

Issue Paper #4

Availability of Permeable Daily Cover Material for Landfill Operations

4.1 Definition and Purpose of Permeable Daily Cover

Landfill daily cover is required by both federal and state regulations to be placed on any area with exposed municipal solid waste (MSW) at the end of each operating day. The purposes of daily cover include:

- Litter control;
- Fire prevention;
- Odor reduction;
- Vehicle access to active face;
- Rodent and bird contact reduction; and
- Erosion control.

Permeable cover options allow for leachate to pass through the daily cover medium. This helps prevent liquid from ponding within the landfill, horizontal leachate movement and side seeps while still providing the benefits listed above.

Alternative daily cover (ADC) is material other than 6 inches of soil that still performs to the same standard in controlling all of the above. ADC is generally used to save air space, money and/or virgin materials. ADC may also be easier to work with than the standard soil cover option. Some ADC is specifically chosen for its ability to limit leachate generation or improve landfill gas collection efficiency. This is not typically the case with permeable ADC.

Examples of permeable alternative daily cover include:

- Shredded tires;
- Processed construction and demolition (C&D) debris;
- Glass Aggregate;
- Spray-on Slurries, such as ConCover[®];
- Foundry sand;
- Coal ash or incinerator ash;
- Contaminated soil;
- Auto Fluff;

- Green Waste and/or Composted Material;
- Paper mill sludge; and
- Water treatment plant sludge.

4.2 Rules and Regulations

4.2.1 Federal Requirements

Federal requirements for alternative daily cover at MSW landfills are described in Subtitle D of the Resource Conservation and Recovery Act (RCRA), Title 40, Section 258.21 which states:

“Alternative materials of an alternative thickness (other than at least six inches of earthen material) may be approved by the Director of an approved State if the owner or operator demonstrates that the alternative material and thickness control disease vectors, fires, odors, blowing litter, and scavenging without presenting a treat to human health and the environment.”¹

4.2.2 State Requirements

The New York State Department of Environmental Conservation (NYSDEC) has regulations regarding landfill cover. Chapter IV-Quality Services, Subchapter B: Solid Wastes, Part 360: Solid Waste Management Facilities, Subpart 360-2: Landfills, Section 360-2.17, Landfill Operation Requirements (c) Daily Cover states:

“A minimum of six inches of compacted cover material must be applied on all exposed surfaces of solid waste at the close of each operating day to control vectors, fires, odors, blowing litter and scavenging. The department may approve the use of alternative daily cover materials of an alternative thickness, upon a demonstration that the alternative daily cover material will adequately control vectors, fires, odors, blowing litter and scavenging without presenting a threat to human health and the environment. Such demonstrations are not subject to variance procedures of this Part.”

Subpart 360-1: General Provisions, Section 360-1.15, Beneficial Use (b) Solid Waste Cessation states: “The following items are no longer considered solid waste for the purposes of the Part when used as described in this subdivision: (10) solid wastes which are approved in advance, in writing, by the department for use as daily cover material or other landfill liner or final cover system components pursuant to the provisions of subdivision 360-2.13(w) of this part when these materials are received at the landfill.”²

¹ Source: Electronic Code of Federal Regulations <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&rgn=div5&view=text&node=40:24.0.1.4.38&idno=40#40:24.0.1.4.38.3.23.2>

² Souce: NYSDEC regulations. <http://www.dec.ny.gov/regs/2491.html>

4.3 Current Daily Cover at Broome County Landfill

Currently the Broome County Landfill (Landfill) uses six inches of soil as daily cover. The Landfill utilizes on-site soil for a majority of the daily cover material. The soil material is currently being excavated from the Section IV Cell 2 footprint in preparation for future expansion. The soil in this area consists of a glacial till which is comprised of a mixture of clay, silt, sand, gravel, and cobbles. Larger material (cobbles) is removed from the soil by the excavator during removal. Additional unsuitable material is also removed during placement as daily cover. The resulting soil material can become relatively impermeable when compacted as daily cover. This characteristic can impact landfill operations from both a landfill gas collection and stormwater management perspective by preventing the upward movement of landfill gas (LFG) and downward percolation of stormwater.

The Landfill also uses a tarp as ADC to cover the waste when weather permits. This option is used when there is no wind and the working face is on a flat surface. The tarp is not a permeable ADC, but it is a favorable system because it does not consume any airspace.

4.4 Examples of Permeable ADC

Provided below are detailed evaluations of each alternative daily cover option:

4.4.1 Tire Shreds as Alternative Daily Cover

4.4.1.1 Introduction

The California Integrated Waste Management Board (CIWMB) prepared a guidance manual entitled “Shredded Tires as Alternative Daily Cover at Municipal Solid Waste Landfills,”³ in which experience from a demonstration project at the Chicago Grade Landfill located in Templeton, California was evaluated. The performance evaluation consisted of the following:

- Protection of Public Health;
- Protection of the Environment;
- Durability;
- Operational Impact;
- Product Characteristics;
- Cost Impact; and
- Engineering Performance.

³ Source: CIWMB. <http://www.ciwmb.ca.gov/publications/tires/21297024.doc>

General characteristics and engineering properties of tires and tire shreds were evaluated. In addition, recommended procedures for landfill owners/operators who consider using tire shreds as ADC were provided including:

- Permitting;
- Acquisition of Tires or Shreds;
- Storage;
- Shred Sizing;
- Mixing with soil (optional);
- Placement;
- Monitoring;
- Documentation; and
- Health and Safety.

4.4.1.2 Performance Evaluation

The findings of the evaluation criteria are summarized below:

- **Public Health:** When used in accordance with the guidance manual, tire shreds as ADC meets public health requirements, though may not control landfill gas.
- **Environment:** When used in accordance with the guidance manual, tire shreds as ADC meets environmental protection requirements in regards to dust, litter, odor, and erosion. It does not contribute to leachate generation or add organics/inorganics to leachate or run-off. Mixing tires with soil (at least 50% soil in the mixture) will mitigate odors if they do exist with tire shreds alone. The soil mixture will also mitigate fire potential. The shreds are permeable and thus allow for leachate infiltration.
- **Durability:** Tire shreds are very durable and, when mixed with soil, provide resistance to burrowing of animals. However, tire shreds will not biodegrade.
- **Operational Impact:** Storage is similar to that of soil requirements, but the production of the shreds requires specialized equipment and additional personnel. Mixing with soil can also add a preparation step. Placement of the tires is relatively easy on a 3:1 slope or less. However, during placement, the tires can be difficult to compact. Additional layers of waste will typically help compact the tires shreds up to 50%,⁴ which can result in less air space consumption than soil. During placement, and prior to additional lifts of waste, metal wires can cause flat tires on vehicles and be a danger to foot traffic.
- **Product Characteristics:** Desirable ADC qualities of tire shreds include: material flexibility, no nutrient source for animals, high permeability, and resistance to adverse weather. An undesirable quality of tire shreds is combustibility. However, when mixed with soil, the combustibility is low.

⁴ Source: Stearns & Wheler, Broome County Section 4 Expansion Literature.

- **Cost Impact:** Use of tire shreds as ADC is generally deemed to be cost effective compared to soil. Tipping fees may be received for accepting tires; volume reductions are achieved by shredding the tires; and there is a decrease in the quantities of soil required for daily cover. However, there may be significant costs associated with shredding tires onsite due to equipment and processing costs. A detailed cost analysis should be conducted to evaluate the costs and availability of scrap tires/shreds compared to soil.
- **Engineering Performance:** Tire shreds as ADC should not have a significant impact on the performance or stability of the landfill.

4.4.1.3 Guidance for Tire Shred Use as ADC

The guidance given by CIWMB is based on this one study; site specific criteria should be evaluated. The guidance includes the following:

- **Permitting:** The landfill owner/operator should issue a letter of intent regarding the use of tire shreds as ADC and submit for approval to the NYSDEC and the local fire department. Tire shreds as ADC is not currently on the NYSDEC Beneficial Use Designation (BUD) list.
- **Acquisition of Tires or Shreds:** Tires should be free of surface contaminants and can either be purchased as whole scrap tires or already shredded tires. If shredded onsite, it is best to have at least two personnel with protective equipment performing the shredding.
- **Storage:** Whole tires should be stored in a manner that does not provide a refuge or breeding ground for mosquitoes, rodents and other vectors. Stored tires or shreds should not be located near flammable materials. The NYSDEC's guidance on stockpiling tire shreds includes periodic temperature monitoring and limits the size of the piles and spacing between the piles to limit potential spontaneous combustion.⁵ It is advised that only shreds to be used that day should be stockpiled near the working face. Shreds should be handled appropriately as to avoid injury from metal wires (which should be no more than one inch from the edge of the tire shred).
- **Shred Sizing:** When measured in any direction, shreds should have a maximum dimension of 12 inches and 50% by weight should be smaller than 6 inches. The use of U-shaped pieces should not be allowed. Tire shreds mixed with soil should meet the same requirements. The thickness on the working face is recommended to be 12 inches.
- **Mixing with Soil (Optional):** Mixing tire shreds with soil can be performed with a dozer either at the stockpile location or on the working face.
- **Placement:** Rubber-tired trucks are generally used to transport tires to the working face despite the risk of the metal wires. The shreds are generally placed in a single lift between 6 and 12 inches thick. Two to six passes of a compactor is recommended to ensure there are no large voids. If shreds are used that are not

⁵ Source: Stearns & Wheler, Broome County Section 4 Expansion Literature.

mixed with soil, then soil (instead of shreds) should be placed and compacted on the working face approximately once a week to reduce the fire hazard.

- **Monitoring:** A program should be developed to ensure that the tire shreds, when used as ADC, meet the performance standards for landfill daily cover. This could be accomplished by maintaining a logbook of visual observations.
- **Documentation:** Both the monitoring program log and the trip tickets of shreds received should be retained in the landfill files for regulatory review.
- **Health and Safety:** Tires and tire shreds are non-hazardous inert materials, however during placement and prior to additional lifts of waste, metal wires can cause flat tires on vehicles and be a danger to foot traffic. Personal protective equipment should be worn when working around/with tires. Also, employees should practice good hygiene and wash hands before eating, smoking or using the restroom.

4.4.1.4 Availability

In the past, the Landfill could request tire chips from the recycler contracted to collect and process the County's whole tires, as a provision of the contract. This practice was discontinued, but may be added back into the contract when it comes up for bid in December 2009.

4.4.2 Construction and Demolition (C&D) Waste as an Alternative Daily Cover

4.4.2.1 Introduction

A number of studies and landfills have used C&D debris as an Alternative Daily Cover. This evaluation includes the results of Allied Waste's Middle Point Landfill near Murfreesboro, Tennessee⁶ and other findings from a number of sources, and is based on the following criteria:

- Protection of Public Health;
- Protection of the Environment;
- Durability;
- Operational Impact;
- Product Characteristics; and
- Cost Impact.

General characteristics and engineering properties of C&D were evaluated and guidance for their use as ADC includes the following:

⁶ Source: <http://www.thefreelibrary.com/Tennessee+approves+use+of+ADC+made+from+C&D+finis.-a0157034850>

- Permitting;
- C&D Sizing;
- Storage;
- Mixing with soil (optional);
- Placement;
- Monitoring;
- Documentation; and
- Health and Safety.

4.4.2.2 Performance Evaluation

The findings of the evaluation criteria are summarized below:

- **Public Health:** When used in accordance with NYSDEC Part 360 regulations, C&D as ADC meets public health requirements.
- **Environment:** When used in accordance with NYSDEC Part 360 regulations, C&D as ADC meets environmental protection requirements in regards to dust, litter, and erosion. C&D that has been reduced in size via a grinder is permeable and thus allows for leachate infiltration. However, if not screened properly some materials can cause problems. For example, drywall (also called Sheetrock[®], gypsum and wallboard) is often the most prevalent material found in C&D loads and can emit a strong sulfur odor when it becomes wet and begins to decay. Some states have considered banning gypsum drywall from landfills because of the development of hydrogen sulfide gas when gypsum is mixed with moisture. Allied Waste's Middle Point Landfill in Tennessee has not found any generation of hydrogen sulfide when using C&D as ADC. (The state does not require the removal of gypsum prior to processing C&D.) The content of C&D varies with different generators, so the loads should be carefully monitored.

Also, green-treated or pressure-treated lumber may also cause problems due to potential contaminants used as preservatives (e.g., chromated copper arsenate or creosote) within the wood.

- **Durability:** C&D debris is very durable and compacts well, when reduced in size. However, not all of it will biodegrade.
- **Operational Impact:** Storage is similar to that of soil requirements. Mixing C&D with soil can also add a preparation step. Placement of the C&D ADC is relatively easy. Because C&D is currently being landfilled in Broome County, its use as an ADC would increase the volume of airspace for waste disposal.
- **Product Characteristics:** Desirable qualities of C&D ADC include: no nutrient source for animals, high permeability, and resistance to adverse weather. Undesirable qualities include: possibility of dust and high levels of gypsum. The CIWMB allows the following C&D materials and fines to be used as ADC: rock, concrete, brick, sand, soil, ceramics, cured asphalt, lumber and wood, wood

products, roofing material, plastic pipe, and plant material when commingled from construction work. As mentioned previously, if gypsum wallboard is not removed, then odors and hydrogen sulfide can form which are both objectionable for ADC.

- **Cost Impact:** Tipping fees are currently received for accepting C&D waste at the Landfill. If C&D were used as ADC, there would be a decrease in the quantity of soil required resulting in cost savings. However, costs would be incurred by purchasing shredding equipment and adding operational costs of processing the C&D. A full cost analysis should be conducted to determine potential revenues and expenses.

4.4.2.3 Guidance for C&D use as ADC

Guidance given by the CIWMB and the State of New York⁷ includes the following:

- **Permitting:** The landfill owner/operator should issue a letter of intent regarding the use of C&D waste as ADC and submit for approval to the NYSDEC and the local fire department. C&D screenings as ADC are currently on the NYSDEC Beneficial Use Designation (BUD) list. New York State operations requirements for C&D as ADC according to Subpart 360-16.4(d) states that applications for approval shall describe sampling and analytical procedures, including testing frequency, to ensure compliance.
- **C&D Sizing:** The CIWMB⁸ recommends 95% of the C&D material have a maximum dimension less than 12 inches and 50% of the C&D material, by volume, have a maximum dimension less than 6 inches, because field studies have shown that any other size of C&D is undesirable as cover. New York regulations state that the amount of fines (materials that passes through a number 200 sieve) be less than 25% by weight.
- **Mixing with Soil (Optional):** The process of mixing soil and C&D should be completed prior to application on the working face.
- **Placement:** Thickness of placement would be similar to that of the virgin soil requirement. C&D should be “ground, pulverized, shredded, screened, source separated, or otherwise processed, alone or mixed with soil in a manner to provide a compacted material free of open voids when applied to meet the performance requirements as alternative daily cover.”⁹
- **Monitoring:** A program should be developed to ensure that the C&D, when used as ADC, meet the performance standards for landfill daily cover. This could be accomplished by maintaining a log book of visual observations.

⁷ Source: New York State Department of Environmental Conservation
<http://www.dec.ny.gov/regs/4400.html>

⁸ Source: CIWMB. <http://www.ciwmb.ca.gov/rulearchive/2004/ADC/WSPresJun03.doc>

⁹ Source: CIWMB. www.ciwmb.ca.gov/rulearchive/2004/ADC/WSPresJun03.doc

- **Documentation:** Tests and monitoring of the C&D content should be documented, and the trip tickets of C&D fines received should be retained in the landfill files for regulatory review.
- **Health and Safety:** C&D is a non-hazardous material. However, employees should practice good hygiene and wash hands before eating, smoking or using the restroom. Personal protective equipment may be necessary.

4.4.2.4 Availability

The Broome County Landfill currently accepts C&D debris, however it is not required to be separated from the MSW. The Landfill does track the tons of dedicated C&D loads (loads not mixed with MSW) brought in by local contractors, so it is possible for the County to evaluate how much would be available for use as ADC. The County accepted approximately 21,350 tons of mixed C&D debris in 2006 and 22,400 tons in 2007.

4.4.3 Glass Aggregate as an Alternative Daily Cover

4.4.3.1 Introduction

Glass aggregate, when mixed with soil or tire chips, can be used as an Alternative Daily Cover. This evaluation is based on the following criteria:

- Protection of Public Health;
- Protection of the Environment;
- Durability;
- Operational Impact;
- Product Characteristics; and
- Cost Impact.

General characteristics and engineering properties of glass aggregate were evaluated and guidance for their use as ADC includes the following:

- Permitting;
- Glass Sizing;
- Storage;
- Mixing with soil (optional);
- Placement;
- Monitoring;
- Documentation; and
- Health and Safety.

4.4.3.2 Performance Evaluation

The findings of the evaluation criteria are summarized below:

- **Public Health:** When used in accordance with NYSDEC Part 360 regulations, glass aggregate as ADC meets public health requirements.
- **Environment:** When used in accordance with NYSDEC Part 360 regulations, glass aggregate as ADC meets environmental protection requirements in regards to dust, litter, and erosion.
- **Durability:** Glass aggregate is very durable and compacts well, when reduced in size. However, it will not biodegrade.
- **Operational Impact:** Storage could be done in a stockpile on-site. Mixing glass aggregate with soil or tire chips can also add a preparation step. Placement of the glass aggregate ADC is relatively easy.
- **Product Characteristics:** Desirable qualities of glass aggregate ADC include: no nutrient source for animals, high permeability, and resistance to adverse weather.
- **Cost Impact:** Tipping fees are currently received for accepting glass aggregate waste at the Landfill.

4.4.3.3 Guidance for glass aggregate use as ADC

Guidance includes the following:

- **Permitting:** The landfill currently has approval to use glass aggregate for ADC, when mixed with soil or tire chips.
- **Glass Sizing:** The glass aggregate the Landfill receives is generally crushed to 3/8th or minus in size.
- **Mixing with Soil or Tire Chips:** The process of mixing soil or tire chips and glass aggregate should be completed prior to application on the working face.
- **Placement:** Thickness of placement would be similar to that of the virgin soil requirement.
- **Monitoring:** A program should be developed to ensure that the glass aggregate, when used as ADC, meets the performance standards for landfill daily cover. This could be accomplished by maintaining a log book of visual observations.
- **Documentation:** Trip tickets of glass aggregate received should be retained in the landfill files for regulatory review.
- **Health and Safety:** Glass aggregate is a non-hazardous material. However, employees should practice good hygiene and wash hands before eating, smoking or using the restroom. Personal protective equipment may be necessary.

4.4.3.4 Availability

The Broome County Landfill currently accepts glass aggregate. The Landfill receives approximately 11,000 tons of glass aggregate per year from Waste Management's

Syracuse recycling facility. Currently, most of the glass aggregate is used for traction on the roads leading up to the working face.

4.4.4 Spray-On Slurries as Alternative Daily Cover

4.4.4.1 Introduction

A number of spray-on slurries are available for ADC. They harden after being applied but can be broken apart to remain pervious during waste filling activities. Examples of products include Pro-Guard,¹⁰ ConCover,¹¹ and Posi-Shell®.¹² (It should be noted that R. W. Beck does not endorse any particular vendor or manufacturer, nor do we claim this list to be complete.)

This summary of findings from a number of sources is based on the following criteria:

- Protection of Public Health;
- Protection of the Environment;
- Durability;
- Operational Impact;
- Product Characteristics; and
- Cost Impact.

General characteristics and engineering properties of spray on slurries were evaluated and guidance for their use as ADC includes the following:

- Permitting;
- Acquisition of Product;
- Storage;
- Placement;
- Monitoring;
- Documentation; and
- Health and Safety.

4.4.4.2 Performance Evaluation

The findings of the evaluation criteria are summarized below:

- **Public Health:** When used in accordance with NYSDEC Part 360 regulations, spray-on ADC meets public health requirements. ConCover, Pro-Guard and Posi-Shell are rated non-hazardous for health, fire and reactivity.

¹⁰ Source: New Waste Concepts. <http://www.nwci.com/proguardSB.html>

¹¹ Source: New Waste Concepts. <http://www.nwci.com/concover180.html>

¹² Source: Landfill Service Corporation. <http://www.landfill.com/posidescription.htm>

- **Environment:** When used in accordance with NYSDEC Part 360 regulations, spray-on ADC meets environmental protection requirements in regards to dust, litter, odor and erosion.
- **Durability:** Spray-on ADC is durable once it is applied and can be used as a temporary cover for a period longer than required for ADC, if necessary.
- **Operational Impact:** When high winds or low temperatures exist, these products can be difficult to apply.¹³ However, labor intensity is reduced because the application is a spray, not a manual spread, and leachate can be used as the liquid base for the mixture in some cases rather than water. Because it is a spray, steep slopes are less of a problem; the spray can be applied with equipment specifically designed for application of this type of ADC or standard hydroseeding equipment can be used. Cement mortar types of products are impermeable until broken up but the polymer products will absorb some water like a sponge and then be more permeable once broken up.
- **Product Characteristics:** Desirable ADC qualities of spray-on ADC include: no nutrient source for animals, good erosion control, and gained air space for waste. Orange County, North Carolina reported that over the life of their landfill, they will have saved an estimated two years of space.¹⁴ Undesirable qualities of spray-on ADC include: adverse weather can make application difficult and the product is not permeable until broken up for more waste placement. Examples of products include Pro-Guard and ConCover which are mixes of polymers, and Posi-Shell which is a cement mortar coating similar to stucco. These products are non-flammable and non-toxic.
- **Cost Impact:** Spray-on systems are designed to be no more than ¼ inch thick, unlike typical soil ADC and therefore they save air space for waste. The cost of application equipment, the material, and labor must be evaluated. Specialized equipment may be required; however, some slurries can be sprayed using standard hydroseeding equipment. Collier County, Florida's landfill reported a savings of \$600,000 to \$800,000 in 10 months compared to the use of soil at their 280 acre landfill that receives between 1,300 and 1,500 tons of MSW per day, according to the WasteAge article "Covering Their Tracks."¹⁵

4.4.4.3 Guidance for Spray-on Slurries as ADC

Guidance for using spray-on slurries includes the following:

- **Permitting:** Spray-on slurries are an approved ADC in New York State.
- **Acquisition of Product:** The dry product is purchased from a local supplier and mixed with water or leachate onsite prior to application.
- **Storage:** The materials come in bags that can easily be stored.

¹³ Source: MSW Management. <http://www.mswmanagement.com/march-april-2009/landfill-air-space-value-3.aspx>

¹⁴ Source: Orange County, NC. <http://www.p2pays.org/localgov/BMPs/PDFs/OrangeCountyCover.pdf>

¹⁵ Source: <http://wasteage.com/>, March 2008.

- **Placement:** The placement of spray-on slurries should be done in accordance with the manufacturer’s guidelines. The material can sometimes be placed using standard hydroseeding equipment. Specialized equipment, like truck mounted units or different tank sizes, are available for application depending on the landfill’s needs and can be purchased or leased. Product thickness when applied is about ¼ inch. Low temperatures and high winds may make application difficult or impossible, so another type of ADC should be used during winter months or during times of inclement weather.
- **Monitoring:** A program should be developed to ensure that the spray-on slurry, when used as ADC, meet the performance standards for landfill daily cover. This could be accomplished by maintaining a log book of visual observations.
- **Documentation:** The monitoring program log should be retained in the landfill files for regulatory review.
- **Health and Safety:** Spray-on slurries are non-hazardous inert materials. However, employees should practice good hygiene and wash hands before eating, smoking or using the restroom.

4.4.4.4 Availability

These products would be ordered from a sales representative for the respective company. Two companies that were discussed above are listed below. (R. W. Beck does not endorse any particular vendor or manufacturer, nor do we claim this list to be complete.)

Posi-Shell sales in New York are handled through the Northeast Regional Sales Manager at 1-800-800-7671, ext. 246.

Pro-Guard and Concover sales in New York are handled through the Vice President of Sales and Marketing for New Waste Concepts, Margie Campbell. Her phone number is 419-872-2190, and her email address is margie.campbell@nwci.com. Ms. Campbell recalls doing a demonstration for Broome County about a year ago with one of their products called Pro-Guard SB.

4.4.5 Foundry Sand as Alternative Daily Cover

4.4.5.1 Introduction

Foundry sand is described as “primarily clean, uniformly sized, high-quality silica sand or lake sand bonded to metal castings,” according to the American Foundrymen’s Society, Inc.¹⁶ This summary of findings from a number of sources is based on the following criteria:

- Protection of Public Health;
- Protection of the Environment;
- Durability;

¹⁶ Source: American Foundrymen’s Society, Inc. <http://www.tfhrcc.gov/hnr20/recycle/waste/fs1.htm>

- Operational Impact;
- Product Characteristics; and
- Cost Impact.

General characteristics and engineering properties of foundry sand were evaluated and guidance for its use as ADC includes the following:

- Permitting;
- Storage;
- Mixing with soil (optional);
- Placement;
- Monitoring;
- Documentation; and
- Health and Safety.

4.4.5.2 Performance Evaluation

The findings of the evaluation criteria are summarized below:

- **Public Health:** When non-toxic foundry sand is used in accordance with NYSDEC Part 360 regulations, it meets public health requirements.
- **Environment:** When used in accordance with NYSDEC Part 360 regulations, foundry sand meets environmental protection requirements in regards to litter, odor and erosion. In general, metal concentrations are below regulatory standards and similar to virgin sands and sandy soils according to the EPA's review of beneficial reuse of foundry sand.¹⁷ However there are some occasions where metal leachate concentrations are above RCRA thresholds. Fine sands also have the potential to cause dust.
- **Durability:** Foundry sand is a durable material that should perform comparable to virgin raw material according to the Federal Highway Administration (FHA).¹⁸
- **Operational Impact:** Foundry sand as an ADC is similar to placement of soil daily cover and can be mixed with soil as necessary.
- **Product Characteristics:** Foundry sand is high quality silica sand that is a byproduct of metal castings from a foundry. Desirable ADC qualities of foundry sand include: no nutrient source for animals, good erosion control, and it is permeable. It is also considered a beneficial use in many states, including New York.¹⁹ Undesirable qualities include: potential for metal or organic contaminants due to binders, curing, and metals used on the sand. There is also a potential for

¹⁷ Source: U.S. Environmental Protection Agency. <http://www.epa.gov/ispd/metalcasting/reuse.pdf>

¹⁸ Source: U.S. Department of Transportation, Federal highway Administration. <http://isdcd.dot.gov/OLPFiles/FHWA/011435.pdf>

¹⁹ Source: New York State Department of Environmental Conservation Granted Beneficial use Determinations. http://www.dec.ny.gov/docs/materials_minerals_pdf/budwst.pdf

very fine sands to cause dust, as was found at Crisp County’s Landfill in Georgia.²⁰ The landfill operators found difficulty with the powder consistency of the foundry sand as it clogged radiators and permeated into their equipment. Foundry sand from specific locations/generators should be evaluated before use as an ADC is allowed.

- **Cost Impact:** There is the potential to collect a tipping fee for foundry sand at the Landfill, and since the placement of sand is similar to that of soil, there would be no additional cost incurred for application.

4.4.5.3 Guidance for Foundry Sand use as ADC

Guidance for using foundry sand includes the following:

- **Permitting:** The landfill owner/operator should issue a letter of intent regarding the use of foundry sand as ADC and submit for approval to the NYSDEC. According to the FHA, agencies in the state of New York have previously approved the use of foundry sand as ADC. Broome County has been granted a BUD (#439-7-04) for the use of foundry sand as ADC. An example of a permit from Ohio requires a “report comparing the effectiveness of the foundry sand to conventional soil cover and other alternative daily covers.”²¹
- **Storage:** The sand can be stored in stockpiles, exposed to the elements.
- **Mixing with Soil (Optional):** Mixing the sand with soil may help control the potential for dust as well as reduce the percentage of any contaminants in a given volume of cover.
- **Placement:** The placement is similar to soil as the foundry sand is basically a fine aggregate. Because dust can occur in dry and windy conditions, it may be necessary to add moisture to the material.
- **Monitoring:** A program should be developed to ensure that foundry sand, when used as ADC, meets the performance standards for landfill daily cover. This could be accomplished by maintaining a log book of visual observations.
- **Documentation:** Both the monitoring program log and the trip tickets of foundry sand received should be retained in the landfill files for regulatory review.
- **Health and Safety:** Foundry sand is a non-toxic material, but when handled, there is potential to create a large amount of dust. Employees should use personal protective equipment when handling foundry sand. Also, employees should practice good hygiene and wash hands before eating, smoking or using the restroom.

4.4.5.4 Availability

Currently there are no foundries located in the Broome County region.

²⁰ Source: Crisp County. <http://www.crispcounty.com/meetings/080627m.html>

²¹ Source: State of Ohio Environmental Protection Agency.
http://www.epa.ohio.gov/dsiwm/document/issued_actions/aa-06-097.pdf

4.4.6 Coal Ash as Alternative Daily Cover

4.4.6.1 Introduction

Coal ash is a non-combustible by-product of furnaces that burn coal. It can range from very fine fly ash particles to more coarse dry bottom ash and wet boiler slag.²² This summary of findings from a number of sources is based on the following criteria:

- Protection of Public Health;
- Protection of the Environment;
- Durability;
- Operational Impact;
- Product Characteristics; and
- Cost Impact.

General characteristics and engineering properties of coal ash were evaluated and guidance for its use as ADC includes the following:

- Permitting;
- Storage;
- Mixing with soil (optional);
- Placement;
- Monitoring;
- Documentation; and
- Health and Safety.

4.4.6.2 Performance Evaluation

The findings of the evaluation criteria are summarized below:

- **Public Health:** Coal ash may include toxic elements such as arsenic, lead, mercury and other heavy metals that could be harmful to humans through ingestion, inhalation or skin contact.
- **Environment:** When used in accordance with NYSDEC Part 360 regulations, coal ash meets environmental protection requirements in regards to litter, odor and erosion. However, heavy metals should not be allowed to percolate into ground water, so a landfill liner is necessary to protect the surrounding environment.²³

²² Source: National Synthesis Report on Regulations, Standards, and Practices Related to the use of Coal Combustion Products, prepared by the University of North Dakota.

<http://www.epa.gov/epawaste/partnerships/c2p2/pubs/natpraccc08.pdf>

²³ Source: CSMonitor.com. <http://features.csmonitor.com/environment/2009/01/09/coal-ash-waste-poses-risk-across-the-nation/>

- **Durability:** Coal ash is a durable material that should perform comparable to virgin raw material according to the EPA.²⁴
- **Operational Impact:** Coal ash as an ADC is similar to placement of soil daily cover and can be mixed with soil as necessary.
- **Product Characteristics:** Desirable ADC qualities of coal ash include: no nutrient source for animals, good erosion control (depending on gradation), and it can be placed easily. Undesirable qualities include: potential for metal contaminants, potential for very fine ash to cause dust, and a potential for fly ash to harden when mixed with water. Coal ash from specific generators should be evaluated before use as an ADC is allowed
- **Cost Impact:** There is a potential for collecting a fee for accepting the coal ash, and since the placement of coal ash is similar to that of soil, there is no additional cost incurred for application. However, storage separation from surrounding soil and water may add cost.

4.4.6.3 Guidance for Coal Ash use as ADC

The guidance includes the following:

- **Permitting:** If the County were to consider using coal ash, the Landfill would need to issue a letter of intent regarding the use of coal ash as ADC and submit for approval to the NYSDEC. Coal ash is currently considered non-hazardous and is unregulated by the EPA, but legislation is currently (February 2009) being considered that would place federal regulations on disposal of coal combustion waste.²⁵ If this bill is passed, a review should be done to ensure proper use of coal ash as an ADC.
- **Storage:** The coal ash should be stored where airborne dust can be limited and water is not allowed to percolate a stockpile that could leach into the groundwater, vegetation or soil.
- **Mixing with Soil (Optional):** Mixing the coal ash with soil may help control the potential for dust as well as reduce the percentage of any contaminants in a given volume of cover.
- **Placement:** The placement is similar to soil as the coal ash is basically a fine aggregate. Because dust can occur in dry and windy conditions, it may be necessary to add moisture to the material or limit the conditions under which it is used.
- **Monitoring:** A program should be developed to ensure that the coal ash, when used as ADC, meets the performance standards for landfill daily cover. This could include visual observations and a log book. Monitoring should ensure that no coal ash contaminants are leaching into surrounding soil or groundwater.

²⁴ Source: US Environmental Protection Agency.

<http://www.epa.gov/epawaste/partnerships/c2p2/pubs/greenbk508.pdf>

²⁵ Source: Vermont Journal of Environmental Law. <http://www.vjel.org/news/NEWS100186.html>

- **Documentation:** Both the monitoring program log and the trip tickets of coal ash received should be retained in the landfill files for regulatory review.
- **Health and Safety:** Coal ash consists of heavy metals, therefore employees should practice good hygiene and wash hands before eating, smoking or using the restroom. Employees working with coal ash should wear personal protective equipment such as a face mask in case material becomes airborne during placement.

4.4.6.4 Availability

Inquiries have been made of the Broome County Landfill regarding the acceptance of coal ash.

4.4.7 Contaminated Soil as Alternative Daily Cover

4.4.7.1 Introduction

The use of non-hazardous, contaminated soils as ADC has been evaluated. The summary of findings includes the following:

- Protection of Public Health;
- Protection of the Environment;
- Durability;
- Operational Impact;
- Product Characteristics;
- Cost Impact; and
- Engineering Performance.

General characteristics and engineering properties of contaminated soils were evaluated and guidance for their use as ADC includes the following:

- Permitting;
- Acquisition of Contaminated Soil;
- Storage;
- Placement;
- Monitoring;
- Documentation; and
- Health and Safety.

4.4.7.2 Performance Evaluation

The findings of the evaluation criteria are summarized below:

- **Public Health:** When contaminated soil is used in accordance with NYSDEC Part 360 regulations, it meets public health requirements. However, there is potential for toxic substances like heavy metals to be present, that could be harmful to humans through ingestion, inhalation or skin contact.
- **Environment:** When used in accordance with NYSDEC Part 360 regulations, contaminated soil meets environmental protection requirements in regards to dust, litter, odor and erosion. However, contaminants should not be allowed to percolate into ground water, so a landfill liner is necessary to protect the surrounding environment.
- **Durability:** Contaminated soil is a durable material that should perform comparable to virgin raw material.
- **Operational Impact:** Contaminated soil as an ADC is similar to placement of virgin soil daily cover.
- **Product Characteristics:** Desirable ADC qualities of compost include: dust and litter control, good erosion control, and it is permeable. Undesirable qualities include: potential for contaminants to affect humans or the environment as described above. Contaminated soil from specific generators should be evaluated before use as an ADC is allowed
- **Cost Impact:** Tipping fees are currently received for accepting contaminated soil at the Landfill and it has been used in the past as ADC at the Landfill. Because the placement is similar to virgin soil, there is no additional cost incurred for application.

4.4.7.3 Guidance for Contaminated Soil use as ADC

Guidance for using contaminated soil as ADC includes the following:

- **Permitting:** The landfill owner/operator should issue a letter of intent regarding the use of contaminated soil as ADC and submit for approval to the NYSDEC.
- **Storage:** The soil can be stored in stockpiles, but care should be taken to ensure that contaminants do not enter the surrounding soils or leach to surface water or groundwater.
- **Placement:** The placement is the same as virgin soil.
- **Monitoring:** A program should be developed to ensure that the contaminated soil, when used as ADC, meets the performance standards for landfill daily cover. The County should obtain analytical data that documents that the material is non-hazardous, as well as maintain a log book of visual observations.
- **Documentation:** Both the monitoring program log and the trip tickets of contaminated soil received should be retained in the landfill files for regulatory review.
- **Health and Safety:** Contaminated soil should be designated as non-hazardous for use in the Landfill. However, employees should practice good hygiene and wash

hands before eating, smoking or using the restroom. Employees working with the contaminated soil may also wish to wear personal protective equipment.

4.4.7.4 Availability

The Broome County Landfill currently accepts contaminated soil,²⁶ and has used it as ADC in the past, however the availability for sustainable quantities is unlikely. The County accepted 13,800 tons of contaminated soil in 2006 and 7,800 tons in 2007.

4.4.8 Auto Fluff as Alternative Daily Cover

4.4.8.1 Introduction

Auto Shredder Residue (ASR) or Auto Fluff is the non-metallic waste product of processing automobiles and household appliances for recycling. It accounts for approximately 25% of a vehicle's weight, and consists of a combination of plastics, rubber, glass, wood products, cloth, paper, foam, dirt, and electrical wiring. The residue comes from things like seat covers and cushions, wire, rubber gaskets and windows.²⁷ This summary of findings is based on the following criteria:

- Protection of Public Health;
- Protection of the Environment;
- Durability;
- Operational Impact;
- Product Characteristics; and
- Cost Impact.

General characteristics and engineering properties of ASR were evaluated and guidance for its use as ADC includes the following:

- Permitting;
- Storage;
- Mixing with soil (optional);
- Placement;
- Monitoring;
- Documentation; and
- Health and Safety.

²⁶ The Landfill accepts contaminated soil that has been tested and/or meets NYS specifications. The hauler is required to have a valid NYSDEC 364 Permit on file with the Landfill scalehouse and a manifest must accompany each load.

²⁷ Source: Rhode Island Department of Environmental Management.
<http://www.dem.ri.gov/programs/benviron/waste/central/asrfact.htm>

4.4.8.2 Performance Evaluation

The findings of the evaluation criteria are summarized below:

- **Public Health:** ASR may include toxic elements such as polychlorinated biphenyls (PCBs) which is an oily liquid that was used as a dielectric fluid in appliance capacitors that were manufactured prior to 1979; lead and cadmium; total petroleum hydrocarbons (THP) from automobile parts that contain oil; and low levels of volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs). All of these could be harmful to humans through ingestion, inhalation or skin contact.
- **Environment:** When used in accordance with NYSDEC Part 360 regulations, ASR meets environmental protection requirements in regards to litter, odor and erosion. However, contaminants should not be allowed to percolate into ground water, so a landfill liner is necessary to protect the surrounding environment.
- **Durability:** ASR is a durable material that should perform comparable to virgin raw material, depending on gradation.
- **Operational Impact:** ASR as an ADC is similar to placement of soil daily cover and can be mixed with soil as necessary.
- **Product Characteristics:** Desirable ADC qualities of ASR include: no nutrient source for animals, good erosion control depending on gradation, and it can be placed easily. Undesirable qualities include: potential for PCB, THP and metal contaminants. ASR from specific generators should be evaluated before use as an ADC is allowed
- **Cost Impact:** The County has accepted ASR in the past and has charged a tipping fee for the material. Because the placement of ASR is similar to that of soil, there is no additional cost incurred for its application. However, storage separation from surrounding soil and water may add extra costs.

4.4.8.3 Guidance for ASR use as ADC

Guidance for using ASR as ADC includes the following:

- **Permitting:** Because ASR has been used as ADC previously, the Landfill should inquire with the NYSDEC regarding the need to submit a letter of intent for approval.
- **Storage:** The ASR should be stored where water is not allowed to percolate a stockpile that could leach into the groundwater, vegetation or soil.
- **Mixing with Soil (Optional):** Mixing the ASR with soil may help to reduce the percentage of any contaminants in a given volume of cover and make placement easier if the gradation isn't optimal.
- **Placement:** The placement is similar to soil.
- **Monitoring:** A program should be developed to ensure that the ASR, when used as ADC, meets the performance standards for landfill daily cover. This could include visual observations and a log book. Monitoring should ensure that no

ASR contaminants are leaching into surrounding soil or groundwater. The County should also obtain analytical data documenting the contaminant levels of the material to be received by ASR generators.

- **Documentation:** Both the monitoring program log and the trip tickets of ASR received should be retained in the landfill files for regulatory review.
- **Health and Safety:** ASR consists of contaminants, therefore employees should practice good hygiene and wash hands before eating, smoking or using the restroom. Employees working with ASR should wear personal protective equipment.

4.4.8.4 Availability

The Broome County Landfill accepted approximately 28,000 tons of ASR in 2006 and 29,200 tons in 2007 and used it as ADC. The Landfill previously had a contract with a local scrap metal dealer (Ben Weitsman & Son), but stopped using the ASR as ADC because PCBs were found in the leachate. The levels of PCBs were below the regulatory limit but the Landfill stopped taking the auto fluff as a precaution. The use of ASR as an ADC remains an option.

4.4.9 Green Waste and Compost as Alternative Daily Cover

Green waste does not appear to be a viable option as an ADC for the Broome County Landfill because finished compost is typically too valuable and would not be cost effective as an ADC. In addition, if green waste or compost was used as an ADC, it would not count towards diversion.

4.4.10 Paper Mill Sludge

Paper mill sludge does not appear to be a viable option as an ADC for the Landfill because there are no large paper mills near Broome County from which to obtain sustainable volumes of materials.

4.4.11 Water Treatment Plant Sludge as Alternative Daily Cover

Water treatment plant sludge does not appear to be a viable option as an ADC for the Landfill because it is not likely there is enough volume to be a sustainable option.

4.5 Impact of ADC Options on Landfill Gas Production/Collection

4.5.1 Shredded Tires

Shredded tires should not significantly impact LFG production or collection.

4.5.2 C&D Debris

C&D debris should not significantly impact LFG production or collection when processed into a permeable material. As noted under Section 4.4.2.2, C&D containing gypsum (drywall) can generate additional hydrogen sulfide gas. Because this gas is generated near the working surface of the landfill, this gas will not be collected until the horizontal or vertical LFG collection is extended closer to the working surface.

4.5.3 Spray-on Slurries

Spray-on slurries typically create a “shell” which will shed stormwater and contain LFG emissions after placement. Once that shell has been broken by equipment, usually the next day, the spray-on slurries should not have a significant impact on LFG production or collection.

4.5.4 Foundry Sand

Foundry sand should not significantly impact LFG production or collection.

4.5.5 Coal / Incinerator Ash

Coal and incinerator ash can consist of bottom ash and/or fly ash. Bottom ash is a permeable material that should not significantly impact LFG production or collection. Fly ash, depending on the specific characteristics of the material, can become relatively impermeable compared to other ADC materials. Individual layers of fly ash can create “ceilings” to the vertical migration of landfill gas. Depending on how these layers are graded they may direct LFG toward the center or edges of the landfill footprint. This must be taken into account when designing the LFG collection system. Breaking up the fly ash at the beginning of daily operations can reduce the gross permeability of the material and reduce its impact on LFG collection. Fly ash should not impact the production of LFG.

4.5.6 Contaminated Soil

Depending on the nature of the contaminated soil, this material can impact the collection of LFG, but should not impact LFG production. If the contaminated soil creates a lower permeability layer when compacted as an ADC, it can create a barrier to the vertical migration of LFG. This should be addressed as part of landfill operations and LFG collection system design. Breaking up the contaminated soil at

the beginning of daily operations can reduce the gross permeability of the soil and reduce its impact on LFG collection.

4.5.7 Green Waste/Composted Material

Not a viable ADC option based on the findings of this Issue Paper.

4.5.8 Autofluff

Autofluff should not significantly impact LFG production or collection.

4.5.9 Paper Mill Sludge

Paper mill sludge could impact the collection of LFG depending on its physical characteristics. Paper sludge can contain kaolin (a clay material) and other fillers. If the paper mill sludge creates a lower permeability layer when compacted as an ADC, it can create a barrier to the vertical migration of LFG. This should be addressed as part of landfill operations and the LFG collection system design. Paper mill sludge can contribute to LFG production. Paper mill sludge contains organic material (primarily short paper fibers) and may generate its own gas.

4.5.10 Water Treatment Plant Sludge

Depending on the nature of the sludge, this material can impact the collection of LFG. If the sludge creates a lower permeability layer when compacted as an ADC, it can create a barrier to the vertical migration of LFG. This should be addressed as part of landfill operations and LFG collection system design. Trafficking the sludge at the beginning of daily operations can reduce the gross permeability of the sludge and reduce its impact on LFG collection. Water treatment plant sludge can contribute to LFG production as it contains organic material.

4.6 Capital and Operating Expenses

Implementing one or more ADC options may incur costs, which may be more or less expensive than using 6 inches of soil. Each option should be analyzed for material costs, the cost of machinery to process or apply the product, the labor costs associated with preparing and applying the material, and should be compared with existing daily cover costs and diversion goals to determine the suitability of the option.

See Table 4-1 for planning level cost estimates for the ADC options discussed in this paper.

4.7 Implementation Requirements

Currently the Landfill uses six inches of soil for daily cover. The Landfill also has a tarp that can be used under ideal conditions (no wind, working on a flat surface area,

etc.). The use of a permeable ADC would require the County to evaluate each option as it relates to:

- Permitting;
- Acquisition of material;
- Storage;
- Handling (i.e., shredding);
- Staffing requirements;
- Placement;
- Monitoring;
- Health and Safety;
- Cost; and
- Other site-specific considerations.

4.8 Addressing Stakeholder Concerns

The stakeholder group most likely to be concerned with the Landfill’s use of a permeable ADC would be the Landfill Citizen Advisory Committee (CAC). As a subgroup of the Environmental Management Council, the CAC acts as a liaison between the County and the communities adjacent to the Landfill and provides public input regarding the design, construction and operation of the Landfill. The County retains all power and responsibility for decisions at the Landfill but must consult with, solicit and consider the views of the CAC.

Stakeholder concerns regarding Permeable ADC may include:

- Concern that the costs associated with ADC will be higher than the costs associated with traditional materials;
- Concern that the quality of ADC products may be inferior to virgin soil or lack adequate standards and specifications; and
- Concerns about the use of materials that have public health risks associated with them.

The County could address these concerns by scheduling meetings with the CAC to first discuss the ADC options that the County is considering and get feedback from the CAC, and then keep them updated as the County moves forward with choosing an option, going out for bids, etc. The County should also obtain analytical data and/or MSDS sheets for materials that may pose public health risks to evaluate their use at the Landfill.

4.9 Benefits and Drawbacks

The use of ADC has benefits as well as drawbacks, as outlined below.

4.9.1 Benefits

The benefits to the County of using a permeable ADC may include, but not be limited to the following:

- Conservation of natural resources by utilizing material other than virgin soil;
- Potential revenue generation and increased diversion from accepting certain materials for use as ADC (e.g., contaminated soil, auto fluff, foundry sand, coal ash, etc.);
- Potential cost savings for ADC materials and product application;
- Potential decrease in the amount of daily cover used (especially with spray-on slurries), thus increasing the life of the Landfill; and
- Potential ease of application compared to placing six inches of soil (especially with spray-on slurries).

4.9.2 Drawbacks

Potential drawbacks of using a permeable ADC may include:

- Could lead to less than desirable surface compaction;
- Tests may be required of the ADC material and results made available to the Landfill before the ADC can be accepted for use;
- Potential exposure of workers to hazardous materials (depending on the ADC);
- Very fine ADC materials near the bottom of a new liner system could potentially clog the leachate collection and removal system and/or it could clog Landfill equipment;
- Weather limitations for the application of certain ADC options (e.g., spray-on slurries); and
- Some ADC options require more airspace, especially when compared to using tarps.

Table 4-1
Planning Level Cost Estimates

ADC Option	Equipment Required (in addition to virgin soil placement needs)	Equipment Cost (additional to virgin soil placement needs)	Product Cost	Operating Cost (other than placement cost similar to virgin soil)	Additional Information
Contaminated Soil	NA	NA	Tipping fee for contaminated soil is currently collected at the Landfill.	NA	Currently at the Landfill, contaminated soil is stored only on the active working face of the lined cell.
Foundry Sand	NA	NA	Tipping fee may be collected at the Landfill.	NA	NA
Coal Ash	NA	NA	Tipping fee may be collected at the Landfill.	NA	Storage for coal ash should be in a location where it cannot contaminate surrounding soils, vegetation or groundwater. Any costs incurred should be included.
Spray-on Slurries	Hydroseeder	Approx. \$10,000-\$15,000 ¹ Lease: \$2,000-4,950/month ⁵	Approx. \$0.02-\$0.03 per sq ft of coverage ³ \$85,500-94,500/yr ⁵	Mixing, loading and spraying can be done by 1-2 people. \$7500-10,000/month ⁵	Placement thickness is approx. 1/4 inch, saving airspace, thus this cost savings should be considered in the analysis.
Shredded Tires	Tire Shredder if shreds are not purchased from an offsite vendor	<u>Shredded on-site</u> : approx. \$250,000-\$500,000 for the shredder ² <u>Shredded off site</u> : \$0	<u>Shredded on-site</u> : Disposal fee is currently collected for tires. <u>Shredded off site</u> : Potential cost of approx. \$4-\$10/ton for tire chips 3"-6" with minimal wire. ⁴	<u>Shredded on-site</u> : \$12-\$25/ton processed; placement cost is additional and similar to soil. <u>Shredded off site</u> : Placement cost is additional and similar to soil.	Price of purchased chips may increase with delivery distance, as processors that sell shreds within 100 miles were not located.
C&D	Shredder/Grinder	Approx. \$250,000-\$750,000	Tipping fee for C&D is currently collected at the Landfill.	Approx. \$25/ton processed; placement cost is additional and similar to soil.	NA
Glass Aggregate	NA	NA	Tipping fee for Glass Aggregate is currently collected at the Landfill	NA	NA
Tarp	Deployment Attachment for Dozer	Landfill already has equipment	\$11,000 - 12,000/yr ⁵	\$2,500 - 5,000/yr ⁵	The Landfill currently uses the tarp as ADC

¹ Source: <http://www.rittenhouse.ca/asp/menu.asp?MID=99>

² Source: <http://www.ssiworld.com/docs/Scrap-Tire-Shredding-Information.pdf>

³ Source: <http://www.nwci.com/lib-infosheets/squarefeet.pdf>

⁴ Source: http://www.empire.state.ny.us/pdf/polution_prevention_recycle/TireReport06.pdf

⁵ Source: Broome County

