

The additional capping remedial alternative will reduce oxygen infiltration and improve the quality of the landfill gas but it may not have a significant impact on the quantity of methane produced. The heat generated by the aluminum reactions will decline as the metallic aluminum content of the waste is consumed. The decrease in the heat generated by the aluminum reactions will allow methanogenesis to resume in the MSW.

5.4.3.5.6 Landfill Gas Temperature

This alternative will not have a direct, immediate impact on the landfill gas temperature. The heat generated by the aluminum reactions will decline as the metallic aluminum content of the waste is consumed. The decrease in the heat generated by the aluminum reactions and the resultant reduction in the secondary reactions in the MSW will eventually result in lower landfill gas temperatures.

5.4.4 Alternative 4 Operation And Maintenance

The long-term operation and maintenance for this alternative will be the same as required for any MSW landfill once the reactions cease and the area is closed. In the interim, until the selected remedy could be completely implemented, a modified version of F&Os Order 4. (Data Collection and Immediate Precautionary Measures) would be continued. A list of short-term and long-term monitoring and precautionary measures required would be developed along with a detailed implementation plan for this alternative, if selected.

5.4.5 Alternative 4 Enhanced Best Management Practices Alternative Summary

The Interim Action and Evaluation Plan (IAEP) submitted earlier on April 11, 2007 by Countywide recommended 8 specific interim actions that should be taken. Their implementation is pending approval of same by OEPA. Countywide is ready and able to perform the Interim Actions on an expanded, expedited, and extended basis. We believe these among all the remedial alternatives are the ones most likely to succeed, and least risky in terms of outcome. The application of these actions can only further improve conditions beyond that already achieved in recent months.

6.0 RECOMMENDATIONS

This Fire Suppression Plan (FSP) has identified and addressed four general alternative categories including:

1. Waste excavation
2. Injection technologies
3. Additional capping
4. Enhanced Best Management Practices

6.1 WASTE EXCAVATION

It appears that waste excavation would entail the excavation of at least the reaction volume, and possibly the entire volume of aluminum waste which is located throughout Cells 1 through 6. The total area at issue here is 88 acres, and the total waste volume is approximately13 million tons. Aluminum waste is a significantly smaller amount estimated at about 600,000 tons, but this waste is interspersed and can not be excavated or handled separately. Waste excavation at an optimistic rate of 2,000 tons per day would take more than 10 years to complete, and would be prohibitively expensive. The excavation process would create significant health and safety concerns to site workers, and would create significant air emissions resulting in over-whelming odor impacts on the community. For these reasons, waste excavation is not feasible.

6.2 INJECTION TECHNOLOGIES

This Plan addresses several injection technologies including magnesium chloride, sodium phosphate, sodium silicate, commercial fire-fighting foam, a surfactant known as FlameOut®, and inert gas. The injection technologies listed here are all intended to have chemical impacts, except for the inert gas which is intended to cool the reaction with a physical benefit but no chemical impact. This report includes a preliminary evaluation of the particular technology's ability to provide chemical benefits by suppressing or controlling the reaction.

Potential success of these injection technologies cannot be determined until the completion of treatability studies which are now underway. Until the results of these studies are in, we believe that there is a very real possibility that these agents may have no benefit at all, and could even be detrimental to reaction suppression by fostering an expansion and/or acceleration of the reaction. The various chemical agents may also impact the integrity of the engineered components. Thus, the injection technologies will require additional study and evaluation.

Of course, regardless of any particular injection technology's theoretical benefit, there is a question as to whether any particular chemical can be delivered in such a way that it could positively impact the situation at Countywide. Uniform delivery of any chemical agent (including inert gases) will be difficult, if not impossible, in a manner so as to deliver the precise amount and concentration of the chemical needed to suppress the reaction. Past experience suggests that it is difficult if not impossible to deliver a product in a uniform, comprehensive distribution such that the agent reaches all parts of the waste mass. This is because the waste mass is heterogeneous and there will likely be large, tightly-packed waste masses that will not be able to be reached by such applications.

Moreover, once such an agent is no longer applied, we have found that areas that were untouched and remain reacting will merely re-start reactions in those areas that had been suppressed. If any injection technology is considered (for the record, it is not recommended here), it cannot be implemented unless preceded by a small, pilot scale project to test for the likelihood of physical or chemical success in the field, and determine the ability to deliver the agent in a uniform and comprehensive manner. We therefore believe that such injection technologies are not feasible on a large scale basis, but are deserving of further consideration for localized applications.

6.3 ADDITONAL CAPPING

Additional capping is the next remedial alternative considered. The F&Os prohibit disposal in most of the 88 acres (Cells 1 through 6) except for such waste necessary to bring the facility up to grade for closure. The F&Os potentially allow for additional waste fill only in the recently settled "bowl" depression area atop this area. This bowl area and additional flat areas atop the 88 acres in Cells 1 through 6 are the heart of the concentrated reaction area.

Final capping can proceed immediately on the east or west sideslope areas of the 88 acres. The reaction is not affecting these areas, and no additional waste deposits will be necessary. Countywide is prepared to start permanent capping of the east or west end as early as 2007. Given the predicted duration of the reaction and the practical area limits that can be capped in one construction season, we estimate that it may take 3-6 years to complete final capping in the entire 88 acre area.

In the meantime, we believe the remaining flat and depressed and settling areas atop the fill should be left as they are, with perhaps some additional temporary cap applied in the next 2 to 3 years. Areas that could receive additional temporary cap will be evaluated to determine whether any benefit will be provided by such.

6.4 ENHANCED BEST MANAGEMENT PRACTICES

Enhanced Best Management Practices (BMPs) are the final category of remedial alternatives addressed in this Plan. Under this alternative, Countywide would implement a proactive, aggressive program including:

1. installation of additional condensate pumps in certain gas wells;
2. installation of additional gas wells where beneficial,
3. enhancement of existing LFG header system,
4. replacement of compromised existing LFG wells,
5. maintenance of the intermediate cover soil,
6. maintenance of the LFG, cover, and other systems,
7. evaluation of, and refinement, the odor neutralizing system; and
8. modifications to and addition to the temporary synthetic cap.

In addition, Countywide would implement a monthly inspection program of the landfill gas system and cap system. This inspection would be accompanied by an evaluation of the performance of these items and recommendations for continued best management practices.

6.5 SUMMARY

It is recommended that we proceed with Enhanced Best Management Practices and permanent capping on portions of the 88 acres. We believe that some areas may benefit from temporary capping; those areas will be identified as an ongoing effort.

We believe that injection technologies have too many chemical unknowns and risks at this time, and cannot be delivered in a successful manner over a large area. If any injection technology is proven to have potential, based on the treatability studies in process, then it could be applied only on an initial, pilot scale, to determine if subsurface injection in a uniform and complete manner can be performed as local applications.

References

Budavari, Susan, ed, 1989. The Merck Index, Eleventh Edition. Merck & Co., Rahway, New Jersey.

Chand, N. and S. Verma, 1989. Effect of chloride-based fire retardant on the physico-mechanical characteristics of sunhemp fibre. *J. Mat. Sci. Letters* 8, 891-892.

Esmail, W., A. Darwish, O. Ibrahim, and M. Abadir, 2001. The effect of magnesium chloride hydrate on the fire retardation of cellulosic fibers. *J. Thermal Anal. Calorim*. 63, 831-838.

Fisher, E.M. and T.M. Jayaweera, 2002. Chemically enhanced water mists for fire suppression – Final progress report. NTIS order no. ADA412149 (http://handle.dtic.mil/100.2/ADA412149).

Krnel, K. and T. Kosmac, 2000. Reactivity of aluminum nitride powder in dilute organic acids. *J. Am. Ceram. Soc*., 83, 1375-1378.

Figures

APPENDICES

APPENDIX A

BORING LOG

APPENDIX B

TREATABILITY TESTING PROPOSAL