Challenges to Emergency Response Hurricane Debris Disposal and the Use of Composite GCLs for Rapid Response Cap Systems

Gary J. Leonards, P.E.
Providence Engineering and Environmental Group, LLC, Baton Rouge, LA
Richard B. Erickson
Vector Engineering, Inc., Grass Valley, CA
Richard S. Thiel, P.E.
Thiel Engineering, Inc., Oregon House, CA

ABSTRACT: The amount of debris generated by hurricanes Katrina and Rita along the gulf coast of the United States created a disposal cost that many are still trying to estimate. The regulatory agencies in the states hardest hit by the hurricanes (Louisiana and Mississippi) are still searching for disposal sites and beneficial use options for much of this material. Although some of the debris has been landfilled in permitted disposal facilities, unfortunately the majority of the hurricane debris has been disposed in facilities operating under emergency authorization. This includes more than 400 disposal/processing/staging sites in the four hardest hit Parishes in the New Orleans, Louisiana area as a result of these two hurricanes. When the approved emergency response disposal sites reach final capacity, the upcoming challenge for the regulatory agencies will be final closure.

This paper discusses the regulatory and local government emergency response to the challenges derived from hurricanes Katrina and Rita in Louisiana with regard to temporary landfill site authorization and closure. This is demonstrated by an overview of the Empire Pit Landfill as a fast pace project for managing hurricane debris and the use of a geomembrane supported GCL (GM-GCL) composite cap lining system.

1. Introduction

The destruction caused along the gulf coast of the United States by Hurricanes Katrina and Rita and subsequent debris generated by these two catastrophic events is something the environmental regulatory agencies and general pubic hope to never deal with or witness again. More than 16 months after landfall of these two storms, much of the southern areas of Louisiana and Mississippi are still in ruins and operating under emergency declarations.

Long before the floodwaters receded from Hurricane Katrina, regulators and public officials were engaged in discussions ranging from immediate public health and safety concerns, to infrastructure issues, and to debris management. The U.S. Army Corps of Engineers estimated that over 16.5 million m^3 (22 million yd^3) of debris was generated in Louisiana as a result of Hurricane Katrina alone.

2. Regulatory Response

Essentially overnight, the life span of several permitted regional disposal facilities were reduced from several years to less than a few months to dispose of only a portion of the magnitude of hurricane debris. The lack of available permitted disposal facilities in the heaviest impacted areas of the gulf coast region forced the state regulatory agencies and local governments into a position they had never been in before.

These agencies, with the assistance of the local governments and the United States Army Corps of Engineers, were required to identify potential sites for staging, processing, and disposal of storm-generated debris. Potential temporary staging and processing sites included parking lots, recreational fields, school yards, and vacant neighborhood lots. Final disposal sites included closed landfills, existing C&D/Industrial/MSW landfills, levee borrow pits and adjacent areas, and suitable remote locations. Subsequently, several hundred sites not previously used or permitted for waste processing or disposal were authorized to aid in the overall debris mission along the gulf coast under an emergency and administrative order (Figure 1). This included more than 400 sites in the four hardest hit Parishes in the New Orleans area alone.

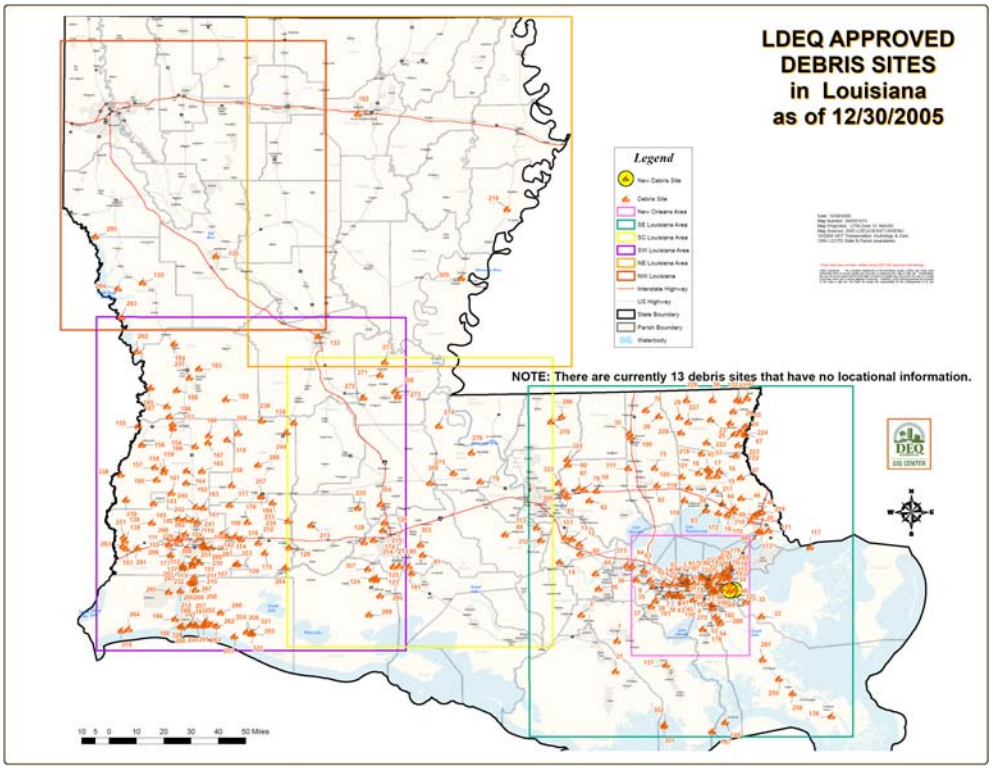

Figure 1. Approved Louisiana debris staging, processing, and disposal sites.

3. Emergency Response Disposal Facilities

The non-permitted sites utilized along the gulf coast region to assist with the debris mission were authorized to operate through emergency authorizations issued by the

Louisiana Department of Environmental Quality (LDEQ) and local governing bodies. These sites went through a very simple screening process to ensure that environmental impacts from the operation of these facilities would be minimal.

None of the temporary sites used in assisting with the debris mission were subjected to the established thorough permitting process through the LDEQ that most always includes some type of public comment procedure. For that reason, it is anticipated that the long-term impacts on the environment could be significant as a result of the operation of the emergency response final disposal facilities. Every attempt was made by the regulatory agencies and local governments to ensure that the temporary disposal facilities accepted only demolition debris and wood waste given that the sites were not required to install any type of engineered bottom liner system or groundwater monitoring system.

Given that emergency response temporary disposal facilities are quickly permitted without typical review processes due to the constraints derived from the catastrophic hurricane events, it is imperative that these facilities are closed with an effective and cost efficient lining system. This requires the design and fast paced construction must include an impermeable barrier that is cost effective, and will meet the long-term hydraulic and strength requirements of a state-of-the-practice cap system to minimize infiltration and potential groundwater contamination.

4. Case History: Empire Pit Landfill, Plaquemines Parish, Empire Louisiana

To illustrate the design, material selection, and proposed closure of an emergency response disposal facility derived from Hurricane Katrina, the Empire Landfill in Southern Louisiana is presented.

The Empire Pit, located approximately 97 km (60 miles) southeast of New Orleans in lower Plaquemines Parish in the town of Empire, was first identified as a potential location for the disposal of hurricane generated debris by representatives from Plaquemines Parish and the LDEQ in October of 2005. Originally the area was utilized as a soil borrow source for construction of a portion of the Mississippi River levees.

Providence Engineering was selected to perform the geotechnical analysis and design of the landfill and closure lining system. Providence representatives mobilized to the site in October of 2005 to install soil borings around the perimeter of the existing borrow pit to characterize the subsurface geology. The soil borings indicated a vast amount of silts and sandy silts in the upper 7.5 m (25 feet).

Given that drinking water in the vicinity of Empire was obtained from surface water bodies and not from groundwater, the facility was approved to accept construction & demolition debris and wood wastes. The Empire Pit received authorization from the LDEQ to begin operation as an emergency debris disposal site in November of 2005 and is scheduled reach final capacity early 2007 and subsequently closed.

The Empire Pit is approximately 7.2 ha (18 acres) in size and the borrow pit had an average depth of 3.6 m (12 ft). The pit was de-watered and, prior to landfilling, the perimeter area used for waste storage and processing operations. Over 1,100,000 m^3 (1,500,000 yd^3) of hurricane generated debris will be disposed in the site over its 14 month life. As of December 2006, the site is nearing capacity and is scheduled to discontinue debris disposal in early 2007.

The regulatory requirement for capping the facility by the LDEQ consisted of final grading of the waste and placement of a soil grading layer, construction of a 600 mm (2 ft) of compacted clay, followed by placement of a 150 mm (6 in) of topsoil layer to support vegetative growth. Alternately, an approved equal incorporating geosynthetics would be considered.

4.1 Evaluation of an Alternative GCL Cap System

Due to the lack of local available quality clay, Providence Engineering evaluated several alternative geosynthetic options with GCLs and geomembranes. The final cap liner chosen included the HDPE geomembrane supported GCL (GM-GCL) which provided an equivalent 600 mm clay requirement with 3.7 kg/m2 (0.75 lb/ft^2) bentonite coating as well as long-term bentonite protection with the geomembrane backing. A 300 mm soil grading layer was placed over the waste prior to installation of the GM-GCL, and soil cover included 450 mm of soil buffer/vegetative layer.

Due to the siting of the landfill, composition of the waste, and fast paced construction, several critical design and performance issues were evaluated in selecting the GCL cap system. A brief overview of the product selection considerations are outlined below.

4.1.1 Cap Differential Settlement. Uniform settlement generally will not negatively impact any components of a liner or cap system. Differential settlement, on the other hand, can result in the separation, cracking, or tearing of various elements and materials in the liner system.

Previous tests evaluating the GM-GCL response to differential settlement (LaGatta et al., 1997) subjected intact and overlapped specimens to up to 29% tensile strains, which resulted in approximately 100 mm of slippage along the overlapped seams. The GM-GCL maintained its hydraulic integrity and effective seal along the seams, permitting no leakage or damage to the intact liner.

The composition of the waste landfilled in the Empire pit was primarily C&D and wood waste which was to be compacted in layers. The depth of fill generally ranged from 3.6 m (the original depth of the pit) up to 6.6 m at the peak of the landfill, thus a relatively shallow fill. Therefore, the anticipated differential settlement of the waste fill was not anticipated to be critical. The specified 300 mm overlapped seams and strength of the geomembrane backing is expected to perform as designed.

4.1.2 Slope Stability. The general orientation of the cap included a 2% grade sloping up to the crest of the fill with perimeter outslopes of 16%. For the mild 2% slopes (7 ha), the GCL specified included of a smooth 0.4 mm (15 mil) geomembrane backing. On the outslopes, the product incorporated a 0.5 mm (20 mil) textured HDPE geomembrane backing to improve friction resistance against the cover soil.

Given the gentle slopes by design and low normal load of the soil cover (<15 kPa/300 lb^2), the hydrated GCL did not present any slope stability concerns and met all stability requirements.

4.1.3 Cover Soil Requirements. The design 450 mm cover soil over the GCL consists of a 225 mm (9 in) grading layer with an overlying 225 mm vegetative cover layer. The depth of cover is adequate to minimize potential damage to the GCL and complies with the regulatory cover requirements. The cover soil placement procedures included covering and protecting the GCL consistent with industry accepted standards, including ASTM D 6102 addressing the installation and soil cover of GCLs. Soil cover placement was to progress from the crest of the cap down slope so as to minimize any potential water ponding on the GCL from rain events or potential surface drainage under the GCL prior to soil covering.

4.1.4 Hydraulic Performance. Given the composite construction of the GCL and effective hydraulic conductivity of $<4 \times 10^{-12}$ cm/sec, the alternative cap design results in potential leakage more than 5 orders of magnitude less than a compacted clay only cap. The GM-GCL has also been previously approved by the LDEQ and used in Louisiana as a replacement for conventional composite liners (geomembrane and CCL) on select projects. Thus, the product was quickly approved for the project.

Regarding bentonite protection and long-term hydraulic performance, the geomembrane backing provides an overlying vapor barrier for the bentonite thus minimizing cation exchange with soluble Ca^{++} and M^{++} from the overlying cover soil. (similar to bentonite protection offered by geomembrane backed fabric GCLs).

4.1.5 Seam Performance. The GCL seams are specified to be overlapped 300 mm thus eliminating the requirement for conventional geomembrane seam welding. The effectiveness of simple overlapped GM-GCL seams is well documented by Thiel et al. (2001) with proper installation and construction quality assurance during soil covering. This saves both time and cost in material deployment for a fast paced landfill closure. The 300 mm seams also allow for more than 150 mm (6 in) of local differential settlement without jeopardizing the self-sealing seams and hydraulic integrity.

Regarding seam orientation, the critical areas are limited to the perimeter 6H:1V slopes. The panels are specified to be deployed perpendicular to the slope, thus

eliminating and horizontal or cross seams on slopes. For the 2% area of the cover, seam orientation is not critical given the gentle grade.

4.2 GCL Material Selection

The GM-GCL was chosen to replace the 600 mm compacted clay requirement for several reasons summarized as follows.

1. The area in which the Empire Pit Landfill is located does not contain a large amount of suitable clay material to be used for the construction of a 600 mm thick clay cap. The installation of a re-compacted clay cap would be cost prohibitive and extremely time consuming. Thus, it is clearly a cost effective alternative to compacted clay.
2. The GCL consists of a one-product composite liner providing both a bentonite layer to replace the compacted clay requirement and a protective geomembrane backing. The product is simply installed to replace both a clay/geomembrane in one product installation.
3. The speed and ease of installation provides a critical time savings when considering a fast paced project as is required in emergency response debris management projects.
4. The hydraulic performance of the GM-GCL and overlapped seams allows for simple deployment without the need for welding geomembrane seams. This results in as savings in both installation time and cost as well as construction quality assurance (CQA) costs. The installation of the material requires no highly technical or costly installation crew or materials.

4.3 Landfill Operations

The site began operations approximately 12 weeks after Hurricane Katrina impacted Southern Louisiana, immediately after the flood waters receded. Although certain aspects of the landfill operations are not consistent with state-of-the-practice procedures, it must be reiterated that this was an emergency response landfill opened under a Declaration of Emergency and Administrative Order issued by the LDEQ. The controls, operating procedures, and closure design were expediently put into place to minimize both the short-term and long-term adverse environmental effects.

Figures 2 through 9 below show the development, operation, and oversight of the Empire Pit Landfill. As of the writing of this paper, the site is reaching its final capacity and will be ready for final closure in early 2007.

Figure 2. The Empire Pit prior to dewatering. Temporary storage and processing of waste adjacent to the borrow pit.

Figure 3. The Empire Pit after dewatering. Processed and staged waste adjacent to the borrow pit for final disposal.

Figure 4. Incoming waste haulage and inspection.

Figure 5. Waste processing and selective shredding.

Figure 6. Continual air monitoring during waste operations.

7. Landfill operations.

Figure 8. Waste fill approaching final grade.

Figure 9. Storage of the GM-GCL geosynthetic material for final capping.

5. Conclusions

The regulatory agencies in the states hardest hit by the hurricanes Katrina and Rita (Louisiana and Mississippi) are still searching for disposal sites and beneficial use options for much of this material. Although some of the debris has been landfilled in permitted disposal facilities, unfortunately the majority of the hurricane debris has been disposed in facilities operating under emergency authorization. When the approved emergency response disposal sites reach final capacity, the upcoming challenge for the regulatory agencies will be final closure.

This paper presents an overview of the regulatory and local government emergency response to the challenges derived from hurricanes Katrina and Rita in Louisiana with regard to temporary landfill site selection and closure. This is demonstrated by an overview of the Empire Pit Landfill as a fast pace project for managing hurricane debris and the use of a composite GCL cap lining systems.

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