



- Geosyntec was retained by the State of New Jersey as an independent consultant to review and evaluate options to address odor problems caused by H<sub>2</sub>S at the Fenimore landfill.

- H<sub>2</sub>S gas in Fenimore
- Evaluation of Landfill Gas Abatement Options
- Summary and Conclusions

## Hydrogen Sulfide (H<sub>2</sub>S) Gas Formation from Gypsum

- Drywall (or sheetrock) consists of 90% gypsum and 10% paper.
  - Gypsum = calcium sulfate dihydrate a naturally occurring mineral
- When wetted, the sulfate in the drywall dissolves into solution.
- H<sub>2</sub>S gas is generated by bacteria that consume the sulfate under anaerobic (absence of air) conditions.
  - The combination of buried gypsum, paper and water provide all the necessary ingredients for H<sub>2</sub>S gas generation.



- H<sub>2</sub>S is produced by sulfur reducing bacteria (SRB) that process the sulfur in gypsum wall board. The bacteria thrive in an environment that is dependent on pH, moisture, and an oxygen deficient environment know as an anaerobic condition. Temperature is also a factor. The gypsum is a major component of the Construction and Demolition Screenings (CDS) (ground up wall board) used for fill at the site.
- Sheetrock contains gypsum, a natural mineral that contains sulfur. When gypsum is buried and allowed to get wet, the calcium sulfate slowly dissolves and anaerobic bacteria (that live where there is no oxygen) will use the sulfur as an energy source and create H<sub>2</sub>S gas.
- That gas then builds up and is stored within the “pore spaces” of the material deposited in the landfill (empty spaces) until it has no place to go but into the air. This process will continue until either all the sulfur in the gypsum is consumed or the environment within the landfill is dried out. Drying out the environment within the landfill will slow and eventually stop the process. Because the gypsum must be wet for the bacteria to use, drying out the landfill will slow down the bacteria and H<sub>2</sub>S gas production

Records from Strategic Environmental Partners show:

- **375,366 cubic yards of fill material was brought to the site;**
- **Of that, about 54% was Construction and Demolition Screenings (CDS) containing gypsum, and**
- **About 60% of CDS was brought to the site prior to Super Storm Sandy.**

H2S gas generation started approximately in the of Spring 2012.

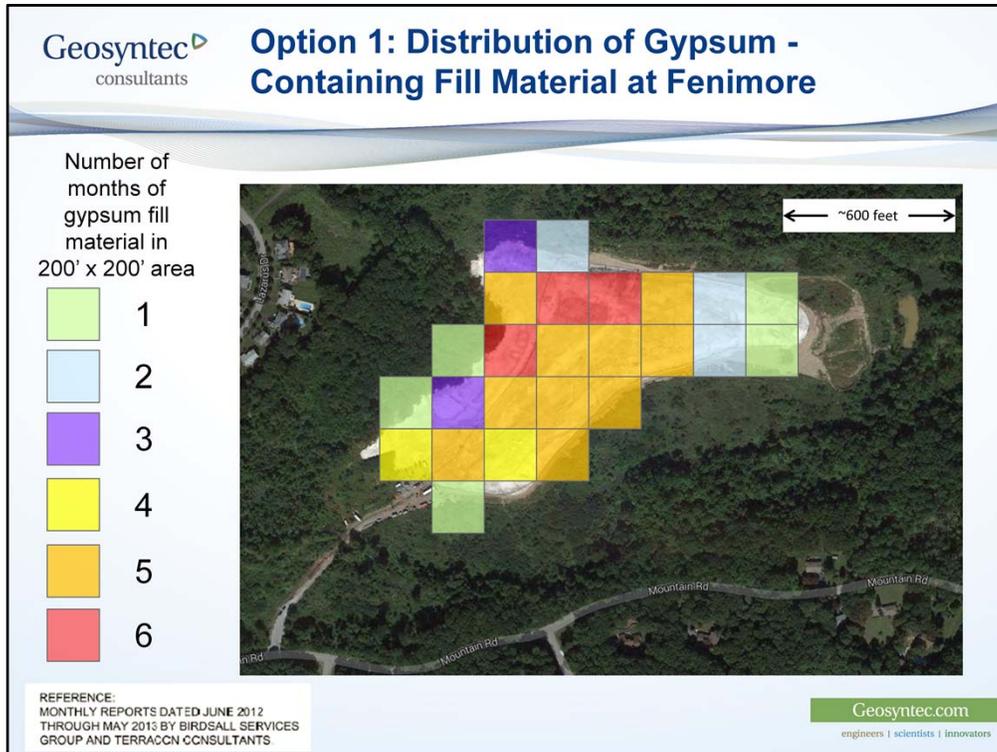
H2S gas concentrations up to 250,000 ppm have been recorded within the landfill.

- According to SEP's records, a total of 375,366 cubic yards of various fill material was brought to the Fenimore landfill between December 2011 through June 2013.
- Of that, about 54% was CDS containing gypsum and most of the CDS (60%) arrived at the site before Super Storm Sandy. Over half of the material brought to the site by SEP has the potential to generate H2S. The period of time that is needed to start the generation of H2S is variable but in this case approximately four (4) months.
- Since more than half of the material can generate H2S, there is a significant quantity of H2S stored within the pore spaces of the material deposited in the landfill. This stored gas is substantial and at great concentrations.

## Three Options for H2S gas abatement at Fenimore:

1. Targeted removal of gypsum-containing fill material and cap in-place the remaining fill material with a system to collect and treat H2S gas;
2. Remove all fill materials and ship off-site for disposal, and
3. Cap in-place with a system to collect and treat H2S gas.

- There are three options we looked at:
  - \* targeted removal of most contaminated with capping and gas collection;
  - \* excavation, and
  - \* capping in-place with gas collection and treatment.



- SEP records kept during operations identified the date, volume, and location of materials that were brought in and landfilled. This slide shows a breakdown of where gypsum-containing materials were placed. As you can see, they were spread all over the site prior to the State take over of the landfill.
- Because of this, we can't skim off a section or excavate just a portion of the site. You would have to move everything in order to sift out the sheetrock, and you still couldn't be sure at the end that you got it all, so you would still have to install a cap. Therefore, trying to remove hotspots is really not an option. So you need to look at either total removal or cap in-place.

- Targeted removal of hot spots is not possible because gypsum materials are throughout the site.
- Therefore, no cost analysis was conducted



- Here is what a typical waste excavation job looks like. Big excavators dig up the waste and put it in a truck. You see that digging into a landfill is not like digging a hole in the ground. The surface is uneven, and you have to create benches to get access.
- In this picture, the waste being removed did not generate H<sub>2</sub>S gas, but at Fenimore, the H<sub>2</sub>S gas makes things more complicated. Let's review the issues.

## Option 2: Removal of All Fill Material for Off-site Disposal

- High concentrations of H<sub>2</sub>S gas are stored within the landfill.
- Excavation will release H<sub>2</sub>S gas.
  - High concentrations of H<sub>2</sub>S gas will likely migrate into the community;
  - Excavated fill material will continue to emit H<sub>2</sub>S gas as it is trucked off-site, and
  - Safety protocols required for workers will slow operations.
- The existing gas collection system will have to be shut down in stages during excavation.
- During removal operations, the landfill will continue to generate H<sub>2</sub>S gas 24/7.

- All the voids in the landfill are currently filled with H<sub>2</sub>S gas. This would escape into to the air during excavation.
- Because of this, all of the workers that are close to the excavation area would have to have supplied oxygen so they wouldn't be exposed to the H<sub>2</sub>S gas.
- In addition, the steep slopes of this site and the numerous safety protocols that workers will be required to follow will slow progress of work on the site. Because of this, excavation is expected to take a minimum of 16 months, with several more months to import soils to cover the site and plant vegetation.
- Throughout excavation H<sub>2</sub>S in significant concentrations will be released. In addition even with best efforts to control gas emissions, as the loaded trucks leaves the site, and moves through the community to the final disposal site, gases will be emitted. Thus during excavation, the potential for a great deal of odor to be released will exist and residents downwind or along the paths the trucks take are expected to be impacted.
- The gas collection system that is operating at the site would have to be shut down in phases during excavation. The phases would be pretty big, because if the suction applied to the landfill is short-circuited by the excavation, then the whole operation shuts down. So now you not only have odors being generated during construction, but a risk that they can't be controlled on nights or weekends either.

## Option 2: Removal of all Fill Material for Off-site Disposal

One idea is to install a temporary structure over the waste excavation, but

- To control H<sub>2</sub>S emissions, structures require level surfaces to allow sealing of the area of work so that air handling and treatment can function correctly. Fenimore has rough, uneven surfaces that would prevent the required seals, thus allowing H<sub>2</sub>S gas to escape.
- The temporary structure would need to be taken down and rebuilt every few days as excavation proceeds. H<sub>2</sub>S gas would escape during this process.

Therefore, construction of a temporary structure is not feasible at Fenimore

One idea to control the H<sub>2</sub>S is to construct a temporary building over the excavation area so you can collect the gas and treat it. But this is unfeasible because of the issues associated with excavating a landfill.

## Option 2: Cost for Removal of All Fill Material and Off-site Disposal

Item	Estimated cost
General costs (contract admin, mobilization, bonds, construction management, etc.)	\$4.7 million
Support construction (erosion control, access roads, air monitoring, safety equipment, etc.)	\$1.2 million
Excavation and trucking of fill material (equipment and labor)	\$14.5 million
Disposal of 375,366 CY at out-of-state landfill	\$16.5 million
Soil cover and stabilization after excavation	\$1.8 million
TOTAL	\$38.7 million

- The estimated summary of the costs for removing all of the fill brought in since 2012, which includes the cost of excavation, hauling and disposal is approximately \$38 million. It is important to note that the gypsum materials brought into Fenimore are not recyclable. They are the leftovers after recyclable materials are removed from demolition wastes. Therefore, they have to be disposed in a landfill, which is expensive. The nearest commercial landfill that would accept this material is in Pen Argyl, Pa., about 40 miles away.

## Option 2: Removal and Offsite Disposal - Conclusions

- Uncontrolled release of significant concentrations of H<sub>2</sub>S gas to the community is likely and could occur 24/7;
- This situation is expected to continue for 16 months;
- Significant daily truck traffic through the neighborhood is required;
- Fill material being hauled off will emit H<sub>2</sub>S gas along the roads even with best efforts to minimize;
- Exposure risk to workers from H<sub>2</sub>S gas;
- Significant cost estimated at \$38.7 million.

Three Phase approach:

- Phase 1 – Enhance gas collection and treatment system
- Phase 2 - Capping (installation of impermeable liner and soil cover)
- Phase 3 – Long-term gas collection and treatment

Now let's look at the third option available

## Option 3: Closure Capping - Phase 1

- Expand and enhance gas collection from 9 to 30 wells, and remove H<sub>2</sub>S from entire area in early Spring 2014.
- The expanded system will be completed prior to the summer when people are outside more.
- The expanded system is expected to collect and treat the vast majority of gas that is generated.

## Option 3: Closure Capping - Phase 2

- Capping minimizes disruption of the landfill and the potential to release H<sub>2</sub>S gas;
- Summer months of 2014 will be used to stockpile clean soil to reduce daily truck traffic in the Fall 2014;
- The installation of an impermeable liner by December 2014 provides an effective barrier to gas and will further dry out the waste (reducing H<sub>2</sub>S generation) while complementing the gas collection system;
- Final grass cover Spring of 2015 with completion by June 2015.

## Option 3: Closure Capping - Phase 3

- Remove interim oxidizer/scrubber treatment system. Technologies being evaluated involve using dry material to filter H<sub>2</sub>S from the gas, and
- Long-term maintenance of the cap and gas collection and treatment system.

## Option 3: Closure and Capping

Item	Estimated cost
General costs (contract admin, mobilization, bonds, construction management, etc.)	\$1.1 million
Preparation for cap (erosion control, access roads, subgrade prep, storm water basin, etc.)	\$2.7 million
Impermeable cap (materials and install)	\$2.2 million
Soil cover and stabilization after cap	\$1.8 million
TOTAL	\$7.8 million

This cost estimate was prepared by Berger

## Option 3: Closure and Capping - Conclusion

- Provides continuous control of H<sub>2</sub>S gas;
- Minimizes disturbance of the gypsum fill material;
- Provides complete encapsulation by December 2014;
- Significantly reduces daily and overall truck traffic;
- Significantly reduces the potential for H<sub>2</sub>S gas generation by preventing moisture from getting in;
- Substantially controls and reduces potential H<sub>2</sub>S gas exposure to the community.

- Targeted excavation (removal of hot spots) is not feasible because gypsum fill materials are throughout the site.
- Full excavation will result in uncontrolled release of H<sub>2</sub>S gas into the community and along the roads used for trucking for an estimated 16 months.
- Full excavation would require a longer timeline for closure and extended H<sub>2</sub>S gas exposure to the community;
- Full excavation would require about 25,000 round trips in and out of the site for an extended period of time.
- The cost of full excavation and removal is estimated to be about \$38.7 million, approximately 5 times the cost of capping.

- Capping in-place with gas collection will effectively prevent odors from H<sub>2</sub>S gas.
  - reduces risks associated with H<sub>2</sub>S gas to the public and workers.
  - can be completed without disrupting the improvements already made to the H<sub>2</sub>S gas collection and treatment system.
  - can be completed in a shorter time frame thus abating H<sub>2</sub>S gas exposure in the community faster and sooner.
  - will require significantly less daily and overall truck traffic than full excavation.