LANDFILL LIFE EXTENSION STUDY - DRAFT
South Wake Landfill
Apex, North Carolina

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EXECUTIVE SUMMARY

SCS Engineers (SCS) has developed this Report to identify potential strategies to assist Wake County's Solid Waste Management Division with implementing the strategic goal to maximize the life of the South Wake Landfill as established by the Board of Commissioners. The BOC's directive to the Division is to extend the landfill's life "through recycling, technology, and other related initiatives." Accordingly, SCS has prepared this report to identify potential strategies available to the County to extend the life of the landfill, assess the viability of these options and evaluate the financial implications. The potential strategies are categorized into two basic themes:

- Waste Diversion and Reduction: Explore initiatives that reduce the generation of solid waste and also divert certain segments of the waste stream from the SWLF.
- Increase the Capacity of the SWLF: Increase the capacity of the existing/future waste disposal units at the SWLF.

To divert and reduce residential waste materials from being disposed at the SWLF, SCS investigated targeting rural communities. A curbside recycling review demonstrated that many of these communities merit attention because they exhibit recycling rates as low as 12.4 percent in FY 2017. Additionally, improvements to residential recycling programs throughout the County have the potential to add three years to the life of the SWLF. To foster a sense of collaboration within the County, various groups and individuals interested in the County's actions on source reduction, recycling, and composting should be identified and invited to participate in periodic meetings to discuss modifications to existing programs and policies or new programs and policies. As a potential new policy, organized recycling collection programs would provide consistency of services, reduce the number of waste collection vehicles, and improve efficiency. An organized collection program in the rural areas of the County could increase recycling and reduce waste disposal simultaneously. This can be accomplished through a contract recycling collections hauler. From there, any new programs such as hauling contracts or franchise agreements for curbside recycling would be simplified. At County collection sites, offering financial incentives to haulers who demonstrate exemplary diversion performance, creating a mattress recycling program, and/or the strategic acceptance of new recycling streams should be considered.

The County should consider targeting specific types of waste generators to enhance recycling efforts. In Wake County, construction and demolition (C&D) debris waste generators, multi-family homes, and commercial recyclers were noted as areas of potential improvement. Additional source separation of residential C&D materials, such as drywall, cabinets, or concrete, at collection centers would increase diversion. Wake County already accepts metal as a separate stream from residential C&D generators at its collection sites, but it could separate other types of C&D waste with extra room at collection centers to improve the C&D waste diversion rate. For example, untreated scrap wood could be accepted. Currently diverted materials and potential future streams of C&D waste could then be routed to alternative private facilities for cost savings, given the breadth of private C&D management companies in the County.

Multi-family complexes present a significant opportunity for the County to increase diverting waste from disposal at SWLF considering the abundance of dense population centers within Raleigh and other municipalities within the County. Because the City of Raleigh is moving forward with this initiative already, it may be most prudent for the County to target its encouragement to the Town of Cary or other unincorporated areas with significant proportions of multi-family residents. Collaboration with Universities should be an immediate action item to increase diversion by students living on and off-campus, while the County should target other multi-family complexes on a case-by-case basis. The County should investigate the type of container recyclable materials and the extent to which the container placement is convenient at multi-family complexes that are served by municipalities such as the City of Raleigh. For complexes the County or its municipalities cannot reach, the County could incentivize private haulers to offer robust recycling services. According to the 2011 Waste Characterization Study (WCS), the amount of commercial waste generated could be reduced by up to 35 percent with **improved commercial recycling.** Scale house records should be used to identify "red flag" businesses. Establishing a dialogue between the government and these business with an advisory group, like Orange County's SWAG, would be a good way to start reducing waste from the top down. While the County does already have Commercial Waste Reduction Grant funding in place, it could take a step further with smaller businesses by becoming directly involved in the initialization and maintenance of small business recycling programs.

Potential **County-operated diversion programs** that warrant further consideration include: implementing pay-as-you-throw; promoting reuse of select waste materials; expanding separate organic waste management efforts; and, providing enhanced recycling services at special events and facilities/events that attract large participants at discrete times (festivals, sporting events, etc.). The degree of difficulty in implementing these programs varies significantly. For example, to promote reuse the County could add private organizations to the County website; whereas, expanding separate organic waste management efforts may necessitate new facilities and new operations, such as composting sites and organics collection routes. Based on projections from the Financial Analysis of Volume Based Residential Solid Waste Collection for the City of Raleigh, a PAYT program would increase the City's diversion rate to 30 percent, from the 22 percent status quo. This change would increase the life of the Landfill by 2-3 years.

Though potentially complex and difficult to implement, research by NC State University (NCSU) found that adding food waste to yard waste programs has the potential to increase the County's diversion rate from 28 to 31 percent. . The City of Raleigh and other municipalities in the County currently accept yard waste and transform it into various compost materials/mulches for local farmers and homeowners. Building on this concept, the next step is allowing for the **addition of food waste to yard waste collection programs.** In partnership with private industry located in the region, four County convenience centers are currently accepting food waste. Expanding the number of food waste drop-offs and/or piloting food waste curbside collection programs should be considered. Additional major capital projects to stimulate diversion that may merit consideration over the long-term planning horizon include Waste-to-Energy plants or mixed-waste MRFs.

The County can also use its **political and social influence** to stimulate diversion. Policies to consider include zero waste framework, material bans, and surcharges applied at the SWLF. With the implementation of any of the aforementioned diversion strategies, the County can **demonstrate leadership** by exemplifying them in its own offices.

SCS has also considered options to increase the capacity of the existing SWLF. These strategies range from relatively simple solutions, such as planning for waste consolidation and settlement, to complex lateral expansion plans. Generally, the largest potential capacity gains will be achieved with the more complex changes to the landfill design. Any one of the strategies outlined herein could be implemented alone or in conjunction with other strategies for increased benefits.

A relatively straightforward method to extend the life of the landfill would be to **increase the angle of the final side slopes** of the landfill from 4:1 to 3.5:1. Slopes as steep as 3:1 are common at other landfills and an initial review indicates that this change would not be detrimental to the stability of the SWLF. This change could potentially **add 3 million cubic yards** of capacity to the SWLF.

A strategy that would require relatively little upfront investment would be to **temporarily overfill the landfill surface elevations** during normal operations. Waste typically settles after it is placed, thereby yielding additional airspace. It is possible to recover this airspace by additional filling, but this can be difficult as the primary working face may have moved a considerable distance away by the time the benefit is realized. A practice that makes taking advantage of this capacity easier is to slightly overfill and reach the intended grades through settlement. For, example overfilling by approximately 3 feet would yield an additional **600,000 cubic yards of airspace**, easier to utilize using this method. It may be possible to more aggressively overfill, but this may increase the risk that insufficient settlement occurs to conform to the permitted elevations.

It is possible to **expand the landfill vertically** without enlarging the facility's footprint. SCS considered expanding the landfill upward by increasing the elevations of the final grades, but this would have limited effect on airspace and may complicate operations. A more feasible approach would be to excavate deeper during cell construction to lower the subgrades. There would be some technical and permitting considerations in this approach, but SCS has identified a potential design that would provide an **additional 1 million cubic yards of airspace**.

A more complex potential option would be to construct a **mechanically stabilized earth (MSE) berm** along the perimeter of the SWLF. The cost and complexity of this strategy will vary based on the size of the proposed MSE berm. SCS considered two scenarios: one in which a relatively small MSE berm is constructed to add an additional **1 million cubic yards** of airspace; and, another scenario in which a slightly larger berm added **2 million cubic yards** of capacity to the SWLF. An initial preliminary review of site stability indicates that the addition of an MSE berm would not negatively impact the stability of the SWLF. Depending on the investment and commitment that the County is willing to consider, more substantial waste volumes could be added to the landfill capacity using an MSE berm.

One of the most complex strategies considered was a **lateral expansion** in which the physical footprint of the landfill is expanded. The landfill site has a number of physical limitations, such as the closed Feltonsville Landfill and surface water features, which would require negotiation to allow a significant expansion. This would require a formidable investment and involve significant permitting efforts. SCS identified an ambitious lateral expansion that could potentially add **12 million cubic yards** of airspace to the facility.

A lateral expansion could be coupled with a **landfill mining** project. One of the closed Feltonsville Landfill cells adjacent to the existing SWLF could be excavated and the solid waste could be screened to separate soil material. Some landfill mining projects have extracted 50 to 85 percent of the filled material as cover soil (Harler, 2012). In the lateral expansion considered, portions of the Feltonsville Landfill could be mined, potentially adding **2.5 million cubic yards** of airspace. Landfill mining is a complex and cost intensive process that also carries significant risk. Coupled with a lateral expansion, this strategy represents the most complex undertaking.

SCS conducted a **review of waste placement operations** of the contractor Waste Industries at the landfill. During this review, it was noted that the contract operator was achieving densities of about 1,400 pounds of waste per cubic yard (lb/cy). SCS believes this value is approximately 20 percent less that other landfills of similar size and configuration, which we understand often achieve in-place density of 1,750 lb/cy. We recognize that certain circumstances, such as initial waste placement in a new cell, impacts the ability to achieve a specified facility-wide in-place density value. Although the operating contractor is exceeding the requirements of the contract, achieving higher densities will **increase** the amount of waste that could be accepted over the life of the landfill **by 20%.** It may be beneficial to consider an incentive, such as a bonus system to motivate the contract operator to achieve higher densities.

SCS has developed the following matrix to organize its recommendations. The interplay of difficulty for the County and the potential impact on the life of the SWLF fueled the analysis.

Executive Summary of Potential Measures and Recommendations to Extend the Life of the South Wake Landfill

Measure	Section of Report	First/Next Step(s)	Potential Landfill Life Impact	Difficulty	Eval[2]
Waste Diversion & Reduction					
Increase Residential Recyclable Materials Diversion					
Assist Select Munis w/Residential Recycling	2.1.2	Develop consistent performance measures; Identify underperforming munis	High	Med	Green
Establish/Formalize Interlocal Collaboration	2.1.3	Form communication mechanism for County, city/towns, & other stakeholders	High	Med	Green
Establish Rural Curbside Collection Service	2.1.4	Feasibility Study; Exploratory RFQ/RFP for service	Med	High	Black
Offer Hauler Awards for Material Diversion	2.1.5	Develop program outline & facilitate hauler feedback to assess amenability	Low	Low	Yellow
Establish Mattress Diversion Program	2.1.6	Assess County facility/operational assets to guage feasibility; Estimate costs	High	Med	Green
Create Economies of Scale	2.1.7	Examine space available at CCs & available recycling markets	Med	High	Black
Construction & Demotion (C&D) Debris Diversion					
Explore MRF Possibilities for CC C&D Debris	2.2.1	Tighten enforcement of contractor/commercial C&D abuse at CCs	Med	Med	Yellow
Source Separate Addt'l C&D Material at CCs	2.2.2	Examine space available at CCs & available recycling markets	Low	Med	Black
Increase/Promote Multi-Family Complex (MFC) Recycling					
Start Serving Complexes in City/Towns	2.3.1	Identify candidate underserved MFCs; Conduct feasibilty study	High	High	Orange
Incentivize Private Haulers Serving MFCs	2.3.2	Assess hauler recognition program; Assess MFC containers per 2.3.4	Low	Low	Yellow
Target Student MFCs/University Collaboration	2.3.3	Initiate/enhance mechanism for dialogue with Universities	Low	Low	Yellow
Promote Commercial Recycling					
Audit/Perform Data Analysis of SWLF Loads	2.4.1	Interview LF scalehouse/operator staff to identify select commercial disposers	Med	Low	Green
Target Small Businesses	2.4.2	Perform assessment & study	Med	Med	Yellow
Collaborate with Stakeholders	2.4.3	Identify major generators & form inter-sector communication mechanism	Med	Low	Green
Business Waste Audits	2.4.4	Perform assessment & study; Walkthrough	Med	Med	Yellow
Pay-As-You-Throw (PAYT)					
Implement Pay-As-You-Throw	2.5.0	Identify method of accepting fee payment at collection centers	High	High	Orange
Expand Organics Management					
Expand Food Waste Education	2.6.1	Increase E&O, marketing; Examine County govt/schools policy	Med	Med	Yellow
Find Post-Consumer Food Waste Partners	2.6.2	Partner w/food rescue agencies; Maintain list of major generators	Low	Low	Yellow
Expand Composting	2.6.3	Expand food scrap collection & backyard program; Maintain generator list	Med	Med	Yellow
Implement Anaerobic Digestion	2.6.4	Conduct study/needs assessment for siting facility on County property	High	High	Orange
Additional Waste Reduction/Diversion Programs					
Lead by Example	2.7.1	Examine County govt & public school policy; Identify/form gurus/committees	Low	Low	Yellow
Stimulate Reuse	2.7.2	Post providers on County website; Identify deconstruction/C&D reuse markets	Low	Low	Yellow
Implement New Policy	2.7.3	Explore political will/legal ramifications	High[1]	Varies	Yellow
Sponsor Additional Special Events	2.7.4	Sponsor/provide repair workshop venue; Continue to attend special events	Low	Med	Black
Landfill Capacity Increase Measures					
Side Slope Angle Increase	3.1.0	Increase the final grade slopes from 4:1 to 3.5:1	Med	Low	Green
MSE Berm	3.2.0	Build a mechanically stabilized earth berm	Med	Med	Yellow
Temporary Overfilling	3.3.0	Fill above permitted intermediate grades	Low	Low	Yellow
Lateral Expansion	3.4.0	Expand the footprint of the Landfill	High	High	Orange
Vertical Expansion	3.5.0	Lower the Landfill base grades	Med	Med	Yellow
Increase Density	3.6.0	Work with contract operator to increase waste density	Med	High	Black

Note:
1. May vary widely depending on policy
2. Recommendation metric only utilizes two factors shown; if additional factors considered, result may be affected

Key		
Symbol	**Color**	**Description**
Green	Green	**Recommended & Endorsed** – Proceed with Implementation
Yellow	Yellow	**Recommended** – Proceed with Further Evaluation & Analysis to Facilitate Future Implementation
Orange	Orange	**Recommended but w/Reservations** – Significant Additional Evaluation & Analysis Necessary before Proceeding w/Detailed Planning Efforts
Black	Black	**Identified as Neutral Action** - Low Priority for Further Consideration

1.0 INTRODUCTION

The South Wake Landfill (Landfill) is owned by Wake County, North Carolina and operated by Wake County Disposal, LLC (which is owned by Waste Industries USA, Inc.). The site is located on Old Smithfield Road near Apex, North Carolina. The landfill began operation in 2008 and current life expectancy estimates project landfill closure in 2048. The Landfill will be developed in phases and, upon completion, is anticipated to have a total footprint of 179 acres and a gross capacity of approximately 30.88 million cubic yards (the gross capacity of the Landfill as originally approved was approximately 32.75 million cubic yards).

The remaining airspace at the landfill is evaluated by HDR on an annual basis using topographic survey data. The most recent report indicates that approximately 3.9 million tons of wasted have been disposed of in the landfill consuming 5.8 million cubic yards of airspace. This equates to an average density of approximately 1,300 pounds per cubic yard. The landfill had a waste intake rate of 440,000 tons between July 2016 and July 2017. The waste intake rate has increased by an average of 2% each year over the last four years. Currently only Municipal Solid Waste (MSW) is disposed at the facility (however the facility has accepted Construction and Demolition (C&D) Debris in the past). All municipalities within the County currently operate recycling programs accepting comingled recyclables.

SCS Engineers (SCS) has developed this Report to identify potential strategies to assist Wake County's Solid Waste Management Division with implementing the strategic goal (GS2.3) to maximize the life of the South Wake Landfill as established by the Board of Commissioners. The BOC's directive to the Division is to extend the landfill's life "through recycling, technology, and other related initiatives." Accordingly, SCS has prepared this report to identify potential strategies available to the County to extend the life of the landfill, assess the viability of these options and evaluate the financial implications. The potential strategies are categorized into the following areas:

- Waste Diversion and Reduction: Explore initiatives that reduce the generation of solid waste and also divert certain segments of the waste stream from the SWLF. Potential actions include reducing waste generation, promoting recycling, introducing financial incentives, and developing alternative waste disposal facilities.

- Increase the Capacity of the SWLF: Increase the mass-based and volume-based capacity of the existing/future waste disposal units at the SWLF. Potential actions include improving compaction, modifying certain specific design parameters of the landfill, incorporating certain, technological elements, and expanding the footprint of the facility.

The considerations and recommendations developed in this Report are intended to serve as strategies that will serve as a basis for planning for the extension of the life of the landfill operation. On 10/10/17, SCS held a kickoff meeting with SWLF stakeholders including Wake County, City of Raleigh, Town of Cary, NC State University (NCSU), and the NC Department of Environmental Quality (NCDEQ). SCS notes that NCSU is currently conducting a study ("A Systematic Exploration of Strategies to Manage Municipal Solid Waste in Wake County, North Carolina") to assess solid waste management scenarios and their potential effects on carbon emissions, cost, and landfill diversion.

2.0 WASTE DIVERSION AND REDUCTION

One consideration before implementing a new diversion effort is how to measure its impact. A common metric for assessing waste diversion is the annual quantity of waste materials per capita going to disposal (i.e., to a landfill or waste-to-energy facility). This method allows the County to track increases or decreases in its disposal rate while incorporating changes in its population.

According to the EPA, the national per capita disposal rate for MSW is about 4.4 lbs/person/day (landfill plus energy combustion). The County per capita disposal rate was 5.6 lb/person/day in FY 2015, meaning that Wake County's disposal is above the national average. The national diversion rate for MSW is about 35 percent, while the County diversion rate for MSW is about 36.6 percent (as of 2011). It's worth noting that the County diversion rate, expressed as a percentage, is likely understated as it does not account for yard waste composting and some private hauler recycling.

Examples of other possible waste recycling/diversion metrics include:

- **Recycling Rate** – the proportion of recyclable materials generated that were placed in the appropriate collection container(s) for recycling collection. The recycling rate is a common metric used to compare and assess recycling programs among businesses, communities, cities and states.
- **Proportion of Materials Placed in Refuse Collection Containers that are Recyclable** – the proportion of waste that should have been placed in recycling collection containers. Some businesses may have a low recycling rate if they do not generate recyclable materials. For example, a restaurant that generates a significant quantity of food scraps may have a low recycling rate but do a good job placing what is currently acceptable for recycling (such as cardboard) in the appropriate recycling collection containers. This metric is sometimes referred to as the "recyclables remaining (RR)".
- **Contamination in Recycling Collection Containers** – the proportion of material placed in recycling collection containers that are not recyclable. Higher contamination rates are a measure of recycling program quality.
- **Capture Rate** – the proportion of a particular waste material that was properly placed in recycling collection containers, or "captured" by the recycling program. For example, a business that generates corrugated cardboard but does not place much of it in the appropriate recycling collection containers does not have a high capture rate for corrugated cardboard. The same business may still have a high recycling rate from properly recycling other recyclable materials.

One or more of these figures could be employed by the County to track its progress with new diversion programs. The selection of a particular metric depends on the program goals. For example, the per capita disposal rate method may be best to assess the overall progress to reduce and divert waste from disposal, whereas the capture rate may be more appropriate to measure a specific program's progress, e.g. the capture rate of corrugated cardboard at the UPS Store.

The following sections address the waste diversion topics deemed in most need of attention during the project kickoff meeting and offer insights for the County to consider.

2.1 RESIDENTIAL RECYCLABLE MATERIALS EVALUATION

2.1.1 Residential Curbside Recycling Review

Each municipality in Wake County has its own collection strategies: some use municipal employees for curbside collection, others contract with private haulers, some have compost programs, and each has its own outreach and education published on its website. Table 1 presents a summary of the individual municipal curbside recycling programs including their reported recycling rates.

Table 1. Review of Residential Curbside Recycling Programs

Municipality	Collector Sector	Collection Frequency	No. of Households Served by Curbside Recycling Program	FY 17 Recycle Rate
Apex	Public	Weekly	13,900	23.7%
Cary	Public	Bi-weekly	39,000	24.4%
Fuquay-Varina	Public	Bi-weekly	9,440	15.4%
Garner	Public	Bi-weekly	5,405	17.8%
Holly Springs*	Private - WI	Bi-weekly	No data	No data
Knightdale	Private - WI	Weekly	4,662	15.1%
Morrisville	Private - WI	Weekly	5,300	25.5%
Raleigh	Public	Bi-weekly	83,210	23.7%
Rolesville	Private - WI	Weekly	2,000	22.7%
Wake Forest	Private – Republic Services	Weekly	11,105	21.9%
Wendell	Private - WI	Bi-weekly	2,287	10.1%
Zebulon	Private? (Republic)	Bi-weekly	1,972	12.4%

Note: Table includes numbers reported to NC DEQ in the State of NC Solid Waste and Materials Management Annual Report for July 1, 2016 through June 30, 2017 and does not include unincorporated recycling data.

= three lowest recycling rates

= mid-range recycling rates

= three highest recycling rates

2.1.2 Focus on Municipalities That Don't Emphasize Recycling

Waste diversion programs typically target population centers for recycling improvements; however, this can leave rural areas years behind in technological advances. In trying to divert waste from the County's Landfill, further analysis of rural area recycling and waste diversion may uncover strategies to help municipalities most in need of improvement. As shown in Table 1, Zebulon and Knightdale seem to have the lowest recycling rates. The same table shows that Morrisville has the highest recycling rate; therefore, its strategies could be useful in some of the municipalities with lower recycling rates. Continued calculation and reporting of recycling rates would help identify trends in the future.

2.1.3 Establish Inter-Local Collaboration

County members have expressed interest in a solid waste planning unit, which would serve to unite the County with municipalities and facilitate increased inter-local communication on solid waste issues. As the second most populous county in the state, this may be an especially productive venture for Wake County compared to others in North Carolina.

In order for waste diversion programs to be effective, the County must have the support from its cities and stakeholders. To foster a sense of collaboration within the County, various groups and individuals interested in the County's actions on source reduction, recycling, and composting should be identified and invited to participate in periodic meetings to discuss modifications to existing programs and policies or new programs and policies.

2.1.4 Establish Rural Organized Collection Program

The County could reduce waste disposal in rural areas through an organized collection program whereby the County or a municipality requires curbside recycling collection in a specified geographic area. This can be accomplished through several possible avenues:

1. Municipal Collection Services - The County or municipality provides the service directly;
2. Contracts - The County or municipality contracts with one or more private haulers; or
3. Franchise Agreements - The County or municipality creates one or more franchised collection areas.

Organized collection programs provide consistency with curbside collection services, reduce the number of waste collection vehicles, and improve efficiency of waste collection services which typically reduces the cost to residents.

An organized collection program in the rural areas of the County, particularly in municipalities such as Garner, Rolesville, and Wake Forest, could increase recycling and reduce waste disposal. Both a contracted and franchised collection system would require the establishment of collection zones and creating agreements with private haulers to service each zone. The agreement can be written to include specific provisions for achieving waste reduction goals. The County or municipality could reward (or require) a certain diversion rate, or that organics collection must be included in curbside service, etc. A contracted or franchised collection program would also allow municipalities to select the best-suited provider for their collection and disposal needs, and capture efficiencies in terms of truck traffic redundancies.

Catawba County serves as an example of a North Carolina County with a long-time franchising system for residential and commercial MSW and recycling.

Case Study: Catawba County

Catawba County has a 10-year franchise contract with Republic Services for MSW collection in unincorporated areas of the county. Under this agreement, Republic Services has agreed to offer recycling and garbage pick-up to any resident who requests it. As an example of adding diversion efforts to a franchise contract, the predetermined fees for service are decreased if the customer recycles. Services are also available for commercial customers, including C&D companies, and at community events.

2.1.5 Offer Awards to Haulers for Increased Material Diversion

One of the ways to influence private haulers to actively participate in waste diversion programs is to provide incentives for achieving prescribed metrics. This could be as simple as offering public recognition to companies who deliver more recyclable material. Many businesses are concerned with "being green" as part of their public image, which is something the County could leverage to increase the commercial sector's participation in waste diversion programs. Monetarily, discount/credits on landfill tip fees could be provided to haulers with exceptional diversion efforts – even targeting a certain type of recyclable material to meet the County's goals.

2.1.6 Establish a Program for Mattresses

Mattresses are increasingly separated from other MSW during the collection phase of the solid waste management process. This development is due to the challenges imposed during both the collections/handling and disposal of mattresses. During drop-off at collection centers, they can interfere with proper compactor operations and also tend to consume excess space in containers. On the working face of the landfill, they tend to be large and unwieldy, making them a detriment to equipment used to spread and compact the waste as they become entangled in the axles, wheels, tracks, and other moving parts. Mattresses are so problematic at the landfill working face, they are often aggregated and set aside and covered at the end of the working day. In addition, because of their relatively low density, they do not provide as much tipping fee revenue for the airspace they consume in the landfill when compared to an equivalent volume of average heterogeneous MSW.

Mattresses could be collected separately from other materials, and be assigned a unique collection fee to address the escalated costs incurred during collection and disposal. Currently, Wake County limits residents of its unincorporated areas to disposal of a maximum of two mattresses at its collection centers at any one time. Similar to the practice in neighboring Orange County, dedicated collection containers at a centralized site would allow for mattresses to be separately handled and diverted from disposal in the South Wake Landfill. For reference, Orange County residents may bring clean and dry mattresses to a central location for further processing/recycling for a fee of $10. The Orange County solid waste website also lists the Habitat for Humanity ReStore of Durham as a destination for mattress reuse/recycling (the non-profit's Wake County operation has an equivalent program) and directs high-volume mattress disposers to a mattress recycling firm located in Greensboro, NC.

Another example fee structure for the County to consider is that of Mecklenburg County, NC. Mecklenburg County, which has similar characteristics to Wake County, has a hierarchy of fees that apply to bulky items, including mattresses, furniture, etc., depending on the vehicle type and whether the hauler is a resident or business. Fees start at $15 per truck (residents may drop off one bulky item free of charge), and increases according to the schedule shown in **Figure XX.**

Figure 1. Mecklenburg County, NC Construction and Bulky Waste Fee Schedule

CONSTRUCTION & BULKY WASTE

	VEHICLE TYPE	FEE ($): RESIDENTS	FEE ($): NON-RESIDENTS & BUSINESSES OR NO STICKER
GROUP 1	1 Item Only Category: vehicles with any of the following: 1 large bulky item; such as a sofa, or a chair, or a table or Mattress Set. Only single items/small amounts less than 1-96 gallon can is eligible in this category. **If more than 1 item, see Group 2 below.**	No Charge	$15.00/unit
GROUP 2	Vehicles with the Following: More than 1 bulky item; Loaded with more than 1–96 gallon can; multiple items; vehicle loaded with more than 25% capacity. Any Work Vans (such as no side windows); Pick-up Trucks (without built up sides), Single axle trailers 8 ft or smaller, Units MUST be less than 3 cubic yards this category.	Bulky Waste: $15/unit Construction & Demolition Debris: $25/unit $9.40/cubic yard measured for loads greater than 3yd³	Bulky Waste: $27.50/unit Construction & Demolition Debris: $40/unit $13.30/cubic yard measured for loads greater than 3yd³
GROUP 3	All Vehicle Types Weighed	$46/ton or $15 load minimum (Bulky Waste) or $25 load minimum (C&D)	$46/ton or $30 load minimum

The addition of unit fees for the disposal of specific waste streams, such as mattresses or box springs, could yield an increase in illegal dumping of the materials by individuals seeking to avoid the fees, which potentially incurs additional enforcement and/or cleanup costs to the County. Therefore, it is important to set the fee assessment at a level high enough to offset additional program costs, but also low enough to discourage unauthorized dumping.

2.1.7 Create Economies of Scale for Area Recyclers

The County can use its existing collection site customers and collection infrastructure to collect and consolidate specific streams of material not currently accepted by area recyclers due current lack of economies of scale. An example of this would be collecting a new stream of recyclables such as polystyrene or plastic film at its collection sites. Once a particular material type is collected and the County is established as a reliable customer of an area recycler or broker, the economics of diversion of that material could become improved enough to entice private industry to collect the material, possibly even in smaller quantities. In light of China's new recycling policies, identifying commodities with strong domestic markets is especially important to the stability and success of any new recyclable material collection streams.

The source-separated collection of atypical-but-recyclable materials with a low density such as Styrofoam or plastic films (or recovery of those materials from single-stream recycling) might be especially beneficial to the longevity of the Landfill from a revenue efficiency perspective: these materials garner less tipping fee revenue relative to the amount of landfill airspace they consume when compared to average MSW. Many solid waste programs are examining the metrics with which they measure recycling program progress for this very reason. The County is uniquely positioned as both the implementer of public education and outreach (E&O) and collection programs policies and owner of the final disposal facility. This allows for the potential to strategize on a systemic level to maximize landfill tipping fees assessed per unit of airspace, the net result of which is increased revenues which can be used to fund further programs. One technique utilized by localities is to maintain an up-to-date list of generators within their jurisdiction which includes the estimated amount of various recyclable or divertible materials produced on a continuous basis, even if said material does not yet have a viable market. Having a system to share such information with potential recyclers or other entities seeking to potentially site a recycling facility locally may ultimately mean the difference between whether or not they locate to Wake County, bringing their diversion capability with them.

2.1.8 Potential Diversion from SWLF

Using FY 17 reporting data, municipal curbside recycling programs collected 49,989 tons of recyclable materials. This equates to a residential recycling rate of 21 percent (assuming all waste and recyclable material reported was generated from the residential sector). According to projections from the NCSU study, working to increase the residential and commercial recycling rates could increase the overall diversion rate to 33.3%, adding three years to the life of the SWLF.

2.2 PROMOTE C&D RECYCLING

Construction and Demolition Debris (C&D) comprised 32 percent of the County's total solid waste stream in 2011. There is no lack of opportunity to reuse or recycle this material in Wake County. While the County already collects C&D from residential customers and its convenience center, a substantial amount of bulky items are currently managed at the SWLF. Increased focus on commercial C&D recycling could reduce material disposed in the SWLF. Segregation and diversion of non-compactable inert material such as bricks and rubble can be particularly effective in prolonging the usable life of the Landfill.

2.2.1 Explore C&D MRF Possibilities

- Existing Waste Industries MRF - Currently, the County sends wood pallets to the Waste Industries C&D Material Recovery Facility (MRF) in Raleigh. In the future, it might consider expanding the types of C&D sent to a MRF, including bricks, cement block, rubble, drywall, etc. SCS called local MRFs in the area for tip fees, organizing the results by increasing price in Table 2.

Wake County may consider disposing of C&D collected at drop-off sites at the Capital Waste Transfer Station or Greenway Waste Highway 55 Reclamation for tip fee savings. Greenway Waste is located adjacent to the South Wake Landfill, and is already accepting C&D that cannot be disposed in the SWLF. This could be a potential opportunity for future public-private relations. The facility recycles gypsum, roofing material, scrap metal, wood, concrete, and brick.

Any of these C&D Landfills that increase their recycling rates could be recognized for their efforts as well.

Table 2. C&D Landfill/Transfer Station Tip Fees

Name	Address	Per Ton Fee	
Greenway Waste Hwy 55 Reclamation	5940 Old Smithfield Road Apex, NC 27539	$40.50	$10.50 minimum, <300 lbs
Capital Waste TS	424 Warehouse Drive Raleigh, NC 27610	$49.50	$49.50 minimum
Republic Services TS (one ton min.)	5565 Thornton Road Raleigh, NC 27616	$50.73	-
Waste Industries MRF	421 Raleigh View Road Raleigh, NC 27610	$59.62	-
Shotwell LF	4724 Smithfield Road Wendell, NC 27591	$65.00	$65 minimum

Note: Capital Waste TS and Shotwell Landfill are operated by the same company

- .

2.2.2 Source Separation at County Convenience Centers

Wake County already accepts metal as a separate stream from C&D waste at its collection sites. It could separate other types of C&D waste with extra room at collection centers. Windows, clean wood or other types of valuable items could be diverted from the C&D waste stream and resold for additional revenue. Concrete, for example, increased in price by 80 percent from 2005 to 2015, according to the US Chamber of Commerce Foundation. The market for shingles is another stream to consider. Shingles can be recycled to make asphalt for paving roads. Premier RAS in Raleigh accepts shingles at $75 per trip (no matter how much is being hauled).

Untreated scrap wood could be accepted and composted in current yard waste processing operations. Catawba County, NC currently composts yard waste with C&D wood scraps, and is in the planning stages of starting to collect Type I food waste and grease from restaurants to add to the mixture. The City of Raleigh maintains a yard debris management facility with a 160-acre capacity, which could be a potential location to handle the untreated wood scraps.

2.2.3 Potential Landfill Diversion with C&D Recycling

In FY 2011, 301,831 tons of Wake County C&D were landfilled, and 64,215 were recycled. This gives a baseline diversion rate of 17.5%. Assuming that the County could double its current C&D

diversion rate with recycling efforts on the same total tonnage received, 128,116 tons of material could be diverted from SWLF.

2.3 PROMOTE MULTI-FAMILY RECYCLING

2.3.1 Serve Complexes in Raleigh and Cary

With more than 300 complexes within the Raleigh City Limits, with many that would likely be interested in recyclables collection, the implementation of multi-family curbside planned for June 2018 could have a significant effect on diversion rates for the County.

When offering collection to multi-family complexes, it is important to work closely with the property managers. This is especially important for Wake County/Raleigh because of its transient student population. Currently, Raleigh offers curbside recycling to multi-family homes with “igloos” or carts that can be requested from the City by managers. The City already has a Block Leader program in place for community volunteers to spread awareness of this program. It could bring this idea to the County to expand the reach of the Block Leaders.

Because the City of Raleigh is moving forward with this initiative already, it may be most prudent for the County to target its encouragement to the Town of Cary or other unincorporated areas with significant proportions of multi-family residents.

2.3.2 Private Hauler Advantages

One of the reasons it is difficult to service multi-family dwellings is because there is a variety of layouts, levels, and spaces available at each complex. As opposed to collecting recyclables at the city or county level, private haulers can have a distinct advantage for multi-family homes. These companies often have a greater variety of resources, making it more likely that they could prescribe unique solutions for different types of structures – town houses, high rises, etc. For multi-family complexes that are out of reach for municipal services, the Municipalities/County could provide incentives for private haulers to service them (e.g. a subsidy, public recognition and/or discount on tip fee).

2.3.3 University Collaboration

A large portion of the multi-family population in Wake County or Raleigh is associated with students at NCSU and other academic institutions. NCSU has recycling and composting operations for its campus buildings, but off-campus housing presents an opportunity for a relationship between the County and the University. NCSU may be interested in collaborating with the County and municipalities to aid its off-campus student population in increasing its diversion. An example of one such system is the University’s dormitory move-in/move-out Goodwill drop-box diversion and reuse program, which currently only occurs at on-campus dormitories. The successful program has not been expanded to off-campus housing complexes. The County and University may also more easily achieve economies of scale when partnering to implement certain new landfill diversion programs.

2.3.4 Container Considerations

Container format and layout can have a dramatic effect on waste diversion rates. The County could collaborate with municipalities to implement the following strategies at multi-family dwellings.

Container Sharing - New York City's Zero Waste Design Guidelines suggest placement of collection containers in a shared location. Usually apartment buildings are next to each other, so sharing service cuts costs for the property managers and/or residents involved, and decreases the clutter and confusion of already crowded urban areas. While keeping in mind City planning rules, this strategy could be extended to community-level shared recycling facilities as well. In dense urban areas such as downtown Raleigh, recycling containers should be installed alongside trash receptacles where possible.

Figure 2. Prominent Placement of Recycling Containers

Advanced Collection Equipment - Savings from sharing containers between multiple apartment buildings/complexes could allow for investment in more containers and container locations. A compactor or baler is a significant capital investment, but the volume reduction would make hauling a more efficient task for private or even public collectors[1]. The cost savings over time would be realized by the reduced number or trips/containers needed to haul the shared residential items.

Placement - The location of the actual collection containers is another unique challenge, especially in urban areas with alleys and other tight spaces. The containers should be placed in a central location as close to the building(s) as possible. The recycling containers should be easy to access, as shown in **Figure 2** (in fact residents have to walk by the recycling containers to get to the dumpster), and/or equal in size to the garbage containers, as in **Figure 3**. Some high-rise apartments can make recycling difficult if they have trash chutes. A way to combat this issue would be to modify the chute to accept recycling, if possible. Easy-to-store containers for each apartment is another good way to encourage diversion in buildings with multiple floors. Outdoor recycling containers should be as large as or larger than the general garbage receptacles.

Figure 3. Recycling Container of Equal Size to Garbage Container

2.4 PROMOTE COMMERCIAL RECYCLING

Commercial generators make up a significant part of Wake County's waste stream. According to the 2011 Waste Characterization Study (WCS), the amount of commercial waste generated could be reduced by up to 35 percent with improved commercial recycling. Additional consideration could be given to compostable materials such as food waste and compostable paper products. The 2011 WCS also indicates that diverting organics could potentially cut out 33 percent of the commercial waste stream.

To effect this change, the County could develop a more targeted education campaign that encourages and/or incentivizes waste generators to source-separate food and soiled paper waste from other waste. There is a lot of useful information available on the County's website, but it may prove more effective to bring initiatives to selected businesses rather than to wait for them to approach the County.

A broader study for the County would involve professional waste audit services, under which a representative group of businesses would be selected. For each participating business, measurements would include the monthly quantity and quality of recyclables and refuse generated. From the data (collected over a designated time span) an extensive numerical analysis would be the finished product to show exactly how diversion could be improved in each case.

2.4.1 Landfill Data Analysis

There's a wealth of data waiting to be collected and utilized from the landfill premises as a cost-free measure to hone in on problem areas in the commercial sector. Scale house records could be used to identify "red flag" businesses based on company name and other descriptions. Another way to pick out businesses is to reach out to areas from which loads are incurring surcharges for OCC.

Another cost-effective option for utilizing existing data is to hire an intern to document loads coming into the landfill for a specified time period. The intern could easily identify loads with significant recyclable contamination and record the name of the hauler.

Wake County could use this data to focus its efforts directly to its top waste producers. The City of Napa, CA determines its 25 largest commercial trash generators each year and audits their waste streams. These businesses receive an in-depth analysis of what could be recycled and how to set up a system to capture all recyclables on-site. Establishing a dialogue focused on recycling with Wake County's top waste producers would be a good way to start reducing waste from the top down.

2.4.2 Target Small Businesses

Implementing a recycling program can be particularly challenging for smaller businesses. The money and effort required to hire a hauler, set up an employee education regime, and maintain recycling infrastructure becomes an obstacle. While the County does already have Commercial Waste Reduction Grant funding in place, it could take a step further by becoming directly involved in the initialization and maintenance of small business recycling programs. Wake County could be a facilitator for partnerships between neighboring businesses, especially in dense urban areas and strip mall-type setups. In this way, smaller businesses can split the bill for their disposal and recycling, clearing up space in the streets, and make recycling more accessible.

A way to do this may be to conduct a study, allowing the businesses to use bins provided by the County as a trial run for their recycling "unit". Offering advice along the way or even helping to supply an example contract for the separate entities could stimulate growth. The County could use its experience and expertise to give insight on private haulers, pick up frequency and times, collection container optimization, etc; essentially personalizing the information it provides on the County Website under Commercial Waste Reduction.

Raleigh already offers a collection services to any business in the Central Business District, and case-by-case service to small businesses in primarily residential areas of the City. Other urban areas in the County could follow suit, taking on businesses that are most feasible for current municipal collectors to add to their routes. Less-populated municipalities in the County could adopt similar programs to pilot a small business collection system.

2.4.3 Collaborate with Stakeholders

Holding a meeting with businesses and other large individual generators to gauge interest in increased recycling efforts is a good way to actually involve the parties affected by the waste reduction strategies. Interested businesses/institutions could attend a special meeting with the County to discuss concerns and ideas. There are stakeholders out there with preexisting practices and/or enthusiasm for recycling initiatives. These stakeholders could inspire and possibly aid others with their own programs.

Continual communication between business, institutional, and government on diversion initiatives could be facilitated by creating an advisory board that includes prominent members from multiple sectors. Orange County's Solid Waste Advisory Group (SWAG) provides a local and successful model of such an advisory board. The SWAG is comprised of local board members: this unites local government leaders from member towns, as well as a representatives from the University of North Carolina (UNC) and UNC Health Care. Solid waste program staff members from the participating jurisdictions should also participate in meetings. In the same way that SWAG develops inter-local initiatives, so too could Wake County's own solid waste advisory board. In addition (or alternatively), with more representation from businesses, the board could bridge the gap between public and private sectors, facilitating increased diversion from the landfill all around.

2.4.4 Business Waste Audits

Conducting a waste audit is a good place to start in the process of implementing or improving a recycling program. Each business has a unique waste stream, and so characterizing the current conditions is important to tailoring a plan to specific needs. Below is the general timeline of a business waste audit.

1. Conduct a Walkthrough. A recycling expert visits the site to note the status quo of disposal and record areas where improvement is needed. Its purpose is to identify potential for recycling initiatives and alternate purchasing opportunities, such as recycled office paper or dining paper products, recycled plastic containers, etc. that are examples of ideas that may arise during the walkthrough.

   The expert should be familiar with factors that affect commercial recycling rates, like capacity. Based on a study SCS conducted in Montgomery County, MD, we recommend that recycling capacity should be no less than 40 percent of trash capacity, so the appropriate amount of bin space should be provided first and foremost. The type of container is another thing to consider. The container should be conducive to the material that is meant to go in it. The customization element of a waste audit becomes important for container selection. For example, if a business disposes of a lot of OCC, the cardboard recycling bin should have an opening large enough to fit larger boxes. Finally, convenience should always be kept in mind. The easier it is to recycle, the more often people will do it. A rule of thumb is to aim for a distance of less than 300 feet for employees to recycle/compost. The receptacles should be easy to access as well; not too high to reach the lid and free from obstructions.
2. Once a Plan is Developed, the Next Step Is to Phase It into Action - This starts with training staff. This should be an ongoing process, to keep employees fresh and to account for turnover. The staff is the cornerstone to the recycling program, so it's crucial that the recycling practices are clear – what goes where, when pick-ups are, and any preparatory steps such as removing labels or lids. This is a good time to add incentives for good practices as well. Perhaps a monthly recognition for an "above and beyond" recycler, to emphasize the importance of the program.

3. Distribution of Tangible Educational Materials - The final piece of groundwork expresses the plan to the public. Posters, signs, and stickers should be in place and easily visible wherever recycling containers are. These should explain what items may be placed in each container, and offer encouragement.

4. Once the Recycling Program Is in Place, Establish Metrics to Track Success - This can also help identify areas of improvement over time. This could manifest itself as a measurement of contamination, percent diversion, or quantity recycled overall, etc. on a mas *or* volume basis.

2.4.4.1 Potential Businesses to Audit

Using business size and sector, SCS compiled a list of possible businesses that Wake County may consider for a waste audit. Table 3 categorizes potential options into sectors of the economy for further analysis.

Table 3. List of Potential Business for Waste Auditing

BIGGEST PRIVATE EMPLOYERS	
• IBM • WakeMed Health and Hospitals • SAS Institute, Inc.	
BIGGEST PUBLIC EMPLOYERS	
Education	**Institutions**
• Public School System • Universities (Wake County is home to six colleges) • Wake Technical Community College	• Museums • Wake County • State of North Carolina

Public Employers – Education and Institutional jobs dominate the overall employment in Wake County (including all of Research Triangle Park), according to the Wake County Economic Development website. These facilities might be large to tackle, but also are more likely to have company-wide sustainability goals and/or the funding to start/improve a diversion program. These employers are also directly linked to the County by nature, making them easier to reach for auditing. Universities are a great place to start for cultivating sustainability, and could be a good ally to have in the community. NCSU's campus, for example, makes up a significant portion of Raleigh, with its student body representing roughly 10 percent of the city's population. Without mention of alumni who would also be likely to join in on University initiatives, higher education offers a unifying presence to feed off of for large-scale change in the way the public thinks about waste.

Private Employers – The healthcare industry is another big player in the economy of Wake County. Between Duke University Health System and WakeMed Health and Hospitals there are 44,944 employees. These entities make sanitation a large part of their business, and so contacting them for a collaborative waste audit could establish a dialogue and culture of diversion between the government and healthcare institutions in the County.

2.4.5 Potential Diversion with Increased Commercial Recycling

According to NCSU's research on Wake County, commercial diversion of OCC, food waste and comingled containers, such as beverage cans, bottles, etc., combined could increase the life of the SWLF by two years. Targeting a whole sector of industry, especially one that is known for producing significant amounts of waste, is more likely to have large-scale and cost-efficient effects.

2.5 IMPLEMENT PAY-AS-YOU THROW

In Pay-As-You-Throw (PAYT) programs, sometimes referred to as Save-As-You-Throw, residents are assessed for waste collection services based on the amount of waste they throw away, similar to the way they pay for electricity, gas, and other utilities. This type of program incentivizes increased reduction and recycling efforts from the source.

If Wake County were to implement a PAYT program at its collection centers, an important decision that would have to be made is how to decide how to track disposal quantities by disposer. Access fees, designated garbage bags, stickers for placement on ordinary garbage bags, or standardized waste collection containers (sometimes requiring the regular purchase of decals for assessment) could all be options: the idea is to find something easily identifiable and uniform to each customer. See **Figure 4** for examples of PAYT unit indicators.

Figure 4. PAYT Program Identifiers

The other variable to consider is how to assess charges for services. Below are the three main ways to manage the materials distribution and collection fee structure:

- **Full-Unit Pricing** – residents must purchase bags or stickers in advance and only waste in approved containers will be collected;
- **Partial-Unit Pricing** – residents are provided a certain number of bags or stickers for their waste that is included for collection with their taxes. Additional bags or stickers must be purchased if the resident produces more waste than is covered.
- **Variable-Rate Pricing** – residents choose a particularly-sized cart based on the amount of solid waste generated. The smaller the cart the cheaper the disposal cost. When implementing such a variable-rate system, the per-unit cost should not be reduced for larger volume carts.

Any combination of containers or pricing allows PAYT to be tailored specifically to Wake County's needs. Many programs choose to provide one container, but allow overflow in pre-purchased bags. Based on projections from the Financial Analysis of Volume Based Residential Solid Waste Collection for the City of Raleigh, a PAYT program would increase the City's diversion rate to 30 percent, from the 22 percent status quo. This change would increase the life of the Landfill by 2-3 years. A benchmarking study included in the Financial Analysis included a comparison of cities' solid waste programs.

The summary presented in **Table 4** shows the variability in effectiveness of PAYT. The cities selected for this study have comparable refuse and recycling services and a similar population to Raleigh. They also are all cart-based programs, not bag-based (no bag programs aligned with the other selection requirements). Charlotte and Greensboro were selected for proximity; note that these cities do not currently have PAYT programs. Raleigh already achieves higher diversion rates than three of the cities with PAYT, while cities such as Austin, Grand Rapids, and Plymouth have achieved more effective diversion rates using a PAYT cart-based system.

Table 4. Summary of PAYT Parameters from City of Raleigh Study

City	PAYT	Diversion Rate	Year of Diversion Rate	Contamination Rate
Raleigh, NC	N/A	22.4%	2016	13.2%
Austin, TX	Cart	31.3%	2016	16.4%
Charlotte, NC	N/A	19.5%	2016	N/A
Fall River, MA	Cart/bags	N/A	N/A	N/A
Gainesville, FL	Cart	17.6%	2016	3%
Grand Rapids, MI	Cart/bags	28.1%	2016	15%
Greensboro, NC	N/A	19.1%	2016	22%
Middletown, RI	Bag	39.2%	2016	10%
Plymouth, MA	Bag	29.2%	N/A	N/A
Sacramento, CA	Cart	17.1%	2013	21.1%
San Antonio, TX	Cart	14.8%	2016	22%

Some North Carolina counties already using PAYT to bill customers include Alamance, Union, Wilkes, and Craven Counties. **Table 5** and **Table 6** break down PAYT programs into curbside and drop-off systems, serving as examples of both implementation methods. According to studies by Skutmatz Economic Research Associates, Inc. (SERA), the results of a curbside or drop-off PAYT system are very similar, in the range of 17% reduction of residential trash and an average of 30% increased recycling rate.

Table 5. Local Curbside PAYT Programs

<table>
<tr><th rowspan="2">County/City</th><th rowspan="2">Program Type</th><th colspan="2">Trash</th><th>Recycling</th></tr>
<tr><th colspan="2">Cost Per Bag</th><th>Cost</th></tr>
<tr><td rowspan="3">Craven[1]</td><td rowspan="3">Sticker</td><td>Up to 33 Gal. (not more than 50 lb.)</td><td>$3.00</td><td rowspan="3">$36/year</td></tr>
<tr><td>34-64 Gal. (not more than 100 lb.)</td><td>$6.00</td></tr>
<tr><td>65-90 Gal. (not more than 150 lb.)</td><td>$9.00</td></tr>
<tr><td rowspan="2">Wilmington</td><td rowspan="2">Container[2]</td><td>Mini cart (35 Gal.)</td><td>$21.36/month</td><td rowspan="2">No additional cost</td></tr>
<tr><td>Maxi cart (95 Gal.)</td><td>$26.29/month</td></tr>
</table>

Note:

1. Each sticker is $3

2. Prices are for disposal containers; bag stickers are assessed at $1.25 ea. and are available for each extra household bag of trash

Table 6. Drop-off PAYT Programs

County/City	Program Type	Trash		Recycling
		Cost Per Bag		Cost
Alamance	Bag	$0.50 (for drop-off at Landfill)		No charge
Union	Bag	SM - 13 Gal.	$0.75	No charge
		MED - 14-33 Gal.	$1.25	
		LG - 34-55 Gal.	$5.00	
Stafford, VA (R-Board)	Per Visit	One-time	$4.00	No charge
		10 Coupons	$30.00	
		Annual Pass	$100.00	
Wilkes	Bag	13 Gal.	$0.35	No additional cost
		30 Gal.	$0.65	
		>30 Gal.	$1.15	

2.6 EXPAND ORGANICS MANAGEMENT

The City of Raleigh and other municipalities in the County currently accept yard waste and transform it into various compost materials/mulches for local farmers and homeowners. Building on this concept, the next step is allowing for the addition of food waste to yard waste collection programs. The NCSU study found that adding food waste to yard waste programs has the potential to increase the County's diversion rate from 28 to 31 percent. In partnership with private industry located in the region, four County convenience centers are currently accepting food waste.

Food scraps alone make up approximately 15 percent of the County's disposal stream. Whether the strategy be to compost or digest anaerobically, diversion of organics from the landfill allows decomposition to happen in a controlled environment. Methane can be easily collected from a digester and used for energy, while aerobic processes in compost produce more carbon dioxide than methane, decreasing the carbon footprint of organic waste. Additionally, compost can be used as a rich soil amendment for landscaping, gardening, and farms. Strategies to mitigate food waste going to the landfill are arranged in order of increasing vigor.

2.6.1 Level 1: Food Waste Education

Encouraging local schools, businesses, and households to compost on-site, recycle, and donate food when possible are good ways to divert food waste without too much financial expenditure. The EPA has a series of resources called the "Food: Too Good to Waste Toolkit." The information provided by the toolkit is written for local governments, with items like presentation slides and posters that can be printed and distributed.

It would also be helpful to provide resources to the public for food waste diversion. For example, posting links to actual businesses that accept commercial food waste on the County's Organic Waste page might be helpful. If possible, partnering with a food bank or composting company might be another good option. The easier it is for people to do the right thing, the more likely they are to do it. Education is a great first step, because the community support may help with implementing more aggressive food waste diversion efforts in the future.

2.6.2 Level 2: Post-Consumer Food Waste Partnerships

Food for Human Consumption - If a partnership was made with an existing foundation (for example a food bank) a designated day could easily be set up for community-wide drop off, as well as generally increased promotional efforts on the part of the County.

Food rescue could entail a partnership with the Food Bank of Central and Eastern North Carolina, for example, which has a location in Raleigh, or the Inter-Faith Food Shuttle. The County could collaborate with food rescue programs like these to donate food, co-host events, or volunteer.

Food for Animal Consumption - If collection of post-consumer waste were performed by the County, a partnership with a local livestock facility could be formed for disposal. The Mohegan Sun casino in CT has been sending food scraps to a pig farm since 1996 (1,000 tons per year in 2010), while Rutgers University dining halls have been doing the same thing since 1960.

One problem with this strategy is that it would be difficult for the County to implement directly. Typically, food scraps need to be refrigerated and run through a pulper for size reduction. These processes are both energy intensive and require new infrastructure if the food waste were to be delivered to the County. One potential alternative would be for the County to facilitate an intermediary entity or "middle man" to coordinate local farms with other stakeholders such as restaurants, universities and/or commercial haulers.

2.6.3 Level 3: Composting

Composting diverts food scraps, yard clippings, and paper products by transforming them into a marketable product. If carried out in-house, a major benefit is that the compost can be used for County landscaping, or sold to nurseries, gardens, golf courses etc., or given/sold to individual County residents, with any revenue generated going directly to the County.

Implementation options include:

- Encourage Backyard Composting - aiding private homes, publicly owned facilities, or businesses in operating their own composting process.

- Collect Food Scraps and Transport them to a Private Composting Facility – food waste collection could be added to current yard waste routes as a pilot program. Alternatively, Organics pickup could also be added on to a normal MSW/recycling route, perhaps even a single pilot route in each participating city/town, and gradually expanded as seen fit. Staging the implementation of pickup services allows time for changes to be made early, before any hiccups become major issues. Curbside service would be the most convenient method of implementation from the viewpoint of customers, however this woul incur significant cost, as the County would likely need to supply new bins to residents and implement costly pickup service.

Another approach could be to start with commercial enterprises, universities, hotels, convention centers, etc., because these entities provide more consistent and homogeneous food waste stream. For an industrial-scale composting operation (run by the County or otherwise), these steady input sources may be preferable, with residential being an option for future implementation.

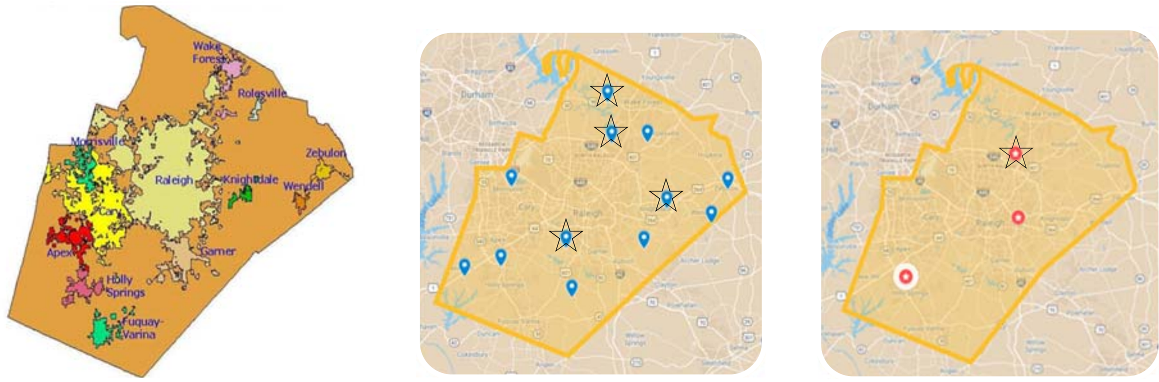
- Open a County-Owned Composting Facility on Landfill Grounds - This could be done at one of the landfills, or on other municipality-owned land (pending agreement). The results of the 2015 Organic Waste Study (HDR Report) show that the most feasible type of composting facility for the County to own is conventional windrow.

  Local or Centralized? The two maps to the right in Figure 5 show a decentralized and centralized system of potential collection locations. The decentralized model would save hauling costs, but composting on-site or further hauling would have to be assessed at each one. A more sophisticated composting operation or AD would be more easily implemented at a centralized collection center. The map furthest to the right shows the two County landfills and the Easte Wake Transfer Station as potential sites. The Raleigh Yard Waste Center could be an option for piloting food waste composting as well. It already has the composting infrastructure and space, however a different permit would be required.

  If centralization is not feasible/desirable, it could save transportation and capital costs to have a network of smaller local composting sites in individual municipalities. Commercial generators of organics may be more inclined to deliver food waste (and/or paper products and yard clippings) to a drop-off site. Curbside collection could easily be instituted down the road once the drop-off system is in place.

- Enter into Public-Private Partnership - Operating a composting facility with a private business could ease the burden of startup with shared funding, siting and/or design responsibilities.

- Hire a private company to collect, transport, and treat organic waste - Local examples of these private entities include the McGill-Delway, Food FWD, and Brooks Contractor composting centers. Brooks Contractor offers food waste collection for industrial-scale operations and large businesses, and also partners with smaller composters who can help smaller businesses who still want to compost. McGill can both accept organics from clients and/or offer a range of compost services including design and operations reviews of clients' composting facilities. Food FWD offers curbside collection for businesses and events, while offering drop-off options for residents. For residential organics, CompostNow offers curbside services in the area.



Area served if organics pickup added to municipal MSW routes

Potential for organics collection at County conv. centers (program already at starred locations)

Potential for organics added at County landfills/transfer station (CC #7 is located at N. Wake County Landfill)

Figure 5. Potential Compost System Layouts

Food Service Industry: Front and Back end Consideration - Recycling stations should be emphasized both at the preparation and consumption stages of food service businesses. The types of recycling available specifically tailored the types of waste produced by the food being served. Consideration should be made for the containers that food and drink are served in, any sanitary products, and of course the food itself. The opportunities for diverting organics in a restaurant are two-fold; preparation and post-consumption. Recycling and food waste are generated at both stages, so providing a means of diversion in both settings is the best way to divert all recyclables/compostable material from landfill disposal. Pre-consumption wastes may include packaging and any scraps from preparation, while post-consumption wastes may be occurring in public spaces (as in a fast food or food court) or back in the kitchen at sit-down restaurants. Subtle differences in the service of each business require special attention to what types of recycling is available and where receptacles are placed.

A sampling of restaurant-specific recycling and organics diversion strategies is listed below:

- **Placement** - convenient access to appropriate bins in kitchen prep stations and in public consumption areas of cafeteria-style eateries (see **Figure 6**) increase the chances of proper food waste disposal.
- **Changes to ingredient packaging** - ingredient packaging can be minimized with right-sized utensils and bulk purchasing of items with a longer shelf life.
- **Changes to takeout packaging** - consider using compostable or recyclable takeout containers, making sure they are appropriately sized to save material.
- **Portion size** - track how often patrons are unable to finish meals, and consider using smaller portion sizes if meals are frequently left unfinished. For buffet-style eating, eliminate trays to discourage taking more food than one can eat.

Figure 6. Easy Access to Kitchen Composting Bins/Recycling and Compost Consumer Accessibility

Case Study: Dodge County, MN Community Composting Program

Dodge County approached food waste diversion by sector within three distinct categories: businesses, school, and residential waste. After meeting with interested parties, action plans were formulated. The system was tailored to each individual category of waste stream; the residential and school composting occurring on-site and centralized collection implemented for businesses. Dodge County budgeted $8,500 to invest in composting containers, bags, and time for setting up each program. The efforts yielded a total diversion of 70 tons per year of organic waste in its first year.

Case Study: Prince William County, VA Balls Ford Road Composting Facility

With a windrow yard waste composting system already in place, Prince William County is in the process of constructing an enclosed aerobic composting system to accept food waste. An agricultural services and production company has partnered with Prince William in this effort, so there is no county capital expenditure. The contracted company is funding and operating the new yard and food waste composting system, which is expected to extend the county's landfill life by approximately 10 to 15 years (assuming the 30% of organic waste in the County's waste stream is entirely diverted to compost). Anticipated commercial tip fees are $35/ton and $38/ton for yard waste and food waste, respectively. SCS expects that installing a composting program would have similar effects *in Wake County, increasing the life span of its landfill, as well as generating a valuable product over time.*

Aerial View of Balls Ford Composting Facility

2.6.4 Level 4: Anaerobic Digestion

Anaerobic Digestion (AD) technology is used extensively in the treatment of biosolids by wastewater treatment facilities, however use for organics disposal in the United States is fairly recent. There are dry and wet systems, depending on the characteristics of the input stream (more liquid or solid). In either case, a sealed off enclosure is used to achieve the absence of oxygen needed for bacteria to break down organic material. The products of this process are marketable biogas (mostly methane), and digestate, which is similar to typical compost after a stabilization period.

An AD plant requires a larger capital investment, around $2-4 million, but comes with low operating costs (about 5% of the capital investment). The advantage of using AD is that the methane gas released from the process is valuable and doesn't seep into the atmosphere as greenhouse gas. According to scenario modeling performed as part of the NCSU study, using AD in place of composting would achieve greater greenhouse gas (GHG) emission reductions than composting, but would incur increased cost per managed ton to accomplish. Another potential drawback is the volume of waste required for an AD plant: the HDR Report estimated over 100,000 tons of organic waste per year would be needed.

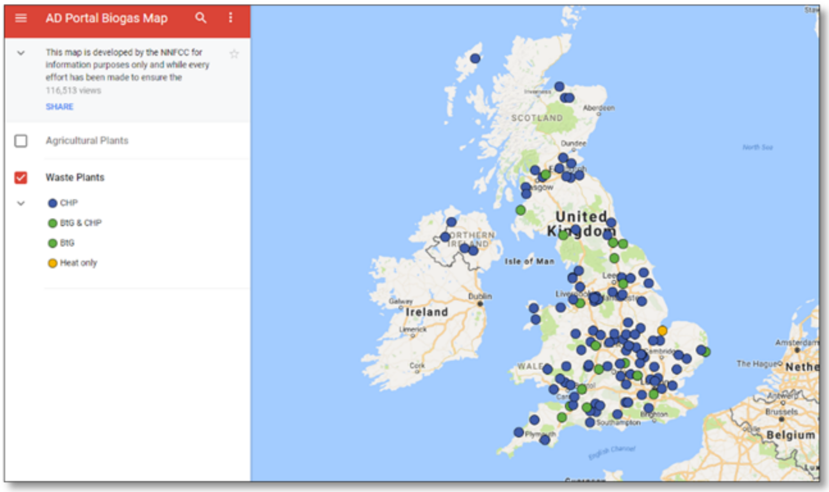


Figure 7. Map of UK Anaerobic Digesters

Europe has been using AD technology to process food waste for years. The map in **Figure 7** exemplifies the breadth of AD usage as a waste management strategy in Europe. The blue dots are plants that burn the biogas product on-site for heat/power. Green dots send their biogas to the power grid. Anaerobic digestion is an up-and-coming technology for use by solid waste managers in the US, but its success in Europe and for other industries (such as wastewater treatment) sets a promising precedent. The options for initiating this technology are similar to those of composting, individual, public-private, or fully private.

Case Study: Full Circle Recycle, Zebulon, NC

Full Circle Recycle has a 750,000-gallon AD unit in Wake County. Their facility is co-sited with a farm, and so the biofuel and methane are both used on-site for heat. Both food waste and yard waste are accepted, typically from grocery stores and restaurants, but residential organics are also accepted.

Case Study: New Bedford, MA Crapo Hill Anaerobic Digester

The New Bedford Landfill began this project in 2014, with its CommonWealth Resource Management Corporation (CRMC) anaerobic digester proving to be a success. The digester processes 3,000 to 5,000 gallons per day of food waste, producing 187,000 kilowatt-hours of electricity by mixing its product gas with the landfill gas at its WtE plant. The digestate is placed in the landfill to catalyze biological processes. A visual representation of the process is displayed in Exhibit XX. The success of this first pilot digester has prompted New Bedford to fund the addition of a larger digester.

2.6.5 Potential Diversion with Organics Management

According to the NCSU Solid Waste Management Planning Study, if food waste were to be collected with yard waste, overall diversion could increase from 24.6% to 26.4%. This addition to an existing route would service over 230,000 homes in the County. These projections assume full cooperation of municipalities' collection programs and yard waste treatment facilities. The treatment method (aerated static pile) need not change, considering that food waste can actually accelerate the degradation in existing yard waste composting operations.

2.7 ADDITIONAL WASTE REDUCTION/DIVERSION PROGRAMS

2.7.1 Lead by Example

County operations and facilities could demonstrate to residents and businesses that minimizing waste is important. The following suggest ways of doing so:

- **Providing Recycling and Composting Receptacles in All County Buildings and Events.** Where possible, on-site composting could be installed to minimize transport costs.
- **Using Compost for Landscaping and Parks Projects.**
- **Publicly Announcing a Zero Waste Initiative for County Facilities.** This could involve a dedicated team to make a zero waste plan, and to implement the various diversion efforts at the county level.

By practicing what it preaches, the County will also better position itself to assist businesses and residents in implementing their own waste minimization strategies, as they will be able to rely on their own experience in reducing waste. This concept could be extended further to the Wake County Public School system to incur the additional benefit of encouraging future generations to reduce/divert waste, further compounding its effect on minimizing landfill space used.

Case Study: Prince Georges County, MD

Prince Georges County, MD is in the process of adopting a zero waste plan for itself, its residences, and businesses. While its agenda is extensive, the County is making efforts to implement the same principles it's asking the community to adopt. These include conducting interior waste audits at County facilities, recycling and compost operations (with on-site composting where possible), preferred purchasing of recycled/reused materials, and purchasing local products when possible. These efforts are to all be supported by the formation of a "green team" who will spearhead all zero waste initiatives, including a rewards program for County employees who are exceptional in their waste diversion.

2.7.2 Reuse

By extending the life of used items, the landfill is avoiding waste altogether. The following services could help the County to deter as much material as possible from entering the waste stream in the first place.

- **Websites** - Planetreuse.com, among others, provide a Craigslist-like service that any business, government, or individual can take part in to buy, sell, or trade used goods. The County could post a link to it on its website.
- **Deconstruction/C&D Reuse Markets** - Many C&D items can be reused, e.g. bricks, wood, and tiles. With a NC branch, The ReUse People of America (TRP) offer deconstruction

services to homeowners and businesses (Figure 84). TRP will first appraise the premises, then give the customer a bid, and if approved they will remove all salvageable items for a determined "donation", which earns the customer a tax break.

- The Reuse Warehouse in Durham offers deconstruction services in the Triangle area, and recovered materials can be donated to the warehouse for resale.
- ReStore has locations in Raleigh, Cary, Fuquay-Varina, and Wake Forest that accept everything from furniture, hardware, and plumbing, to doors and cabinets.
- The Scrap Exchange in Durham accepts industrial discards, offering them to local artists and crafters.

Figure 8. ReUse People Staff Recover Wood from a Demolition Site

- **Encouraging Residents to Use Rental and Sharing Programs** - For items not used often, a rental system can save a lot of wasted material, especially for students who aren't permanent residents. This could mean a library, donating to museums, and choosing reusable bags and mugs rather than disposable ones.
- **Promoting the Swap Shop** - At the Raleigh Yard Waste Center anyone can bring used items or take home items already there. These types of facilities could be added in other municipalities or at County facilities.

2.7.3 Use of County Policy-Making Authority

Further disposal surcharges or bans could be introduced to reduce the disposal of wastes that can be recycled.

2.7.3.1 Landfill policy

- **Require a Surcharge for loads Carrying Recyclables** - Vermont has a recycling "ban" which requires that any load carrying ten percent or more of mandated recyclable items incurs an added fee. This policy is enforced with periodic random load inspections.

- **Add More Unwanted Items to Landfill Ban List** - Food waste bans exist, but are hard to implement and enforce unless there is an obvious alternative path in place. Therefore, if a composting operation was developed for the County, a food waste ban would be a more viable option.

- **Incorporate Zero Waste Framework** - Labeling new policies as "zero waste" can help to establish a culture of waste reduction, and emphasize the government's dedication to the cause.

Case Study: Ohio State's Zero Waste Football Stadium

Ohio State's Zero Waste Football Stadium is a good example of the type of change that can be implemented when recycling and composting is emphasized in public spaces. Ohio State provides only recycling and composting containers in its stadium. This program is above and beyond, but the emphasis of recycling and composting in public spaces makes waste diversion a community activity. This strategy has reduced the stadium's waste stream by 61%, and in 2012 the facility had a 98.2% diversion rate.

Volunteer Educating Fans at an Ohio State Game Zero Waste Station

2.7.3.2 County-Level Policy

- **Require Construction Permit Applications to Have Solid Waste Plans** - Nearby Orange County, NC has a separate Solid Waste Management Recyclable Material Permit Application as part of its building permitting process. It requires builders to divert clean wood waste, scrap metal, and corrugated cardboard produced during construction from disposal, and to declare how the material will be hauled to the Orange County C&D Landfill for recycling. Demolishing buildings can produce large quantities of recoverable bulky waste material. Recycle/reuse opportunities are simplest before the bulldozer destroys the building. Often wood and windows can be recovered pre-demolition, when it's much easier to sort recyclables into piles for hauling.

- **Mandate commercial recycling through an updated ordinance** - Washington D.C. requires all commercial establishments to offer recycling opportunities in their facilities. Targeting businesses and public places can improve diversion rates drastically. Additionally, with private companies increasingly showing interest in "being green" as a means to market to increasingly environmentally conscious customers, some businesses may actually support recycling bans. However, this option would likely require a method of enforcement and funding and/or general assistance from the County to small business who may have trouble financing increased recycling.

2.7.4 Special Events

Designated events held by the County for the disposal of unwieldy or confusing items could minimize the landfilling of unwanted HHW, E-waste, and bulky items. These three types of items are commonly targeted for special events.

- **Repair Workshops** – the County could sponsor events with skilled repairmen to avoid landfilling of broken items as shown in **Figure 78.** A small engine repair, bike repair, or tailor could all be types of people to hire for the day. Having someone who could potentially repair computer problems or bulky items such as washing machines might be strategic for the landfill's purposes.

Figure 9. Repairman fixing appliances at a Repair Cafe, OR

- **Staff from the County (or Municipalities) Could Coordinate with Community Events** -Certain large-scale events occurring in the County, including fairs, concerts and street markets, are currently being equipped with recycling and composting bins via County programs. Because large events typically produce excess waste that could be avoided, we suggest assessing the extent to which this existing effort could be enhanced and expanded with the appropriate staff, bins, and signage on-site. Examples include events such as NCSU athletic competitions, high school football games, Carolina Hurricanes games, concerts, and conferences held and the Raleigh Convention Center. These events provide excellent venues for E&O efforts and spreading awareness of new County waste programs.

2.8 ORDINANCE REVIEW

SCS reviewed the Wake County Solid Waste Management Division Ordinance (Ordinance) as it pertains to waste diversion and reduction for any potential conflicts with potential future programs. Any changes to be made to the collection of solid waste in the County would require reference to the sections listed below.

Section 50.05: Licensing Solid Waste Collectors - Any new haulers (for example, if multi-family recycling is performed by a private company) need to obtain an operating permit and pay a fee to the County to haul MSW or recyclables.

Section 50.09: Sanitary Landfill Management - The Landfill has banned yard waste, white goods, used oil, scrap tires, and lead-acid batteries (part (D)). These items are accepted by waste reduction and recycling programs on-site, for a fee. Items which could be potentially added to this list in the future would require determination of their recycle tip fees.

Section 50.16: Residential Backyard Composting - There is also some mention of composting, but the policies to be followed are for private landowners. If any private or public composting efforts were enacted would need revision.

Section 50.17: Recyclable and Corrugated Cardboard Surcharge Program - The recyclable old corrugated cardboard (OCC) surcharge program is an existing portion of the Ordinance that encourages recycling. The surcharge for disposal of OCC could be extended to other items that the County is particularly interested in diverting from the Landfill. Items mentioned previously in this Report include E-waste or a surcharge for general recyclable items.

Section 50.18: Flow Control - Addition of an organics program may require updating the flow control measures, if any waste materials would then be shipped out of the county or to a private institution. The current flow control ordinance requires all solid waste generated within the designated County area be transported to and disposed of at County facilities. The County defines what is included in “solid waste” and the “geographic area” in its Solid Waste Management Plan.

2.9 ALTERNATIVE DISPOSAL FACILITY IMPLEMENTATION

The NCSU study explored the potential cost effectiveness of two potential alternative disposal options for the South Wake Landfill in the context of cost, diversion potential, and GHG emissions avoided. These two potential alternative disposal options included the implementation of a thermal waste-to-energy (WTE) plant or an anaerobic digester in the County. One potential way to extend the life of the SWLF would be to site one of these facilities within its boundaries

2.9.1 Waste-to-Energy Facility

There are over 1,300 WTE facilities worldwide. Although a majority are located in Europe and Asia, there are currently 77 WTE plants operating in 22 states managing around 10% of the nation’s MSW (85,000 tons per day). This is equivalent of a base load electrical generation of approximately 2,700 megawatts to meet the needs of more than two million homes, while servicing the waste disposal needs of more than 35 million people. Many of the nations of the world or communities in the US which utilize WTE for waste disposal have limited open space for the development of landfills and have large urban populations.

WTE plants are not a new technology in the United States: the first facility was established in 1975. However, only one new facility has opened or undergone a significant expansion in this country since 1995. In addition to waste size reduction and disposal, an aim of WTE is to recover the inherent energy value of the (ideally) dry and combustible portions of the waste stream. In addition, processing after (and sometimes before) the combustion process allows for the recovery of ferrous and non-ferrous metals which are sold for their scrap value. Many WTE plants use the energy generated by the process for electricity and heat on-site, and some sell it to power companies. Ash is left as a residual stream of the combustion process, which is one advantage of locating WTE plants on landfills.

Many newer “Waste Conversion” processes derive valuable solid or liquid end products from the MSW in processes similar to combustion, but with different operational parameters. These facilities are primarily being constructed at pilot or otherwise small-scale applications in the US, but are popular in Europe. Some plants are able to produce fuel such as alcohol compounds like ethanol or other chemical products. Another popular European waste management method is the utilization of mechanical-biological treatment (MBT) facilities. MBT involves the processing of MSW to extract recyclable and other inorganic-material for recovery, followed by a physical and biological process to transform the remaining material into a “refuse derived fuel” (RDF) or “solid recovered fuel” (SRF).

The NCSU study found that for Wake County, the combination of WTE for energy recovery and the implementation of a mixed waste MRF provided the highest possible GHG emission reductions for the hypothetical system at the maximum diversion level. The implementation of a WTE plant would extend the life of the landfill significantly, as the combustion process results in a typical mass and volume reduction on the order of 80 to 90%. The residual bottom and fly ashes would still have to be landfilled, but could potentially be integrated into building materials, a material recovery technique employed abroad.

The nation’s youngest WTE facility is the Palm Beach Renewable Energy Facility in West Palm beach, FL, which opened its doors in 2015 and cost over a half billion dollars to complete, though it is the largest individual WTE facility in terms of electricity generation in the US. As evidenced by this most recent project, WTE is expensive to implement and operate. They are typically not utilized in areas with relatively low landfill tipping fees. Even with a future close of the SWLF, Wake County may have difficulty justifying the high tipping fees required for a facility such as a WTE plant due to the several competing private landfills in the region.

2.9.2 Mixed Waste Processing Facility

The NCSU study proposed a mixed waste MRF as another potential facility the County implement to extend the life of its landfill. A mixed waste MRF represents a technology distinct from a typical MRF such as that operated by Sonoco located within the County. Mixed waste processing is a technology that incorporates a series of mechanical stages to separate waste into recyclables, organics, and residual material to be landfilled. Some of the mechanical steps are typically size and density sorting, magnetic sorting, and even shape (2D vs. 3D objects) sorting accomplished via an intricate system of conveyors, mechanical materials sorters, separators, compacting/baling mechanisms. One distinct advantage of using a mixed waste processing facility is that, unlike with a MRF, its processes are not dependent on active participation by generators. A single cart can be used to collect all solid waste, with separation being handled by professionals and machinery.

Mixed waste processing technology allows for diversion rates in the ballpark of 80 percent; however there have been concerns about the health and safety of staff handling the unsegregated waste. Technological innovations in optical sorting and robotics appear to be improving the outlook on this technology, although there have been a few recent mixed waste processing facility closures due to financing issues. As with WTE plants, sufficient economies of scale are required for financial viability.

The City of Raleigh's robust yard waste collection program as well as NC's ban on the landfilling of yard waste would both be positive contributing factors to the viability of a WTE facility or mixed waste MRF. This is because, for WTE, the presence of high-moisture content material such as green yard clippings (or food waste) can reduce the heat capacity of the combusted material and therefore the plant's electrical output, and for mixed waste processing, these materials can result in hard-to-sort MSW and high contamination levels. A mixed-waste MRF would require a smaller footprint than a WTE facility, and may result in relatively less public opposition during the facility's development.

With the land already under County control, a MRF could be developed at the South Wake Landfill for the purposes of directing certain customer loads that are known to contain high percentages of recyclable material to unload at the on-site MRF. Upon sorting these loads to recover recyclables, the remaining wastes would be transported to the landfill working face for disposal. A County-controlled MRF located at the Landfill would provide valuable flexibility and efficiency of transport for designated haulers with routes that include customers with substantial quantities of recyclables within their waste streams that are currently being delivered to the facility.

3.0 INCREASE THE CAPACITY OF THE SWLF

SCS considered options to increase the capacity (also referred to as airspace) of the SWLF by improving compaction, modifying certain specific design parameters of the landfill, incorporating certain technological elements, or expanding the footprint of the facility. These options could be implemented independently of (without or in addition to) the strategies outlined in Section 2.0. Each option outlined below has been considered as a standalone measure; however, multiple measures could be implemented to more significantly extend the life of the SWLF. The change in capacity at the SWLF resulting from implementing multiple strategies may not be as straight forward as adding the individual capacity increases outlined below.

The level of effort associated with implementing the strategies outlined below is variable as are the corresponding airspace gains. The best strategy for the County to implement will ultimately depend on the cost, permitting efforts, constructability challenges, acceptable risk, and time the County is willing to put forth and the airspace needs that have ultimately been identified.

With the exception of operational changes such as overfilling and increased in-place waste compaction/operating densities, all of the proposed modifications to the existing design of the landfill as depicted in the Facility's Solid Waste Permit-To-Construct will likely require an amendment and be subject to NCDEQ approval. For those strategies that increase the permitted capacity of the landfill by less than 10% (~3 million cubic yards) the changes may be considered a minor amendment and public participation will not be required. The County may also be able to recover the 1.87 million tons of capacity that was removed when the landfill footprint was reduced in July of 2010 in addition to this 10%, but discussions with North Carolina Department of Environmental Quality (NCDEQ) should be conducted to determine how that volume will be handled.

A larger volume increase (greater than 10%) will require a major permit amendment and application submittal. The complexity of the permit amendment will depend on the particular life extension strategy being pursued, with the side slope angle increase being less complex and a lateral expansion being very complex. Any major modification to the permit would require a public comment period and may also require a public hearing. A public hearing may be required depending on the number of requests for such hearing made during the public comment period. Then NCDEQ will determine the necessity of a public hearing. A lateral expansion will likely require additional permits such as wetland and stream mitigation permits, depending on the exact expansion location.

3.1 SIDE SLOPE ANGLE INCREASE

The South Wake Landfill currently utilizes 4H:1V (4:1) slopes in the design of the proposed final grades. This slope is somewhat conservative and slopes as steep as 3:1 are common at private sector and municipal landfills. The County could increase this slope to provide additional airspace. SCS analyzed the impact on airspace that using final grades with 3.5:1 slopes would have on the landfill.

3.1.1 Conceptual Alternative Final Grade Design

SCS developed alternative final grades for the facility that utilized 3.5:1 slopes. The cross section in Figure 10 shows both the currently permitted final grades and the hypothetical alternative final grades, as well as the base grades. In addition to modifying the slopes of the final grades, SCS used the additional area created at the top of the slopes to extend the slopes up to the 600-foot elevation. The currently permitted slopes stopped at the 580-foot elevation.

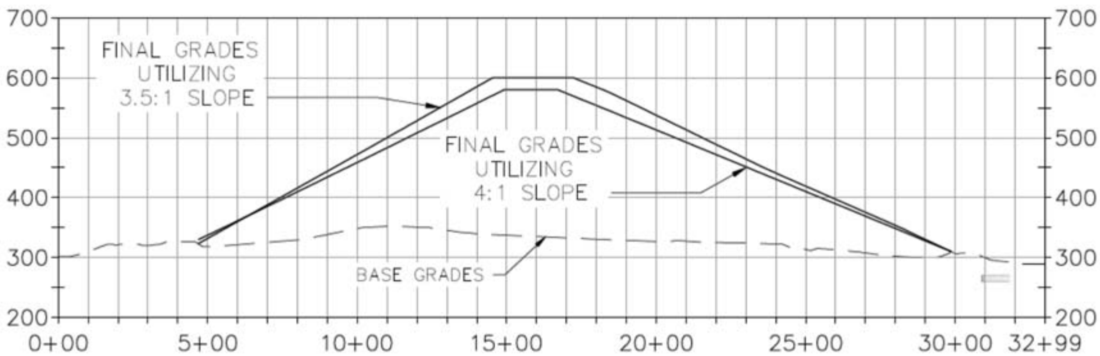


Figure 10. Final Grade Slopes

Modifying the final grade slopes in this manner will provide approximately 3 million cubic yards of additional airspace for the facility that could be used to dispose of an additional 2 million tons of waste at the typical waste densities achieved at the facility. This would provide the facility with an additional 4 years of life assuming a disposal rate of 500,000 tons per year. The mass-based quantity of waste contained within the additional airspace could be increased beyond 2 million tons if greater densities are achieved through improved compaction and consolidation of the waste. Furthermore, there is potential for additional airspace gains using 3:1 slopes if the County wished to consider this approach.

SCS' analysis considered modifying the final grades for all of the cells (both existing and future) at the facility. The County may want to consider a more detailed evaluation to determine the practicality of modifying the final grades in areas where final cap installation is in progress.

Recognizing that increasing the angle of the side slopes would warrant re-evaluating landfill stability, SCS has performed preliminary global stability analysis to demonstrate that changing the final grades appears to be technically feasible. Additional discussion of the stability analysis is included in **Appendix A.**

Utilizing the proposed alternate final grades would require additional solid waste and air quality permitting. There may be a minor increase in closure costs as the change in final grades may create a larger surface area for the facility. This increase in surface area is not anticipated to be more than 1 percent of the total surface area.

3.2 MSE BERM

Constructing a mechanically stabilized earth (MSE) berm (also referred to as an MSE wall) along the perimeter of the waste disposal limits could offer the facility the potential to gain additional airspace. An MSE wall is constructed using geosynthetics and soil to create a near vertical wall. Construction of an MSE wall creates additional airspace adjacent to the landfill without expanding the footprint of the facility. MSE berms are typically constructed using compacted soil as the structural fill element; however, encapsulated MSE berms can be constructed out of waste materials such as coal ash or contaminated soils, offering a beneficial use for these materials. While encapsulated MSE berms utilize a geomembrane to contain the wastes that serve as the structural fill to prevent environmental releases, there can be public perception challenges to address.

3.2.1 Conceptual MSE Wall Design

Based on discussions with County staff, SCS identified the north side of the Landfill as the best location for considering an MSE berm. SCS identified a low point in the proposed traditional perimeter berm that will need to be constructed when these cells are developed and developed grading to reflect installation of a hypothetical MSE wall. The proposed MSE wall would be approximately 30 feet tall at the highest point and would slope down at a 2 percent grade to the east and west to tie into the existing perimeter berm. The location and grading of this proposed MSE Wall is shown in **Figure 11.**

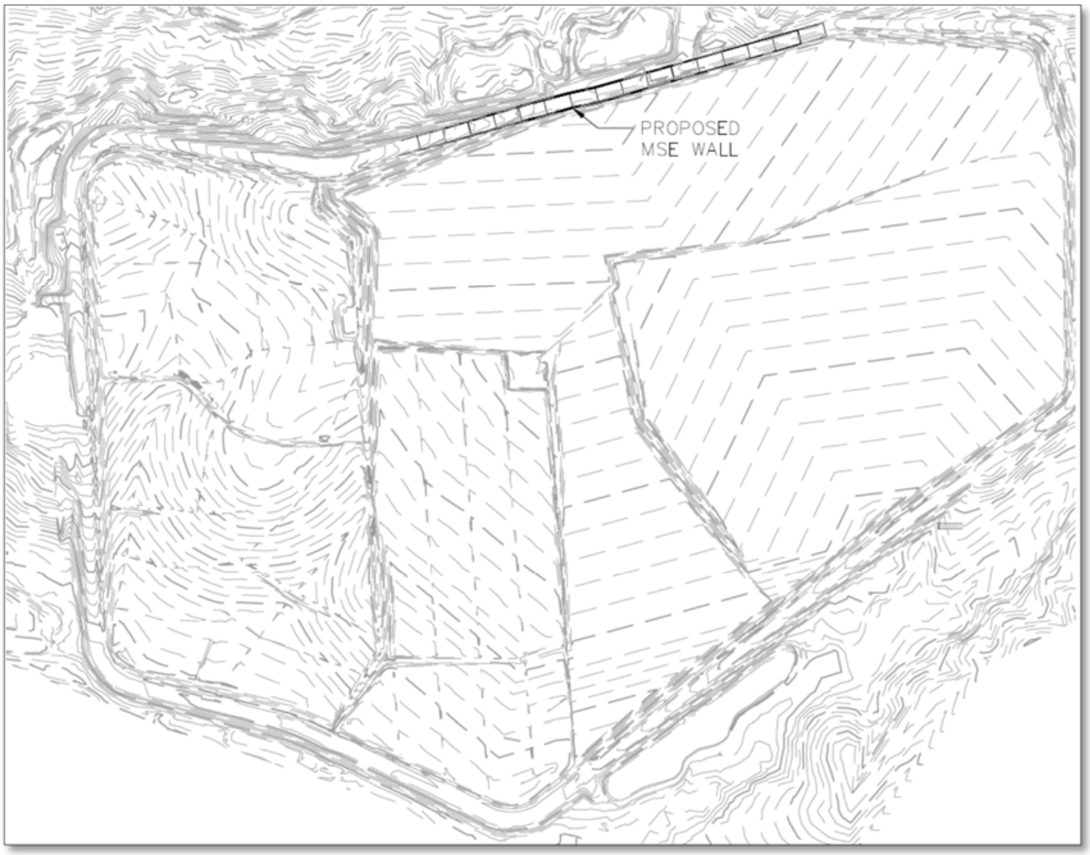


Figure 11. MSE Wall Grades

The height and length of this hypothetical berm is relatively small compared to other MSE walls that SCS is aware of at US landfills which were designed to significantly extend landfill life. SCS has conducted a preliminary stability analysis of such a berm and based on this limited analysis, constructing such a berm is feasible at the SWLF. A summary of the stability analysis is included in Appendix A.

Constructing an MSE wall would allow the County to raise the final grade elevations on the north side of the landfill. Proposed final grades utilizing the MSE berm are shown in the cross section in Figure 12. These final grades would add approximately 1 million cubic yards of airspace that could be used to dispose of an additional 650,000 tons of waste at the typical waste densities achieved at the facility. This would provide the facility with an additional 1.3 years of life assuming a disposal rate of 500,000 tons per year.

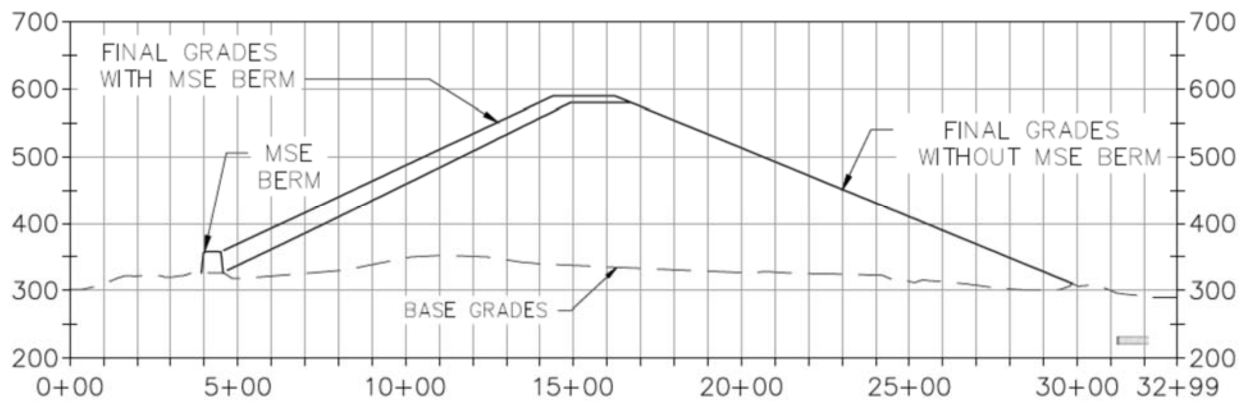


Figure 12. Final Grades and MSE Wall

Typical construction costs for an MSE wall of this size would likely range between $500,000 and $1,000,000. This preliminary budgetary cost reflects a traditional MSE berm in which compacted soil is used as structural fill and construction of an encapsulated MSE berm would involve additional costs for the containment (liner) system. Actual costs would depend on the design, technology, and construction method used. This approach could create additional capacity for less than $2 per additional ton of waste landfilled.

An MSE wall could feasibly be constructed after waste filling has occurred in the adjacent cells, however this approach may be more challenging to implement. Constructing a wall prior to filling or modifying construction plans to accommodate a wall would simplify construction and reduce costs. Introduction of an MSE wall would likely require significant permitting and design efforts, depending on the size and nature of the wall.

The County could construct a taller or longer MSE wall if this approach to life extension was chosen. For example, increasing the wall height to 40' and increasing the length to accommodate the increased height would allow the Facility to realize approximately 2 million cubic yards of additional airspace that could be used to dispose of an additional 1.3 million tons of waste at the typical waste densities achieved at the facility. This would provide the facility with an additional 2.5 years of life assuming a disposal rate of 500,000 tons per year. Increasing MSE wall height can significantly increase construction costs and the typical costs associated with this larger wall configuration could range from $1,350,000 to $2,700,000. Constructing MSE walls is technically challenging and introduces additional long term risks. These challenges and risks increase as the size of the wall increases; however, there are numerous examples of MSE berm applications, both traditional and encapsulated, at US landfills. MSE walls also have unique maintenance and monitoring requirements that are different from conventional landfilling methods.

3.3 TEMPORARY OVERFILLING

One potential method of gaining additional airspace at the SWLF is to fill the landfill beyond the permitted final grades. This allows the facility to preemptively capture airspace that becomes available through settlement. One advantage of this approach is that it does not actually increase the long-term facility-wide capacity of the SWLF, but uses that capacity more effectively. SCS is aware of several landfills at which overfilling is allowed by the solid waste permit and Pennsylvania DEP has a formal program, termed the "settlement accommodation plan" (SAP), that outlines methods for landfills to predict the regeneration of airspace and capture this asset by overfilling.

SCS has used the data available through aerial topography and intake tonnages to estimate the impact of settlement at the SWLF. SCS also considered the impact of landfill life if the facility overfilled by approximately three feet, which equates to the thickness that would be required for the final and intermediate cover. We are aware of many landfill facilities that cease waste placement upon achieving the final elevations prescribed in the permit and then rely on the waste being allowed to settle before installation of the final cover.

The facility could potentially chose an even more aggressive approach and overfill a greater thickness governed by a deliberate, intentional settlement accommodation plan. This approach may require regulatory approval as the facility's grades may temporarily exceed those provided in permit documents. Overfilling also presents some risk as the waste composition and density at time of placement may change over time. This may limit the accuracy of historical data as an indicator of potential opportunity for overfilling. This could potentially result in relocating waste placed above permit grades at a significant cost.

Any plan for overfilling will require monitoring to ensure that settlement is sufficient to accommodate additional fill over time and to identify any potential to increase overfilling thickness.

3.3.1 Waste Densities at the SWLF

SCS has reviewed the aerial topography captured at the SWLF between 2008 and 2017. SCS also reviewed the disposal tonnage information included in the South Wake Land Airspace Management Report, dated July 2017 and prepared by HDR. SCS analyzed the changes in topography on an annual basis to calculate how much volume had become available through settlement and how much volume had been used in the waste filling process. Those values were compared with the quantity of waste filled for that year. From these values, it is possible to estimate the density of the waste when it was placed. A summary of these values is shown in Table 7.

Table 7. Annual Waste Filling Data

Beginning Year	Ending Year	Settlement Volume (yd^3)	Fill Volume (yd^3)	Net Volume (yd^3)	Waste Filled (tons)	Density (lbs/yd^3)	Fill Density (lbs/yd^3)
2008	2009	71	1,378,972	1,378,901	570,559	828	828
2009	2010	13,068	456,289	443,221	317,306	1,432	1,391
2010	2011	12,790	960,999	948,209	538,701	1,136	1,121
2011	2012	24,382	570,855	546,473	414,156	1,516	1,451
2012	2013	24,006	567,233	543,227	418,529	1,541	1,476
2013	2014	45,918	458,431	412,514	367,422	1,781	1,603

2014	2015	32,376	526,042	493,666	437,881	1,774	1,665
2015	2016	59,917	673,917	614,000	436,631	1,422	1,296
2016	2017	90,199	694,673	604,474	442,659	1,465	1,274
Total		302,728	6,287,411	5,984,684	3,943,844		
Average[1]						1,318	1,255

1 The average values were calculated based on the total volumes and weights of the waste filled between 2008 and 2017.

Two distinct waste density values were calculated for each year which are included in **Table 7**. The first calculation method labeled simply "Density" calculates density based on the net volume change from year to year. This value includes the impacts of volume utilized for waste filling and volume gained through settlement. This value provides insight into the long term density of waste at the landfill, but may not reflect the waste density at time of placement.

The calculation of the values labeled "Fill Density" provides more insight into the actual density of the waste at the time of placement. These values are calculated based on only the volume increase identified in any given year. It should be noted that settlement that occurs within the area where waste filling occurs is not captured in this volume. Therefore the actual density of the waste at the time of placement may be lower than the value of the "Fill Density". Neither value attempts to capture the effects of daily and intermediate cover which may have an impact on these values relative to the ratio of waste to soil fill.

When considering the long term values for both methods of calculating density the average density based on the total net volume change is 1,318 pounds per cubic yard and the average density based on the total volume filled is 1,255 pounds per cubic yard. Based on these values, the average ton of waste place at the SWLF occupies 1.59 cubic yards at the time of placement, but has a reduced volume of 1.52 cubic yards over the long term. This represents an approximate 5% reduction in the waste volume over time.

3.3.2 Measuring Settlement at the SWLF

To provide additional insight into the impact of settlement at the SWLF, SCS examined waste elevations along a single alignment over time.

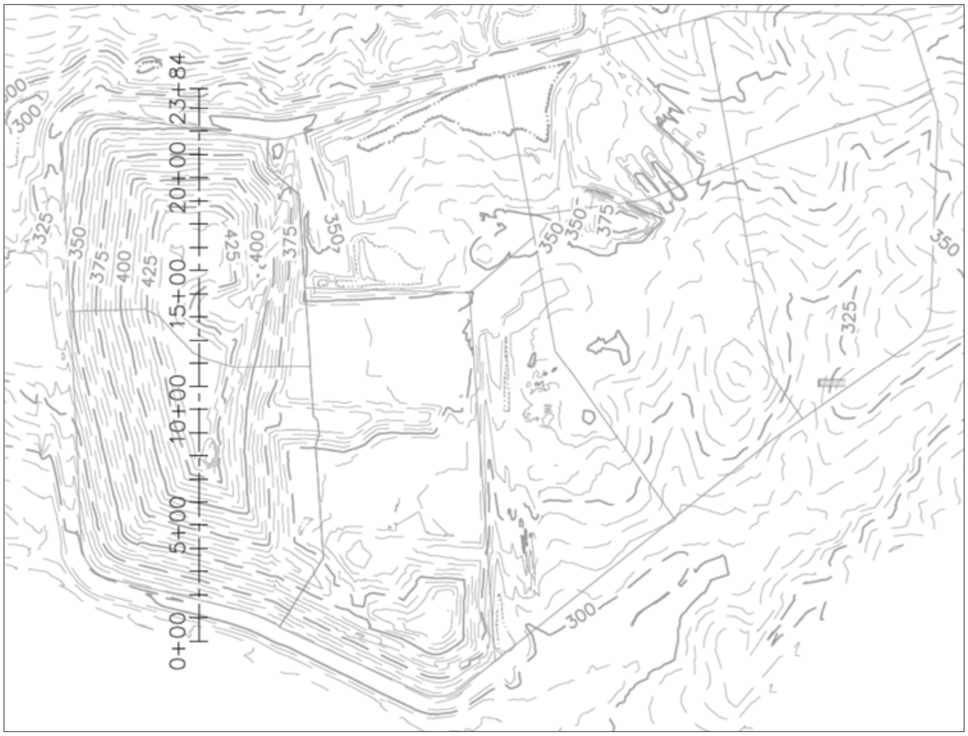


Figure 13. Alignment Used in Settlement Analysis

An alignment that captured the elevations along to relatively flat "top deck" of the landfill was chosen. The location of this alignment is shown in **Figure 13.**

A profile of the surface topography of the landfill was created along this alignment for each year of landfill operation between 2009 and 2017. Those profiles are shown in **Figure 14.** Before 2015, elevation changes indicate that filling is occurring in the landfill. As the filling shifted into Cell 2A and waste placement operations ceased in Cell 1A and Cell 1B, elevations along the alignment begin to drop, indicating settlement.

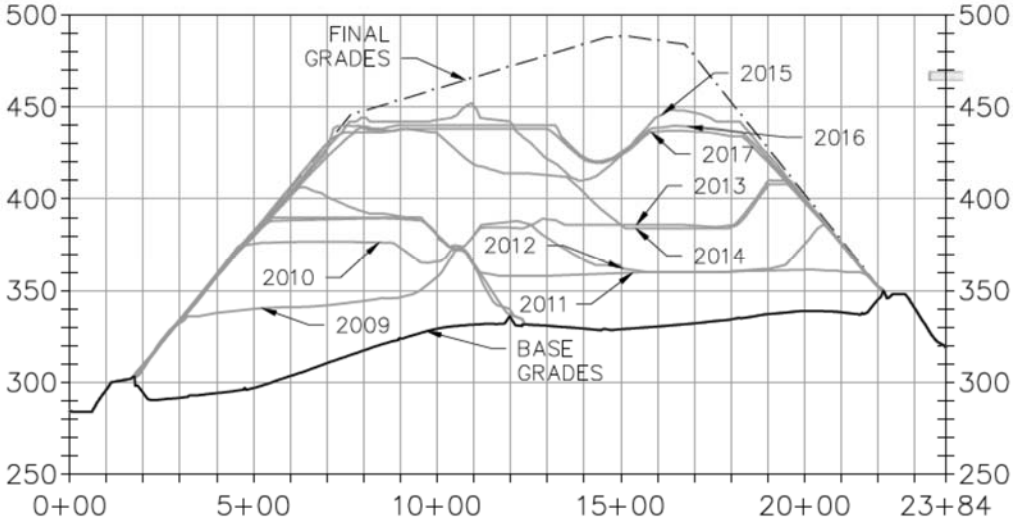


Figure 14. Profile of Elevation Changes at the SWLF

The change in elevations can be measured to calculate how much settlement has occurred along the alignment since 2015. SCS measured the settlement along this alignment at eight station locations where settlement clearly occurred between 2015 and 2017. A summary of these data is shown in **Table 8.** The stations selected were those located along the flat "top deck" of the landfill, where there was no indication that filling had occurred between 2015 and 2017. The waste thickness was considered to be the difference in elevation between the base grades and the waste elevations captured by the aerial topography that year.

Table 8. Settlement Measurements

Station	2015 Waste Thickness (ft)	2016 Waste Thickness (ft)	2017 Waste Thickness (ft)	Elevation Change (ft)	Elevation Change (%)
8+00	126.70	122.07	121.10	-5.60	-4.42%
9+00	121.34	117.44	116.54	-4.80	-3.96%
10+00	118.08	116.08	113.67	-4.41	-3.73%
11+00	115.49	113.49	111.49	-4.00	-3.46%
12+00	113.84	110.86	108.86	-4.98	-4.37%
16+00	114.22	108.23	106.13	-8.09	-7.08%
17+00	114.75	106.99	104.46	-10.29	-8.97%
18+00	107.73	102.61	99.74	-7.99	-7.42%
Average					-5.43%

Based on the eight stations considered, the landfill experienced an average decrease in thickness of approximately 5%. This settlement is consistent with the reduction in waste volume discussed in Section 3.3.1. This analysis suggests that the Facility could overfill the flat top deck area in Phases

1A/1B by approximately 5 to 8 feet and maintain final grade elevations within two years due to settlement.

3.3.3 Remaining Capacity Method

SCS applied the Remaining Capacity Method to the SWLF. The Remaining Capacity Method (RCM) establishes a graphical relationship between remaining airspace (in units of cubic yards) and tons of waste in-place. A "best fit" linear regression line is calculated and drawn through the points. This exercise is useful to identify the projected future mass-based quantity of waste at the point where the line intersects the X-axis and there is no remaining capacity left.

SCS used this method by initially comparing the base grades at the SWLF versus the final grades depicted in the Phasing Plan drawings prepared by Richardson Smith Gardner & Associates (RSG) dated 6/12 to calculate the initial available airspace. The resulting value of 32,076,119 cubic yards (CY) is consistent with the total volume of the landfill presented on page 5 of the letter titled "Gross Capacity and Phasing Information, South Wake MSW Landfill", prepared by RSG dated 06/16/10.

- SCS repeatedly measured the volume difference between the final grade surface and each of the aerial surveys (dated 07/11/09, 04/05/10, 07/01/11, 06/30/12, 07/16/13, 06/10/14, 06/30/15, 07/02/16, and 07/03/17) to estimate remaining capacity at the SWLF. All calculations were performed using AutoCad Civil 3D 2014 Version.

A graph was developed plotting the remaining capacity in the cells (based on the airspace volume calculations) against the waste quantities landfilled since the SWLF began operations. This graph represents a linear "best fit" line for the nine data points.

The elevations used for the volume calculations included the airspace required for installation of the final cover. SCS consider that the SWLF may implement one of two approaches, as follows:

- Place waste to achieve the maximum elevations allowed by the Permit, expecting that consolidation of the waste and settlement will occur and enable placement of the final cover system. This action consumes the final cap/cover airspace with waste and relies on settlement to result in lower landfill surface elevations so that installation of the final cover system can be accomplished. As long as sufficient settlement is realized, the top of final cap grades will be in accordance with the Permit. SCS has modeled this scenario as "Run 1 – Consume Final Cap/Cover Volumes" as shown in **Figure 14**.

- Cease waste placement upon achieving grades lower than the maximum elevations allowed by the Permit to preserve the necessary airspace for installation of the final cover system (3 foot thickness). This action preserves the final cap/cover airspace and does not rely on settlement to lower landfill surface elevations. Accordingly, the final cover system can be accomplished and final cap grades will be in accordance with the Permit without reliance on settlement. SCS has modeled this scenario as "Run 2 – Preserve Final Cap/Cover Volumes" as shown in **Figure 15**.

3.3.4 Run 1: Consume Final Cap/Cover Volume

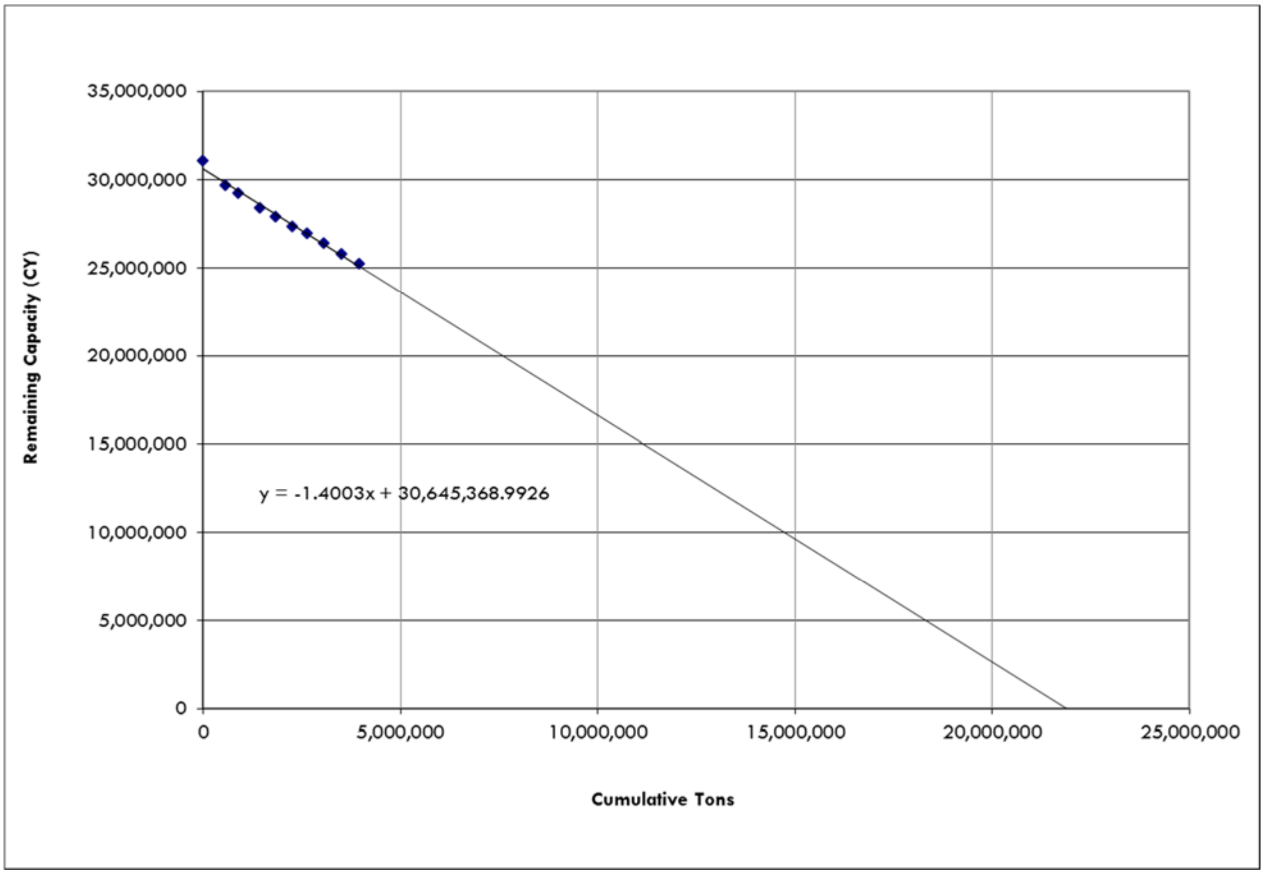


Figure 15. Remaining Capacity Analysis Run 1

The data points on the graph above represent the initial Net Airspace capacity of the subject cells and the eight subsequent aerial surveys. The data used in developing this Run 1 graph is shown in Table 9.

Table 9. Run 1 Capacity Data

Surface	Cumulative Tons	Remaining Capacity (CY)
Design Capacity	0	31,090,109.56
2009 Topography	570,559	29,713,744.59
2010 Topography	887,865	29,270,389.66
2011 Topography	1,426,566	28,456,442.46
2012 Topography	1,840,722	27,910,313.57
2013 Topography	2,259,251	27,367,601.91
2014 Topography	2,626,673	26,955,237.55

Surface	Cumulative Tons	Remaining Capacity (CY)
2015 Topography	3,064,554	26,443,917.21
2016 Topography	3,501,185	25,829,929.38
2017 Topography	3,943,844	25,240,876.28

1. SCS calculated the Net Airspace by reducing the volumes calculated using Autodesk Civil 3D to reflect the volume of the 4-foot thick liner system.

The equation for the best fit line is as follows:

$$y = -1.400x + 30{,}645{,}369$$

With “y” being Remaining Capacity (CY) and “x” representing Cumulative Tons

Setting the equation equal to zero, we conclude that the SWLF can accommodate a total of **21,884,860 tons.** This is where the line intersects the x-axis. Considering the difference between the total cumulative waste quantity that correlates to no remaining capacity (21,884,860 tons) and the waste in-place as of 07/03/17 (3,943,844 tons), SCS estimates that approximately **17,941,016 tons** can be placed into these cells after 07/03/17 to achieve final grades.

Considering the remaining waste quantity that will consume the remaining capacity verses an assumed annual waste acceptance rate of 500,000 tons, the SWLF has approximately **35.9 years** of remaining life as of 07/03/17.

The slope of the best fit line can be used to calculate density. The slope of -1.4003 indicates that for every ton added, the remaining capacity is reduced by 1.4003 cubic yards. Calculating the inverse of this value yields that for every cubic yard of capacity, 0.7441 tons of waste can be placed. This density is equivalent to 1,428 lbs/yd^3. This value is within 10% of the long term density values discussed in Section 3.3.1.

3.3.5 Run 2: Preserve Final Cap/Cover Volume

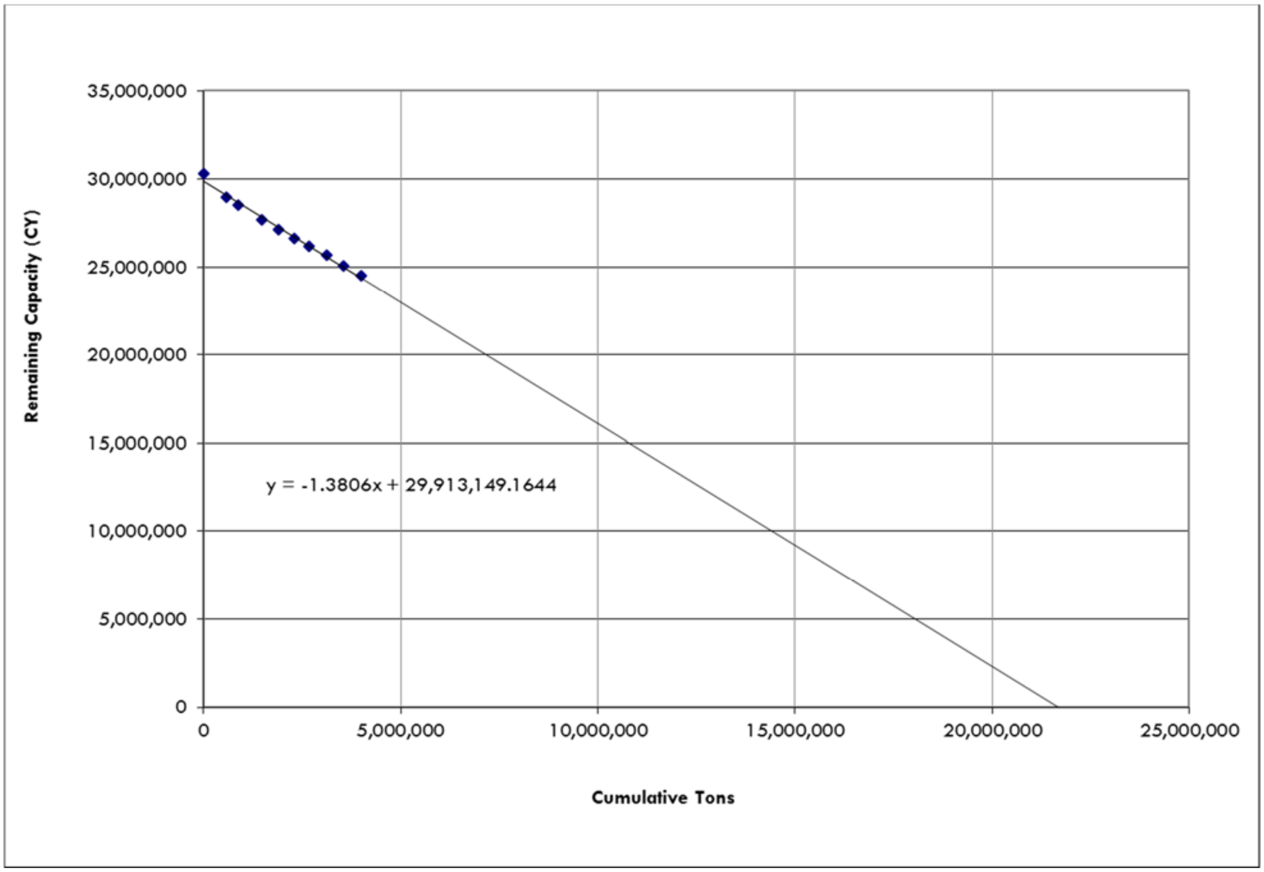


Figure 16. Remaining Capacity Analysis Run 2

The data points on the graph above represent the initial Net Airspace capacity of the subject existing cells and the nine subsequent aerial surveys, assuming that waste placement ceases at elevations lower than the final grades as appropriate to enable construction of the final and intermediate cover systems. Table 10 below presents the data used in developing this Run 2 graph.

Table 10. Run 2 Capacity Data

Surface	Cumulative Tons	Remaining Capacity (CY)
Design Capacity	0	30,350,602.80
2009 Topography	570,559	28,974,237.83
2010 Topography	887,865	28,530,882.90
2011 Topography	1,426,566	27,716,935.71
2012 Topography	1,840,722	27,170,806.82

Surface	Cumulative Tons	Remaining Capacity (CY)
2013 Topography	2,259,251	26,628,095.16
2014 Topography	2,626,673	26,215,730.80
2015 Topography	3,064,554	25,704,410.46
2016 Topography	3,501,185	25,090,422.63
2017 Topography	3,943,844	24,501,369.53

1. SCS calculated the Net Airspace by reducing the volumes calculated using Autodesk Civil 3D to reflect the volume of the 4-foot thick liner system, the 2-foot thick cap, and the 1-foot thick intermediate cover.

The equation for the best fit line is as follows:

$$y = -1.3806x + 29{,}913{,}149.16$$

With "y" being Remaining Capacity (CY) and "x" representing Cumulative Tons

Setting the equation equal to zero, we conclude that the SWLF can accommodate a total of **21,666,775 tons.** This is where the line intersects the x-axis. Considering the difference between the total cumulative waste quantity that correlates to no remaining capacity (21,666,775 tons) and the waste in-place as of 07/03/17 (3,943,844 tons), SCS estimates that approximately **17,722,931 tons** of waste have been placed in the active cells after the landfill achieved final grades.

Considering the remaining waste quantity that will consume the remaining capacity verses an assumed annual waste acceptance rate of 500,000 tons, SCS estimates that the SWLF has approximately **35.3 years** of remaining life as of 07/03/17.

The slope of the best fit line can be used to calculate density. The slope of -1.3806 indicates that for every ton added, the remaining capacity is reduced by 1.3806 cubic yards. Calculating the inverse of this value yields that for every cubic yard of capacity, 0.7423 tons of waste can be placed. This density is equivalent to 1,449 lbs/yd^3. This value is within 10% of the long term density values discussed in Section 3.3.1.

3.3.5.1 Additional Airspace

Comparing the remaining life values calculated in Run 1 and Run 2, indicates a difference of 0.6 years or approximately 7 months of life. Based on the settlement analysis in section 3.3.1 and section 3.3.2 the SWLF could accommodate the additional waste quantities and still have enough remaining airspace to accommodate final cover installation.

3.4 LATERAL EXPANSION

SCS considered an option for lateral expansion of the landfill, in the form of a "piggyback" on the adjacent closed Feltonsville Landfill positioned north of the site. This option is one of the more aggressive lateral expansion options and would potentially offer the largest increase in available airspace. It would also likely be the most difficult option to execute. In addition to permitting cells on the adjacent landfill, challenges to the lateral expansion include water resources permitting and relocation, interference with proposed infrastructure projects, and cell construction in low lying saturated areas.

The conceptual lateral expansion configuration that could potentially be considered is shown in **Figure 17.** SCS' initial assessment of the airspace gained through such an expansion indicates that such an expansion could increase the waste disposal capacity of the landfill by 40%. The lateral expansion would provide approximately 12 million cubic yards of additional airspace that could be used to dispose of an additional 8 million tons of waste at the typical waste densities achieved at the facility. This would provide the facility with an additional 16 years of life assuming a disposal rate of 500,000 tons per year.

Figure 17. Proposed Conceptual Lateral Expansion

As part of a hypothetical lateral expansion, the County could also consider mining the existing Feltonsville Landfill. Depending on the age and composition of the waste, 50% to 85% (Harler, 2012) of the material excavated during landfill mining is soil. Considering the regular need for cover soil at the SWLF, most of this recovered soil material could be re-used on site. For example, if 5 million cubic yards was mined from the closed landfill, it could provide an additional 2.5 million cubic yards of airspace and 2.5 million cubic yards of cover soil. This additional airspace would allow for the disposal of approximately 1.5 million tons of waste at the typical waste densities achieved at the facility and would provide the facility with an additional 3 years of life assuming a disposal rate of 500,000 tons per year. There is also potential for the recovery of recyclable materials that would provide additional airspace gains and potential revenue. However, recent concerns regarding contamination levels of recyclables make this uncertain. Any consideration of landfill mining should include further study, material excavation, and a possible pilot project to confirm material characteristics.

3.5 VERTICAL EXPANSION

SCS considered two possible options for a vertical expansion of the South Wake Landfill. The first option was to consider raising the final elevations of the facility. The second option is to lower the base grade elevations for the future phases of the landfill including Phases 2B, 3, 4, 5, 6, and 7.

3.5.1 Final Grade Elevation Increase

During initial discussions regarding a possible vertical expansion, Wake County Solid Waste Division Staff indicated that raising the proposed final elevations was not the preferred method. After reviewing the final grades depicted in the Phasing Plan drawings prepared by Richardson Smith Gardner & Associations (RSG) dated 6/12, SCS concurs with the County's assessment.

The surface area of the top of the landfill (580-foot elevation) is limited (approximately 2.8 acres). Waste filling operations on a smaller top deck footprint, which would be required if final grades were raised, would present significant challenges. The potential increase in airspace attributed to raising final grades over such a small area is relatively insignificant. Unless the surface area at the 580-foot elevation is increased by some other means (MSE wall, steeper sideslopes, lateral expansion), raising the final grade elevations is not a practical means of significantly extending the life of the South Wake Landfill.

3.5.2 Base Grade Elevation Decrease

The proposed base grade elevations at the South Wake Landfill essentially mirror the elevations of the groundwater table (phreatic surface) as depicted in the Phase 2 Design Hydrogeologic Report on Figure 7, dated April 2013 prepared by Smith + Gardner Engineers. The base grade elevations could be lowered through the use of groundwater underdrains. This change would provide additional airspace for the landfill, but would require additional excavation and additional infrastructure to facilitate groundwater removal.

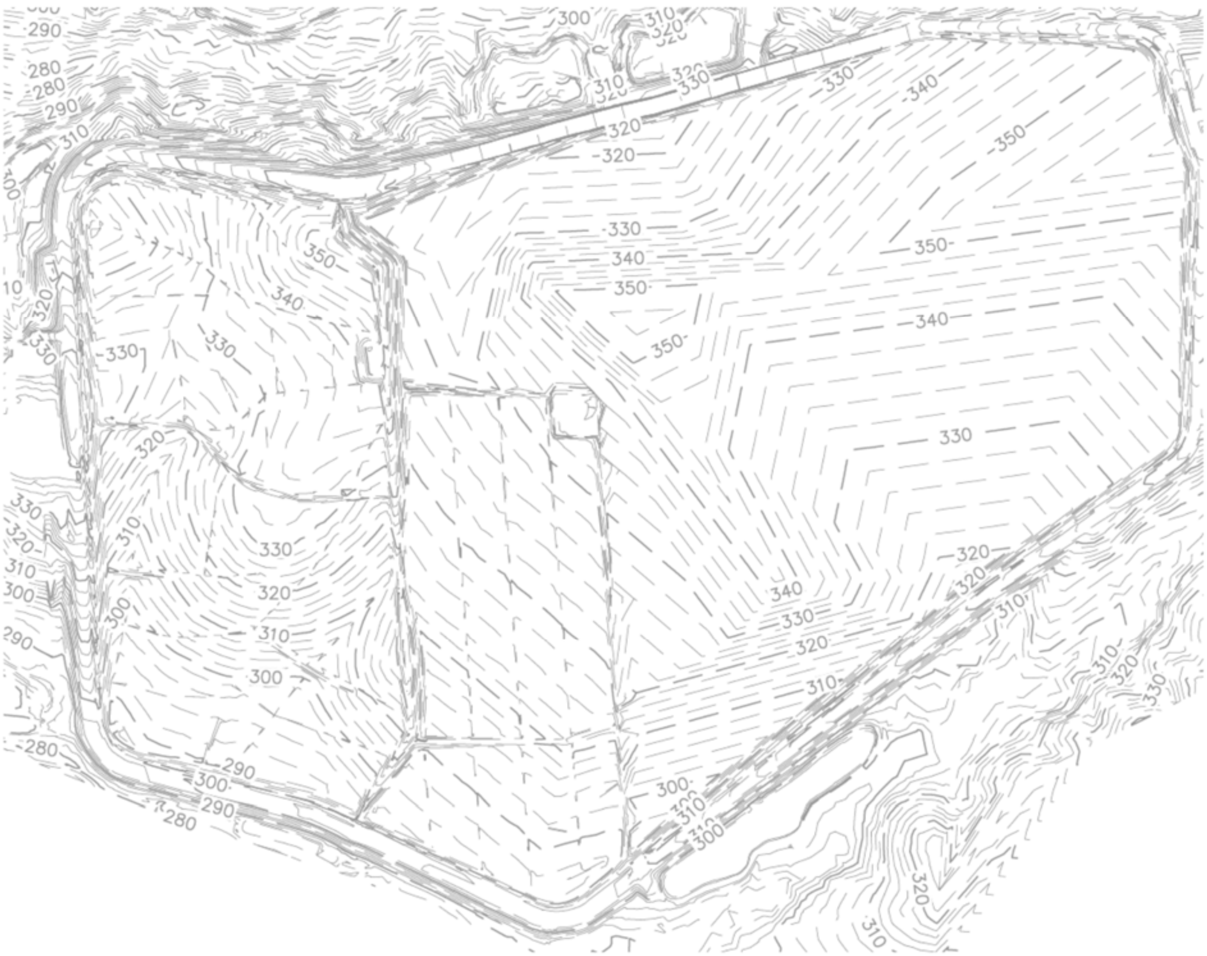


Figure 18.   Permitted Base Grades at the South Wake Landfill

The current base grades are sloped upward at grades varying between 2.5% and 10% from the toe of the perimeter berm and are offset from the inferred groundwater contours based on well and piezometer data. The original base grades that constitute the bottom of the landfill cells are shown in **Figure 18.** SCS considered an alternative scenario in which the grades are sloped using 2% slopes from the toe of the perimeter berm where possible. The base grades developed by SCS are shown in **Figure 19.** Only the base grade elevations within cells that the County has yet to construct were revised for this analysis. The existing cell divisions were maintained as the high points of the base grade surface and the general direction of the slopes towards the permitted sump locations were maintained.

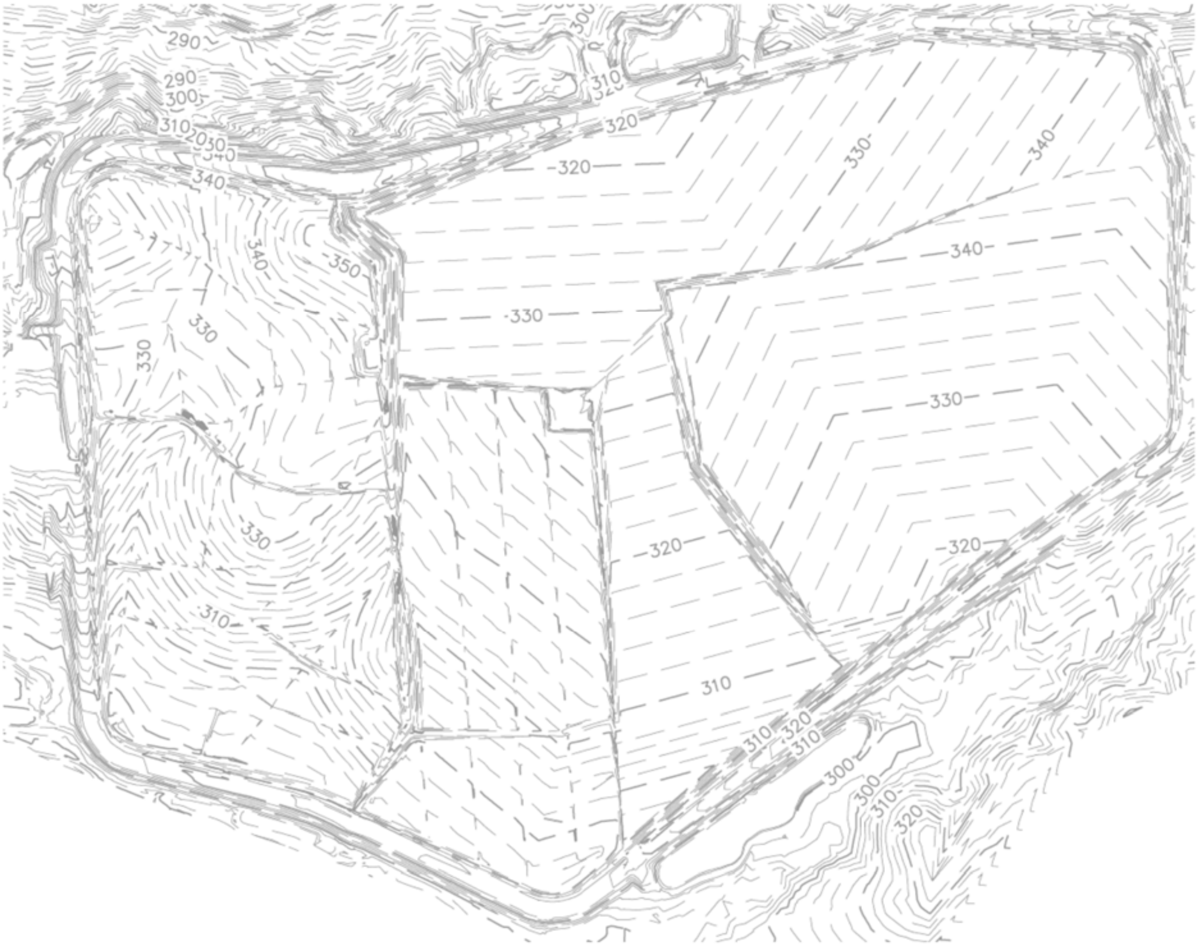


Figure 19. Proposed Alternate Base Grades for the South Wake Landfill

The alternative scenario base grade elevations would provide approximately 1 million cubic yards of additional airspace that could be used to dispose of an additional 650,000 tons of waste at the typical waste densities achieved at the facility. This would provide the facility with an additional 1.3 years of life assuming a disposal rate of 500,000 tons per year.

This additional capacity would all come from the excavation of additional in-situ earthen material during cell construction. The base grade elevations selected are intended to avoid excavation into the bedrock below based on the top of bedrock elevations depicted in Phase 2 Design Hydrogeologic Report on Figure 5 dated April 2013 prepared by Smith + Gardner Engineers. Some excavation into bedrock may be necessary because the non-uniform nature of bedrock may not be fully captured by the limited boring data. The County could choose a more aggressive approach and excavate into the bedrock below to gain additional airspace. Bedrock excavation would incur additional cost, but those costs may be acceptable if they allow the County to defer siting of a new landfill or other solid waste disposal facility.

This design would require excavation and removal of in-situ material below the groundwater table. This would require the installation of a groundwater underdrain consisting of a perforate pipe placed in a trench filed with drainage stone below the landfill base grades. An example of a groundwater underdrain detail is shown in **Figure 20**. The ideal configuration is to design and position the underdrains so that they drain via gravity and discharge into surface water. In the event this configuration is unachievable, the underdrains may require the installation of pumps to remove groundwater. SCS recognizes this approach is not typical of landfills in North Carolina and may require additional documentation during the permitting process.

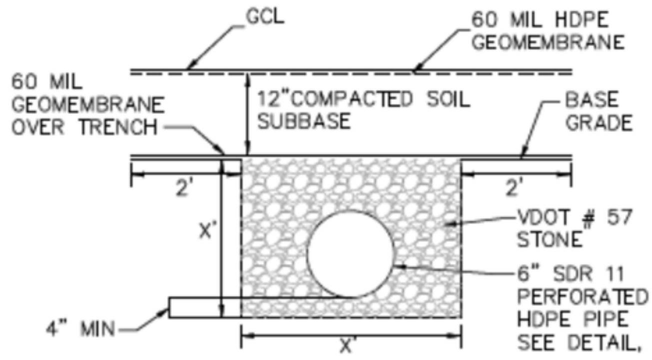


Figure 20. Example Groundwater Underdrain

Lowering base grade elevations has the advantage of providing additional airspace without changing the post-closure visible landscape of the facility. The added capacity will be below grade and will not change the visible impact to the surrounding area. A potential downside to this approach is that it must be implemented before additional cells are constructed to be effective, while other methods of life extension could potentially be implemented towards the end of the landfill's projected life.

3.6 OPERATIONS AUDIT

Contracting with a consultant to conduct an operational audit is another approach to extending landfill life. Field reconnaissance and disposal data analysis would allow improvements to made in efficiency and safety both at the landfill and collection centers. As part of this review SCS has conducted a preliminary audit of landfill operations.

3.6.1 Preliminary Audit

On Wednesday November 29th, 2017 Charles Warren, P.E. and Dan Jansen, Senior Project Advisor of SCS Engineers met with Lee Squires, P.E., Solid Waste Facility Manager of Wake County Environmental Services at the SWLF. The purpose of the visit was to observe operational activity at the landfill. During the introductions Mr. Squires introduced Troy Mitchell, Landfill Operations Supervisor for Waste Industries (WI) that maintains an operating contract for approximately 20 years.

A physical tour was performed by the SCS employees with Mr. Squires and Mr. Mitchell. Facility infrastructure construction was being performed during the evaluation. The haul roads were well maintained and traffic flow was easy to follow to the active working face. Unloading at the active working face was well organized by a WI's spotter on the ground.

Mr. Mitchell explained that WI had two 826 CATAPILLAR Compactors, CAT D-8 and a CAT D-7 working the waste at the working face, however one Compactor was down for maintenance. The daily working face was held to tight boundaries and being compacted as best as the available equipment could achieve. The outside slopes were well vegetated and compost material was utilized on the slopes as well. No excessive erosion was noted during the evaluation. The facility's leachate tank and pre-treatment facility was observed to be in working order.

3.6.2 Audit Conclusions

The facility's density is currently 1,400 lbs. /cu yd. It has been observed and is the goal of many solid waste landfills to obtain and maintain 1700 – 1800 lbs. /cu yd. During the evaluation it was observed that one 826 Compactor, D-8 and the D-7 were placing and compacting the daily waste. The contractor has two 826 CAT Compactors for the facility, however one is problematic.

Perhaps replacing the two 826 CAT Compactors with one 836 CAT Compactor could help the facility reach 1700 lbs. /cu yd. density. 1,700 lbs. /cu yd. would be approximately 20% increase in density, thus fully utilizing permitted airspace to extend the life of the facility.

Currently WI is required to meet a density requirement of 1,100 lbs. /cu yd. per the operating contract. WI is already exceeding this requirement and no incentive has been identified to encourage additional compaction. Changes to the contract to provide financial incentives or penalties to encourage additional compaction of the waste may help motivate WI to make investments to increase waste compaction at the facility.

One such incentive could be to offer an annual tiered bonus system for achieving a certain density based on the annual survey data. For example, if WI achieves a density of 1500 lbs. / cu yd. they would be paid a certain incremental amount for each ton of waste accepted at the SWLF that year. The tiered nature of this hypothetical bonus program would establish a larger incremental bonus offered at the 1,600 lbs. / cu yd, threshold and a slightly larger fee for achieving 1700 lbs. / cu yd. and so on.

The benefit to the County would come from more efficient use of airspace. For example, at a density of 1400 lbs. / cu yd. a cell with 500,000 cubic yards of airspace can receive 350,000 tons of waste. At a density of 1500 lbs. / cu yd. that same cell can receive 375,000 tons of waste. This incremental increase in density facilitates an additional 25,000 tons of waste (~7% of the capacity) for the same cell construction and closure costs.

It should be noted that over time settlement may reduce the discrepancy between the densities to some degree. The ability to take advantage of the airspace gains associated with long term settlement can be limited if the working face has moved a significant distance away. The financial implications of delaying capital expenditures related to construction and closure should also be considered. Any bonus plan should be given careful consideration to determine if there is appropriate upside for the County.

4.0 RECOMMENDATIONS

SCS believes using a combination of County-wide waste diversion and reduction strategies and measures to physically increase the capacity of the South Wake Landfill will provide the optimal approach to prolonging its potential lifespan. These strategies entail various types and levels of considerations, including potential first or next-steps, impacts on landfill life expectancy, and difficulties of implementation. Table 11 below summarizes the recommendations/evaluations ("Eval") resulting from this Study.

Note that the two primary criteria used to compile the listing of potential measures and recommendations include the "Potential Landfill Life Impact" (Low = some lifespan increase; High = highest lifespan increase) and "Difficulty," which can be considered a rough proxy for cost. This listing should not be considered comprehensive, but simply attempts to comment on notable potential measures discussed in the Report designated by strength of recommendation. Within the context and scope of this Study, SCS did not perform any preliminary cost estimates, and individual landfill life expectancy increase measures would have varying degrees of success per unit cost. Overall, the below compilation of observations and recommendations serves as a general guide, and further study is required prior to any significant actions being taken.

Table 11. Summary of Potential Measures and Recommendations to Extend the Life of the South Wake Landfill

Measure	Section of Report	First/Next Step(s)	Potential Landfill Life Impact	Difficulty	Eval[2]
Waste Diversion & Reduction					
Increase Residential Recyclable Materials Diversion					
Assist Select Munis w/Residential Recycling	2.1.2	Develop consistent performance measures; Identify underperforming munis	High	Med	🟢
Establish/Formalize Interlocal Collaboration	2.1.3	Form communication mechanism for County, city/towns, & other stakeholders	High	Med	🟢
Establish Rural Curbside Collection Service	2.1.4	Feasibility Study; Exploratory RFQ/RFP for service	Med	High	⚫
Offer Hauler Awards for Material Diversion	2.1.5	Develop program outline & facilitate hauler feedback to assess amenability	Low	Low	🟡
Establish Mattress Diversion Program	2.1.6	Assess County facility/operational assets to guage feasibility; Estimate costs	High	Med	🟢
Create Economies of Scale	2.1.7	Examine space available at CCs & available recycling markets	Med	High	⚫
Construction & Demotion (C&D) Debris Diversion					
Explore MRF Possibilities for CC C&D Debris	2.2.1	Tighten enforcement of contractor/commercial C&D abuse at CCs	Med	Med	🟡
Source Separate Addt'l C&D Material at CCs	2.2.2	Examine space available at CCs & available recycling markets	Low	Med	⚫
Increase/Promote Multi-Family Complex (MFC) Recycling					
Start Serving Complexes in City/Towns	2.3.1	Identify candidate underserved MFCs; Conduct feasibilty study	High	High	🟠
Incentivize Private Haulers Serving MFCs	2.3.2	Assess hauler recognition program; Assess MFC containers per 2.3.4	Low	Low	🟡
Target Student MFCs/University Collaboration	2.3.3	Initiate/enhance mechanism for dialogue with Universities	Low	Low	🟡
Promote Commercial Recycling					
Audit/Perform Data Analysis of SWLF Loads	2.4.1	Interview LF scalehouse/operator staff to identify select commercial disposers	Med	Low	🟢
Target Small Businesses	2.4.2	Perform assessment & study	Med	Med	🟡
Collaborate with Stakeholders	2.4.3	Identify major generators & form inter-sector communication mechanism	Med	Low	🟢
Business Waste Audits	2.4.4	Perform assessment & study; Walkthrough	Med	Med	🟡
Pay-As-You-Throw (PAYT)					
Implement Pay-As-You-Throw	2.5.0	Identify method of accepting fee payment at collection centers	High	High	🟠
Expand Organics Management					
Expand Food Waste Education	2.6.1	Increase E&O, marketing; Examine County govt/schools policy	Med	Med	🟡
Find Post-Consumer Food Waste Partners	2.6.2	Partner w/food rescue agencies; Maintain list of major generators	Low	Low	🟡
Expand Composting	2.6.3	Expand food scrap collection & backyard program; Maintain generator list	Med	Med	🟡
Implement Anaerobic Digestion	2.6.4	Conduct study/needs assessment for siting facility on County property	High	High	🟠
Additional Waste Reduction/Diversion Programs					
Lead by Example	2.7.1	Examine County govt & public school policy; Identify/form gurus/committees	Low	Low	🟡
Stimulate Reuse	2.7.2	Post providers on County website; Identify deconstruction/C&D reuse markets	Low	Low	🟡
Implement New Policy	2.7.3	Explore political will/legal ramifications	High[1]	Varies	🟡
Sponsor Additional Special Events	2.7.4	Sponsor/provide repair workshop venue; Continue to attend special events	Low	Med	⚫
Landfill Capacity Increase Measures					
Side Slope Angle Increase	3.1.0	Increase the final grade slopes from 4:1 to 3.5:1	Med	Low	🟢
MSE Berm	3.2.0	Build a mechanically stabilized earth berm	Med	Med	🟡
Temporary Overfilling	3.3.0	Fill above permitted intermediate grades	Low	Low	🟡
Lateral Expansion	3.4.0	Expand the footprint of the Landfill	High	High	🟠
Vertical Expansion	3.5.0	Lower the Landfill base grades	Med	Med	🟡
Increase Density	3.6.0	Work with contract operator to increase waste density	Med	High	⚫

Note:

1. May vary widely depending on policy

2. Recommendation metric only utilizes two factors shown; if additional factors considered, result may be affected

Key		
Symbol	**Color**	**Description**
🟢	Green	**Recommended & Endorsed –** Proceed with Implementation
🟡	Yellow	**Recommended –** Proceed with Further Evaluation & Analysis to Facilitate Future Implementation
🟠	Orange	**Recommended but w/Reservations –** Significant Additional Evaluation & Analysis Necessary before Proceeding w/Detailed Planning Efforts
⚫	Black	**Identified as Neutral Action** - Low Priority for Further Consideration

END OF REPORT

Appendix A – Stability Analysis

A1. Conceptual Alternative Final Grade Stability Analysis

SCS analyzed two final slope configurations at South Wake Landfill for stability. Analysis included a baseline scenario using the existing 4:1 slope, and an alternative scenario using the proposed 3.5:1 slope. The stability modeling was performed using the PCSTABL5M computer program (Purdue University, 1985), a model that SCS Engineers has used extensively for waste stability evaluations of this nature.

The material properties for the subgrade and waste were obtained from the Slope Stability report prepared by Smith and Gardner in November 2012. The unit weight, cohesion, and friction angle values can be found below:

- Subgrade:
  - Unit Weight – 100pcf, 110pcf Saturated
  - Cohesion – 100psf
  - Friction Angle – 25 degrees
- Waste:
  - Unit Weight – 70pcf, 90pcf Saturated
  - Cohesion – 500psf
  - Friction Angle – 30 degrees
- Liner:
  - Unit Weight – 100pcf
  - Cohesion – 0psf
  - Friction Angle – 20 degrees

The analysis was conducted using two cross sections that were analyzed for both circular and block failure analysis. Circular failure analysis of the baseline scenario is shown in Figure A- 1Figure 1 for the first cross section and Figure A- 2 for the second cross section. Block failure analysis of the baseline scenario is shown in Figure A- 3 for the first cross section and Figure A- 4 for the second cross section. For the alternative final grade analysis circular failure of the first cross section is shown in Figure A- 5 and in Figure A- 6 for the second cross section. The block failure analysis for the alternative final grades is shown in Figure A- 7 for the first cross section and in Figure A- 8 for the second cross section.

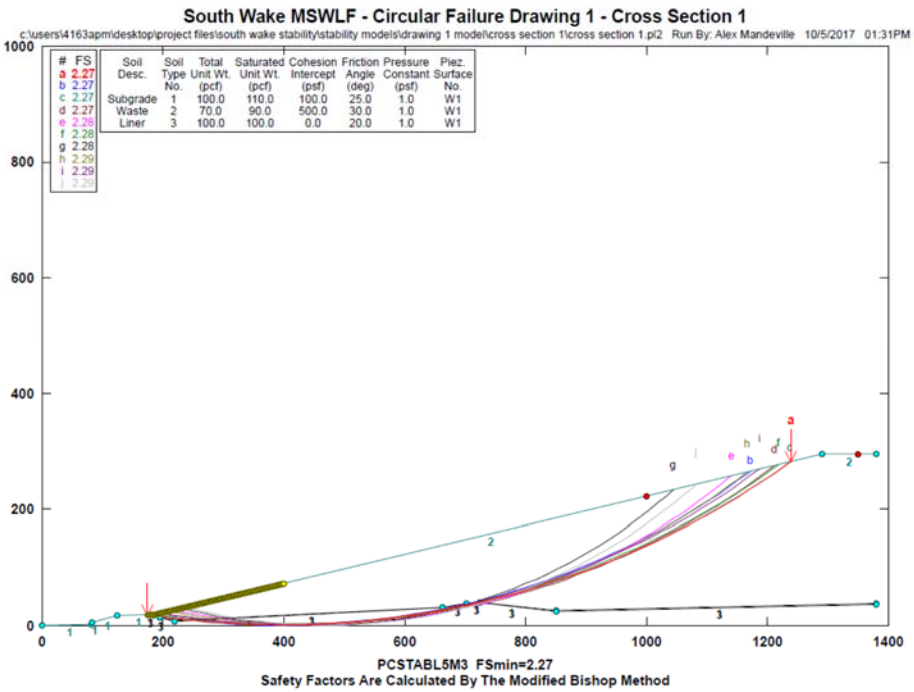


Figure A- 1 Baseline Scenario: Cross Section 1 - Circular Failure Analysis

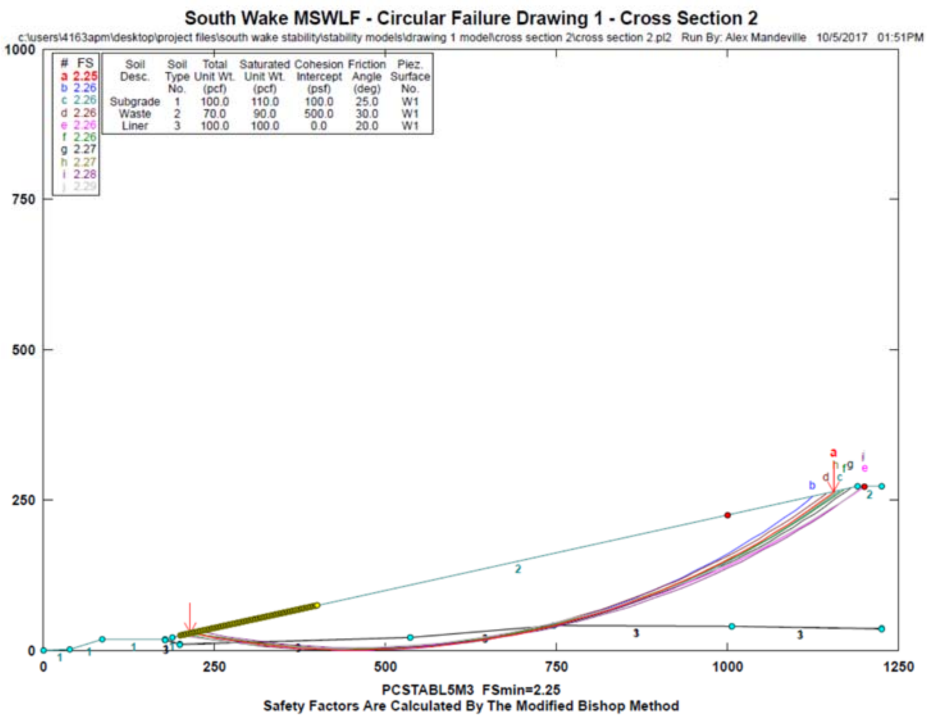


Figure A- 2 Baseline Scenario: Cross Section 2 - Circular Failure Analysis

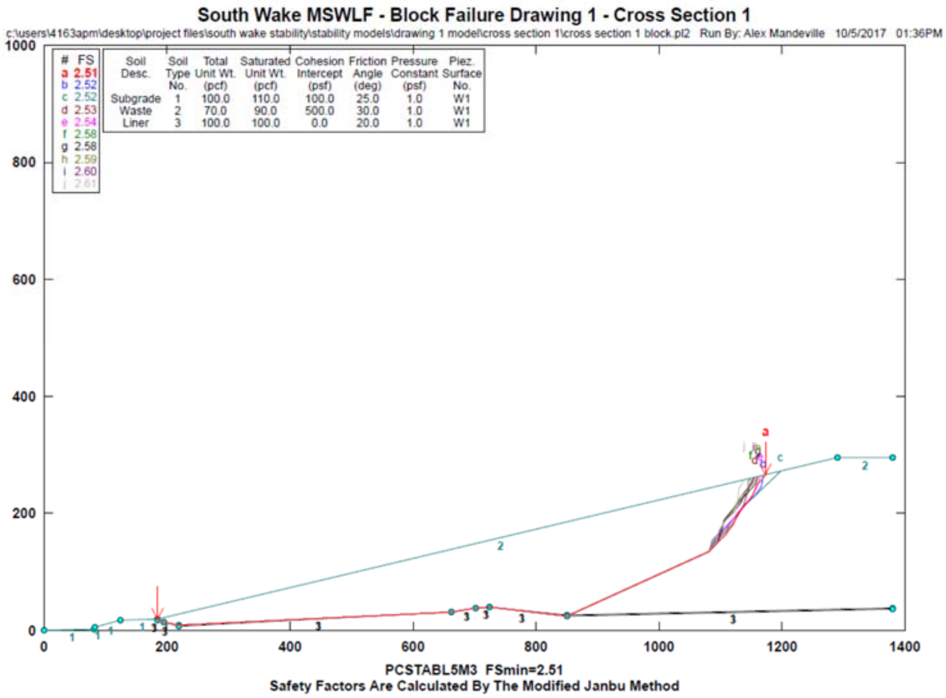


Figure A- 3 Baseline Scenario: Cross Section 1 - Block Failure Analysis

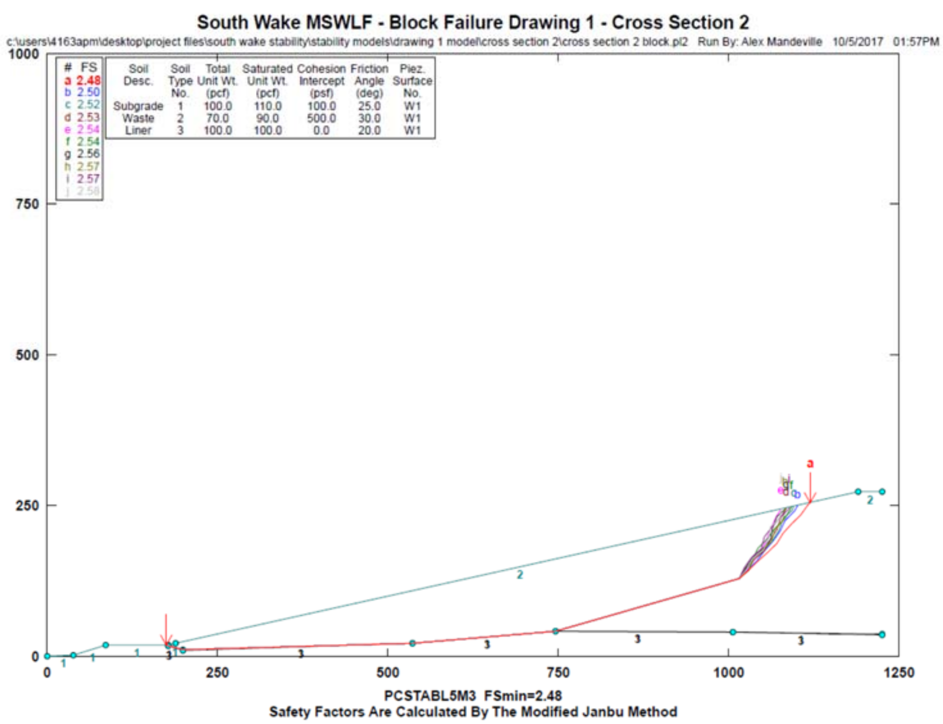


Figure A- 4 Baseline Scenario: Cross Section 2 - Block Failure Analysis

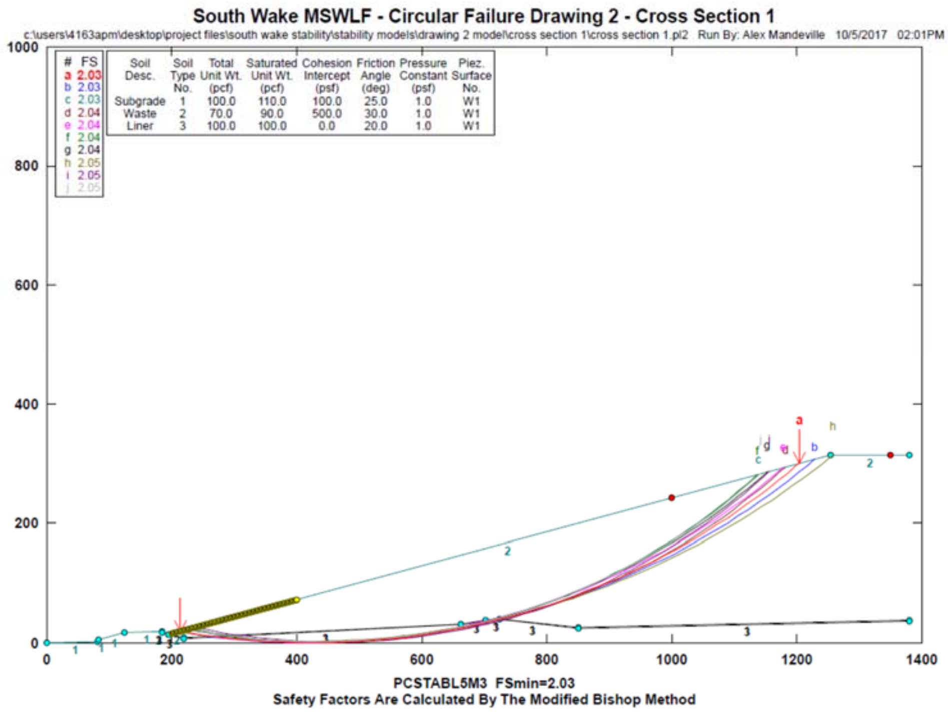


Figure A- 5 Alternative Final Grades: Cross Section 1 - Circular Failure Analysis

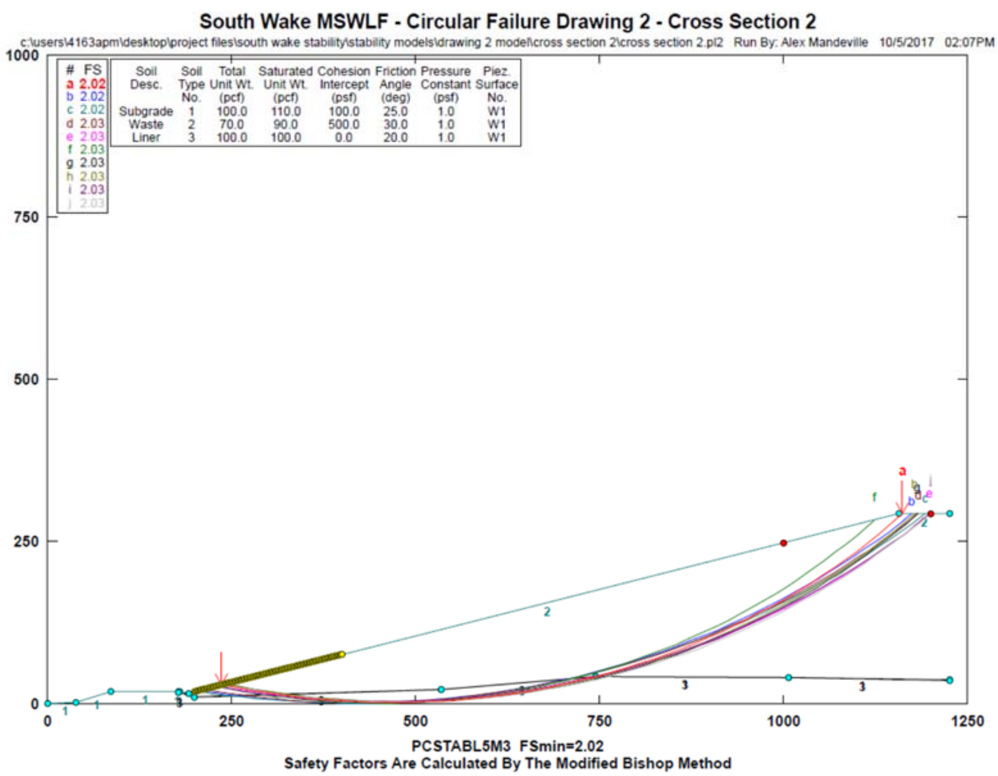


Figure A- 6 Alternative Final Grades: Cross Section 2 - Circular Failure Analysis

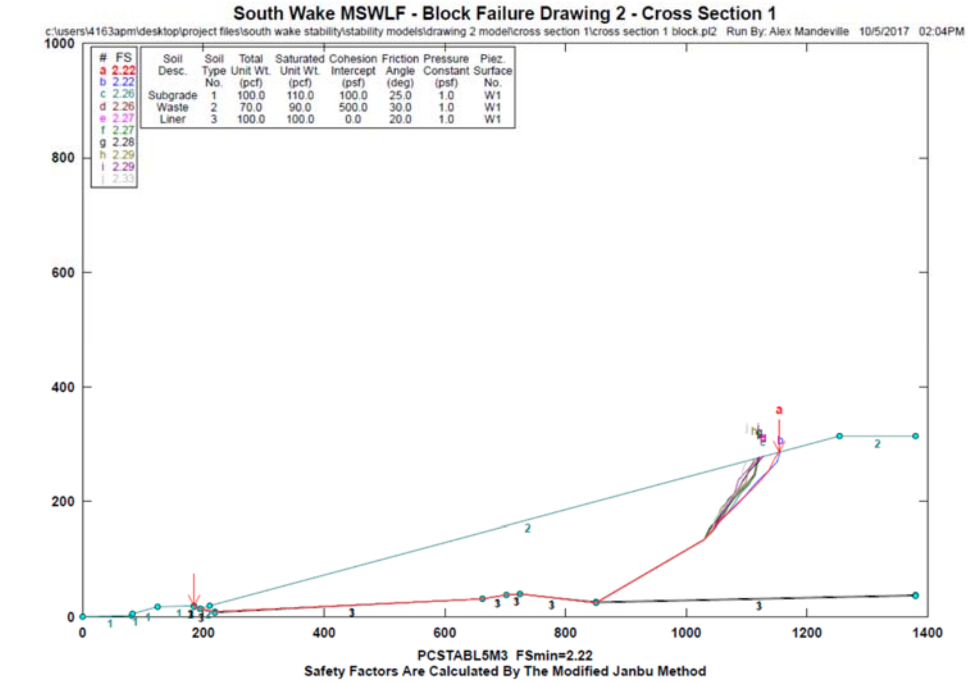


Figure A- 7 Alternative Final Grades: Cross Section 1 - Block Failure Analysis

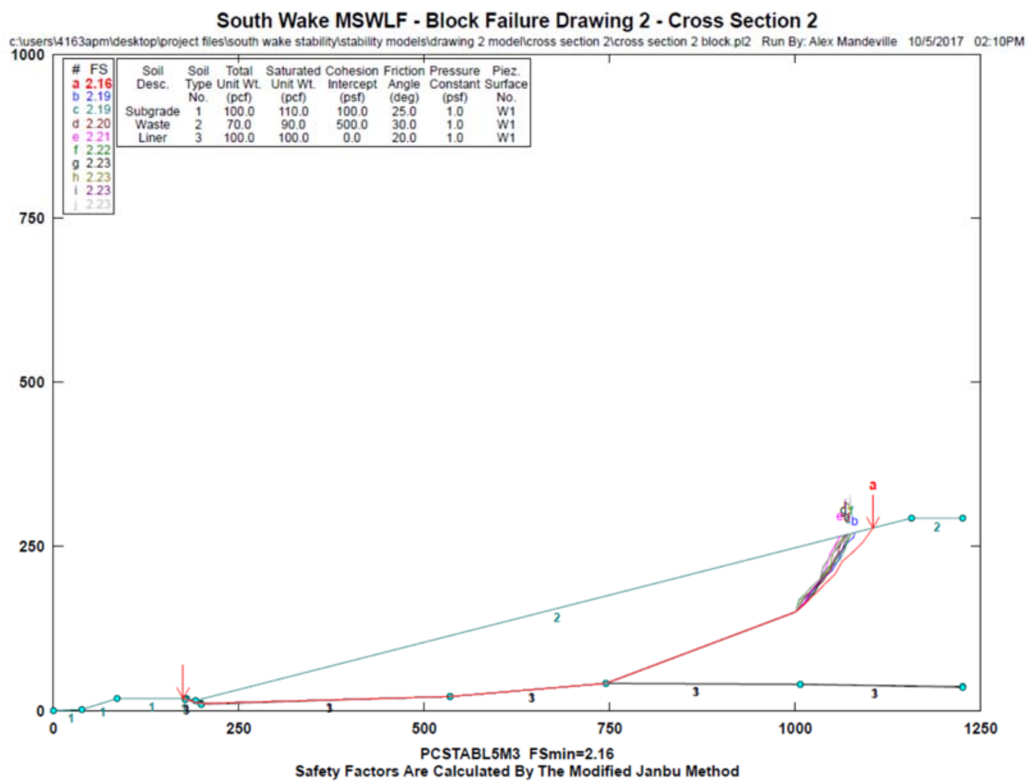


Figure A- 8 Alternative Final Grades: Cross Section 2 - Block Failure Analysis

The stability models above show a very slight change in the factor of safety (FS) when changing from a 4:1 slope to a 3.5:1 slope. In the baseline scenario, a FS from 2.25 to 2.51 is achieved. When the slopes are increased to 3.5:1 for the alternative final grades, the FS ranges from 2.02 to 2.22. A safety factor greater than 1.5 is typically considered acceptable for this application. The additional waste added to the slope reduces the FS by around 0.25 as shown in **Table A-1**.

Table A- 1 Slope and FS Analysis Under Different Scenarios

Title	Slope	FS
Baseline Scenario - Cross Section 1 - Circular Failure	4:1	2.27
Baseline Scenario - Cross Section 2 - Circular Failure	4:1	2.25
Baseline Scenario - Cross Section 1 - Block Failure	4:1	2.51
Baseline Scenario - Cross Section 2 - Block Failure	4:1	2.48
Alternate Final Grades - Cross Section 1 - Circular Failure	3.5:1	2.03
Alternate Final Grades - Cross Section 2 - Circular Failure	3.5:1	2.02
Alternate Final Grades - Cross Section 1 - Block Failure	3.5:1	2.22
Alternate Final Grades - Cross Section 2 - Block Failure	3.5:1	2.16

A2. Preliminary MSE Wall Stability Analysis

SCS analyzed two final slope configurations at South Wake Landfill for stability. The baseline analysis for this scenario is the same scenario that was described for the baseline scenario in Section 3.1.2. The baseline scenario was compared to an arrangement which included a 4:1 slope with an MSE Wall at the toe of the slope. The stability modeling was performed using the PCSTABL5M computer program (Purdue University, 1985), a model that SCS Engineers has used extensively for waste stability evaluations of this nature.

The material properties for the subgrade and waste were obtained from the Slope Stability report prepared by Smith and Gardner in November 2012 and are the same as the values outlined in section3.1.2. SCS estimated the material properties based on common construction practices and the actual values may vary depending on the methods and materials used to construct the MSE wall. The unit weight, cohesion, and friction angle values used for the MSE wall can be found below:

- MSE Wall (30ft tall):
    - Unit Weight – 110pcf, 120pcf Saturated
    - Cohesion – 1300psf
    - Friction Angle – 35 degrees

The analysis included circular failure analysis shown in Figure A- 9 and block failure analysis shown in Figure A- 10 For reference, the baseline circular analysis is shown in Figure A- 1 and the baseline block failure analysis is shown in Figure A- 3 in section 3.1.2.

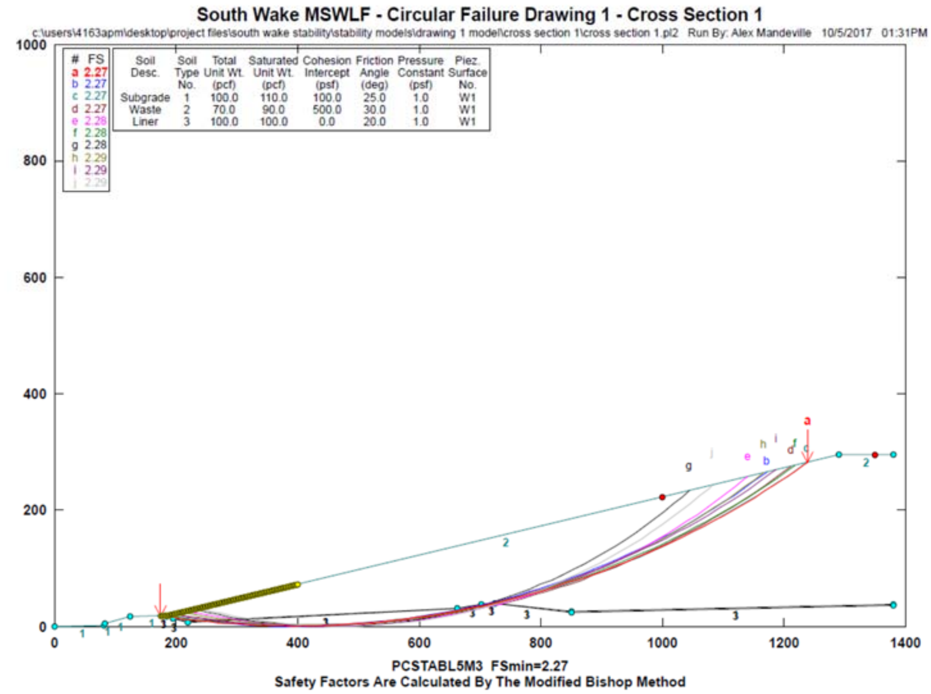


Figure A- 9 MSE Berm: Circular Failure Analysis

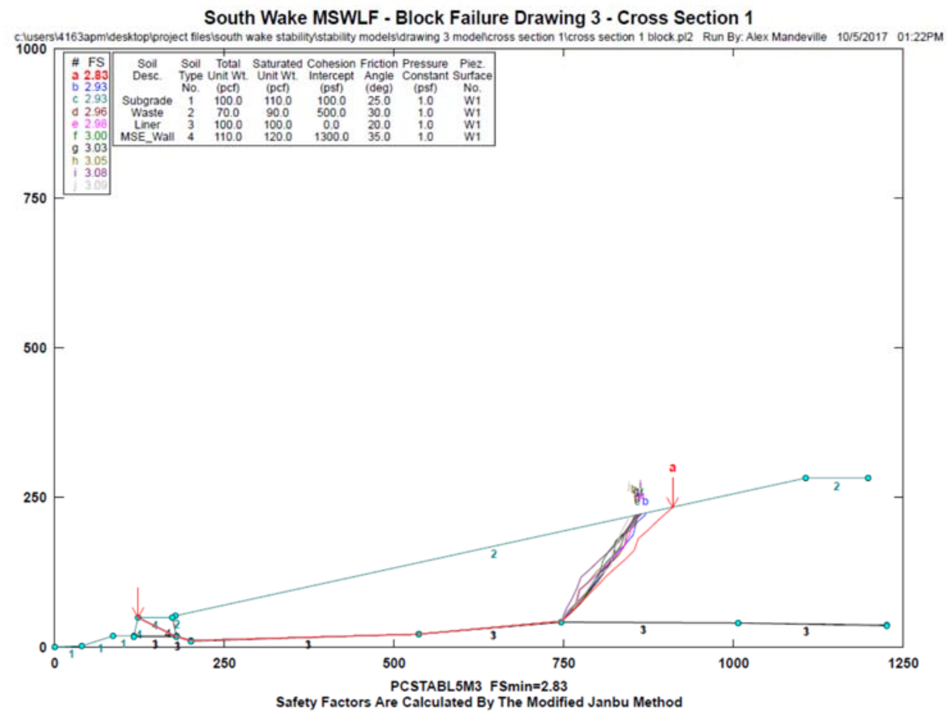


Figure A- 10 MSE Berm: Block Failure Analysis

When the MSE Wall is added at the toe of the slope there is a slight reduction in the factor of safety for the block failure mode but also an improvement in the factor of safety for the circular failure mode as shown in Table A-2. The analysis indicates that construction of an MSE wall is a feasible method for the County to extend the life of the South Wake Landfill. Further analysis will be required based on the final design, technology, and construction method used.

Table A- 2 Results of Preliminary Slope Stability Analysis

Title	Slope	FS
Baseline Scenario - Circular Failure	4:1	2.27
Baseline Scenario - Block Failure	4:1	2.51
MSE Wall - Circular Failure	4:1	2.83
MSE Wall - Block Failure	4:1	2.35